



Is urban sprawl a threat to sustainable development? A review of characteristics and consequences

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Abstract

During recent decades, urban sprawl has been substantially debated in the literature, carrying significant social, economic and environment implications, much earlier than of sustainable development concept being introduced. Often, urban sprawl is defined in terms of undesirable development. Urban sprawl is also associated with negative urban expansion and excessive resource consumption. To mitigate urban sprawl, urban growth management has been timely implemented by understanding urbanization characteristics and their socio-environment and economic driving forces. While sustainable urban development is a highly developed spatial form of integrated cities, urban sprawl mostly occurred in lower densities accompanied by expansion of urban periphery, is acknowledged as the opposite force, with its character of scattered and leapfrogging development. Therefore, urban sprawl is the most impactful urban development patterns that occurred at an unprecedented rate that threaten sustainable development. This article examined the characteristics and the consequences of urban sprawl and how it affects sustainable development.

Keywords: urban growth, urban sprawl, urbanization, sustainable development.

Introduction

Uncontrolled urban growth has become a general concern prior to sustainable development concept being introduced. Therefore, urban growth management has been implemented to circumscribe strategies and policies to mitigate the presence and the consequences. However, without adequate information on the characteristics of urban growth pattern, and as much as realizing the diversity in socio-environment and economic transformation, urban growth has created sprawl that is worse than before. This paper is a review of current research and application regarding urban sprawl characteristics and consequences. This paper is driven, first

by the increased publication of urban sprawl research in the scientific communities (Chen et al., 2014). Through research, urban sprawl has been defined, measured, quantified and analyzed in a multidimensional aspect. Research offer some innovative ways how to deal with urban sprawl. The need to provide evidence of presence of urban sprawl is simply because the importance in the quantification of sustainable development.

Conceptualizing of Urban Sprawl

Urban growth is basically an agglomeration process associate with a progressive development of physical and functional implication. Agglomeration through higher productivity promotes urban or physical growth. The dynamic of urban growth is a relation between social, economic, environmental, spatial, technological and institutional (Drobniak, 2014; Raven et al., 2017; Viana et al., 2019). These elements play their own role to influence rapidly growing urbanization. Uncontrolled urban growth is also associated with negative expansion and urban sprawl (Ghosh, 2019; Shao et al., 2020). While urban agglomeration is a highly developed spatial form of integrated cities (Fang & Yu, 2017), urban sprawl mostly occurred in lower densities accompanied by expansion of urban periphery, is acknowledged as the opposite force, with its character of scattered and leapfrogging development (Mills 1981; Brueckner & Fansler 1983; Lowry, 1988; Hayden, 2004; Downs, 1999; Ewing, 2008; Ahyuni & Nur, 2020). Though urban sprawl is a global phenomenon, but it is always viewed in different ways on how and why it was resulted (Hosseini & Hajilou, 2019; Abulibdeh et al., 2019).

In Eastern Europe, urban sprawl was considered as an outcome of post-socialist of autocratic transformation into liberalization of economic and social well-being (Kovacs et al., 2019; Gotovac & Kerbler, 2019). In the USA, early spatial form of sprawl occurred after World War II because the perception of the new suburb is safer, more desirable and cheaper than urban alternatives (Benites-Gambirazio, 2017; Franklin & Plane, 2019; Dibble et al., 2019). In Asia, most recently China and India are experiencing the largest and most rapid urban sprawl because of their enormous economic transformation (You, 2016; Lv et al., 2016; Du, 2017; Zhang & Xie, 2019; Shao et al., 2020). Thus, urban sprawl has been conceptualized in a multidimensional way, instigated by different values, driven by different forces, shaped by different characteristics, but sharing similar consequences to sustainable social, economic, political and environmental development.

Characteristics of Urban Sprawl

The presence of urban sprawl is worldwide, and it is not exclusive to any particular type of functioning city. Derived from the definition and theory of urban sprawl, the article suggests general characteristics of urban sprawl as below:

Automobile dependance and low accessibility

Dispersed and low-density development create an automobile dependency and lower the accessibility for public transit network (Ewing, 2008). This type of urban expansion also highly effecting the cost of providing public transport hence its efficiency and competitiveness (Mendonça et al., 2020). The costly public transportation is because the struggle to consolidate

demand and supply at cost efficient level of services in low density and scattered development. As density decrease, less unit of developed space are deserted into single parcel of land. Subsequently, dispersed and low-density development also result in less activities, which mean less demand for transportation. Moreover, the inflating cost of providing necessary transportation infrastructures of inner city and fringe development is inevitable. Insufficient infrastructure for public transport has escalate the traveling time due to low volume and inefficiency in transit-oriented transportation. As a result, more people choose to drive than to use public transportation, hence enticing people to use public transit become more difficult. Then, a higher transportation infrastructure cost in addition to a low volume of users of public transportation has resulted in poor accessibility. Subsequently, all the above aspect has contributed to the catastrophic need for people to individually drive to work.

Dispersed and low-density development

Dispersed or scattered and low-density development are urban sprawl most described and recognizable character. Contrary to compact development which concentrated in the urban center, this urban sprawl pattern developed in urban periphery and beyond that, decrease in density as they go further away from urban center. The urban growth pattern into its periphery and rural areas such as dispersed or scattered development are also an essential character of urban sprawl. This type of development has risks of causing encroachment of rural agricultural and environmentally fragile land (Deilami & Kamruzzaman, 2017; Nope et al., 2020). In low-density suburbs, agricultural and arable land is interwoven with residential and urban infrastructures, and dispersed public amenities e.g. health facilities, public schools, community halls. The central areas of low-density suburbs are centripetal because they pull businesses and services compellingly. The agricultural and arable land which is surrounding the low-density suburbs are centrifugal due to dispersed agricultural and interspersed natural resources. As a result, the provision of infrastructures and utilities in this setting is significantly costly.

Modified travel mode and pattern

Traffic volumes and travel mode are closely linked to urban land use. Rapid urban and economic growth not only altering urban land use and adjoining urban periphery, it also transformed how population live, work, travel and fulfilling needs (Soteropoulos et al., 2019; Hasanzadeh et al., 2019). Extensive observation of urbanization trends such as suburbanization and urban sprawl has indicated direct and indirect consequence on mobility and travelling pattern. Upgraded roads into expressway allow people to commute greater distance between residential and urban center. These urban expansions are basically followed by increasing change in internal transportation routes, which effect the work traveling time and distances, which eventually change travel mode and pattern.

Lee (2020) has studied the effect of metropolitan sprawl on commuting trips in the continental United States. The metropolitan sprawl area is divided into lower, medium and higher metropolitan sprawl. The study establishes multivariate regression models between urban form, commuting trips, and emissions from road traffic to determine the sustainable travel mode and pattern. The finding concluded that lower metropolitan sprawl associated with more pedestrian commuters, higher sprawl associated with motorized commuters, with longer

commuter time and distance. Emission from motorized commuters are also derived from higher metropolitan sprawl.

Soteropoulos et al. (2019) study on how the spread of urban development has effect on travel mode: (i) walk, (ii) bike and train, (iii) bus, tram and metro, and (iv) car and their travel behavior. The study found that people living in high density urban area choose travel mode (i) and (ii), travel less but more satisfied with their daily travel compares to people living in low density sprawl choose mostly cars with frequent travel but were not satisfied with their daily travel. The travel behavior pattern of people living in suburbs is car dependence, thus give rise to vehicle miles travel and is reflected in reducing the traveling sustainability. Lee, Soteropoulos et al. and many other previous studies have revealed that urban sprawl has colossal implications for sustainable transportations.

Spatially segregated land use

Spatially segregated land use is a type of suburbanization that has tendency to discontinuity-large closely settled areas intermingled haphazardly with unused area which probably due to large scale of speculation (Clawson, 1962). For example, blocks of low-density housing estates built surrounded by acres of rural agricultural region or environmentally fragile without any relation of this adjacent land uses. The adverse effect is not only encroachment but also socio-environment deprivation. This urban sprawl feature created ever greater pressure on land and people, whereas modification policy is increasingly complex. Some of spatially segregated land use had caused the social structure segregation where people of different color or beliefs has been segregated into different neighborhood. These spatially segregated land use can occur in a city scale or a regional scale.

A study on phenomenal urban expansion and racial composition in the city of Atlanta by Ambinakudige et al., 2017 was conducted to answer overarching questions: has the economic growth and urban sprawl had caused racially segregated neighborhood. The study is using hotspot analysis to study temporal changes and index of dissimilarity and index of interactivity in the three sub-regions of Atlanta. The study found two of the sub-regions was predominantly by the people of color. The other one is considered racial diversified. The economic growth and the urban expansion are where the racial diversified sub-regions located, whereas the people of color settled in the less fortunate segregated urban sprawl sub-regions. This trend is expected to continue, with less economic growth and opportunities sub-regions are not only spatially segregated but socially as well. These pattern of sprawl produces spatial separation, displacement, racial segregation in an urban area and led to the transformation to other urban sprawl effects (e.g. poor accessibility, resource depletion, value deprivation).

A study on spatially segregated land use pattern and overlapping territory between agricultural and industrial of arable land in 52,600-kilometer square Romanian Plain was performed by Grigorescu & Kuscicsa (2017). The plain has a total of 650 localities of densely populated areas, moderately populated areas and low-populated areas interwoven throughout the area. The spatial transformation begun after post communism turned to the market economy resulted in massive land use changes caused by intensification (production and workforce based) and extensification (land conversion for crop and commodities) of rural, forest and rangeland. This forced industrialization and urbanization has encroached fertile and arable land, the industrial areas becoming the rough neighborhoods and the traditional rural-agricultural society turned into the urban-industrial society in the 1990s. By 2000s, the spatially segregated land use had caused

excessive land fragmentation where huge farms become several small and abandoned farms, where productivity decreased, and change rural-urban function.

Large single-use development

Single-use development in single use zoning is a type of land use planning tool that designated an area to have only either residential, industrial or commercial development which eventually turned into sprawl because it appears mostly in suburban areas (Rosni et al., 2018). A study by Hall (2007) argued that the original idea of single-use zoning was to remove factories from residential neighborhood. But later, it become a means for excluding the poor and the general population from middle and upper-class residences. Many regulations including subdivision were imposed to maintain the exclusivity of such zoning such as minimal lot sizes, residential square footage and design aesthetic. The study also stated that other reason for having a residential single-use zoning is because the strong need for privacy, the desire to have nonpareil environment for child raising and a rural-like settings.

A study of spatial analysis and mixed used development in Kuala Lumpur by Rosni et al., (2018) using geospatial index was conducted to measures the phase of segregated urban sprawl. The segregated urban sprawl is demoting mixed-use development into single uses, reduces functionality and efficiency of urban land use system, thus causing high dependency on motorized vehicle and deterring the use of public transportation. Single use development is a result of poor planning of land use and zoning policy. Single-use development was previously allowed in zoning regulations by the local authorities until they realized the negative consequences has outweigh the positive. The study suggests transit-oriented development as a necessary approach to remedy the dependency on motorized vehicle and promoting sustainable development trough mixed used in the future development.

Polycentric development

Polycentric development is a state of having more than one center (as of development control). The role of polycentric development on promoting urban sprawl however is split between scholars. A study on the role of urban polycentric planning in China's Mega Cities by Liu & Liu (2018) was aimed to address the performance of planned and unplanned polycentric. Chinese polycentric development is a result of fast urbanization. Chinese mega cities are overpopulated and overcrowded, and this state of condition is due to monocentric spatial form. To remedy, planning policies has embraced polycentric development strategy to ease the pressure in the monocentric urban center. The planned polycentric provide new development areas for firms and industries to operate in the fringe of the city's boundary, creating new demand of workforce and settlement. The unplanned polycentric however, does not have structuring workforce growth and disproportionate rate of population growth and urbanization. Thus, the study confirmed that unplanned polycentric is being direct to uncontrolled growth and eventually sprawl.

Polycentric development can also be accounted as an integrated spatial planning policy and economic growth as explained by Zambon et al., (2017). The study subsequently argued that the polycentric development is intended and has a way to achieve a greater, more balanced and more sustainable development of urban center and sub-center development. Earlier European cities have a descriptive character of compact and dense. In the last two decades, urban agglomerations have experienced enormous rates of land conversion due to the sprawled residential into the periphery areas. Providentially, the periphery urbanization has transformed

into large and medium sized city networks. These polycentric urban areas have relevant implications in the spatial development of larger cities, fostering marked shifts towards discontinuous sprawl. In short, spatially balanced, functional and economical polycentric city's composition driven by decentralization of people and coexistence of multiple polycentric is believed to be able to create urban competitiveness.

Based on the literature, it is clear that urban sprawl is a complex urban phenomenon, apart from being characteristically described, is difficult to generalize the features. Hence, attributes from 'compact' to 'sprawl' form is more likely to be described in a continuum rather than any generalized or specialized characteristics. In other words, urban sprawl may have at least one of the characteristics or two or more, but none of them have *one size fit all* premises.

Urban Sprawl consequences to sustainable social, economic, political and environmental development

Notwithstanding of how urban sprawl is defined, theoretically distinct, characterized and measured, sprawl response often to disorienting sets of social, economic, political and environmental consequences (Nijman & Wei, 2020). Past scholar has long attended to issues of inequality and unsustainability at various scale, such social segregation, fiscal disparities, economic deprivation, employment discrepancies and so on. The consequences of sprawl, either positive or negative, are assessed based on these set of aspects.

Social consequences

Urban sprawl has enormously increased the distance and time taken for journey to work and created a complex web of traffic flows which cause congestions (Wang et al., 2020). The spatially segregated land use of urban sprawl also means basic services such as schools and health facilities located further away from residential therefore increasing travel time and distance. This include restricted access to public transit which essential for the underprivileged (Ewing et al., 2016). The vital hours spending travelling on a daily basis especially during peak hours in the long run could deteriorate the quality of health. A study on spatial analysis of demographic of Atlanta by Ambinakudige et al., (2017) finds that the type of land use segregation of urban sprawl also aggravating socio-spatial separation thereupon and affecting social interaction, formation of urban gaps and racially segregated neighborhoods. The study also claimed that the socio-spatial separation of urban sprawl would further hinder employment opportunities particularly in the fringe area. Urban sprawl can also cause intensified fiscal disparities among communities, which extend to several aspects of inequality. Suburban wealthy communities have a larger tax reserve, and fewer social service to provide, therefore expanded public service disparities, for example public schools and inner-city services. Another study on how sprawl affect social inequality in America by Lee et al., (2018) investigate whether social well-being and inequality is caused urban sprawl. The study suggest urban sprawl has direct effect in social well-being, and an indirect effect to income inequality. For example, urban sprawl caused long commutes, and this is linked to household disposable income and suppressing social interaction. The study also indicates the growing concentration of social inequality and social segregation is both causes and consequences of other social problems.

Economic consequences

Attention has been given to economic consequences of urban sprawl especially urban decline and reduced urban economic agglomeration. Past research has evidenced connecting urban sprawl with reducing economic agglomeration and productivity in the core urban area. Wolff et al., (2018) suggest urban sprawl seems to have particular impact on economic activity in the core urban area because urban decline had force business and industrial to relocate to the periphery either to reduce operational costs or to accommodate high level business for high inner city society. Since economic sector is linked with geographical factors, only high-level business and services are operating in the core urban area. These urban economic agglomerations created demand for multinational companies, large corporations and industries players to benefits from significant costs of transportation, pool of human resources, huge local markets and knowledge spill overs. Furthermore, the well-to-do families have tended to escape the core urban area to avoided overcrowding cities and moved to suburban sprawl. This has caused widen economic disparity and fluctuating costs of land, services and goods in the periphery.

In undeveloped country, most people rely on agricultural production and land is a vital resource and assets. A study by Dadi et al., (2016) investigate the impact of urban sprawl in Ethiopia. The agriculture and rural population were extensively affected by residential and infrastructure expansion. The low-density and leapfrog sprawl encroach agricultural lands and has been contrary to the government policies to minimise land conversion, thus undermining the livelihoods and socioeconomic of poverty-stricken population. The loss of arable land and agricultural productivity has severely effecting majority of population because agriculture is the principal occupation and the biggest derived household income. The urbanization has neither come with additional employment nor economic opportunities. The government has unsuccessful to expand industrialized economy, instead the rate of industrial enterprises has reached rock bottom without new employment and the GDP of the country has never been worse. The supposed infrastructure expansion was not benefitted the rural population in term of access to electricity or clean water. What made the matter worst is the converted lands for industrial purposes were not at all even developed.

However, an opposite finding from a study by Wang et al., (2020) is looking at the consequences of urban sprawl in China and how urban decentralization has benefitted the economy in term of having less expensive new towns in suburban sprawl. The study suggests urban decentralization and suburbanization improved housing condition and redirecting spatial development. Urban decentralization also decelerate urbanization through proper spatial and growth control. Another mitigation strategy to reverse the consequences of sprawl is urban renewal – infrastructural renewing in existing urban core area. Urban renewal on large scales provide good opportunities for economic resuscitation in the core area and gradually follows to the periphery. Urban renewal also replaces the composition of residence and the ongoing demographic trend towards smaller households, counterbalancing the negative effect of population decline on housing demand. Both urban decentralization and urban renewal strategy has enhanced the quality of living in the suburban sprawl and the existing cities in China.

Political consequences

A continuously increasing number of volumes on development is appearing parallel with the occurrence of sprawl. Urban sprawl has been described in terms of the political structure of

metropolitan regions (Burchell, 1998; Downs, 1999; Egidi et al., 2020). Low density, scattered, and leapfrogged development apparently effect the spatial and locational aspect of local government expenditures. This is due to the increment in providing public services costs to cater for larger area with lower population density. Thus, in order to maintain the quality of service provision in newly urbanizing areas, every now and then, new local governments and special districts are often formed (Lewis, 1996; Foster, 1999). The course is fundamental due to the perpetuation of urbanization in periphery because new local governments or corporations can ensure its continued existence (Carruthers, 2003). These changes in the structure of the urbanized area has direct consequences not only to the public services but also to the political structure and possibly their electoral boundaries.

Ehrlich et al., (2018) examine urban sprawl and the role of institutional setting in Europe. Urban sprawl in Europe is particularly pronounced and occurs outside functional urban areas. The study founds out a strong link between urban sprawl and local political fragmentation, allowing intervention policy such as land use planning and fiscal incentives to permit suburban development in the periphery. However, implementing growth restriction via land use planning seems not corresponding to mitigate urban sprawl. Land developer can easily circumvent the growth restriction by moving into a neighboring, less restricted jurisdiction. Land fiscal incentive is much more effective way to restrict growth because group of similar social and financial status would have exclusive control over minimum lot size and density instrument. Liu et al., (2018) ties together the same conclusion where political and institutional framework has not been able to correspond to urban sprawl. On the other hand, land fiscal incentives have accelerated urban development, due to overreliance on the continuously increasing land finance.

Environmental consequences

Environmental degradation is the most affected cost associated with urban sprawl that are intensified by the characteristics and pattern of this advancement. Urban sprawl reduces open space, forest and agricultural land. The low density, scattered and leapfrog development requires lengthy infrastructures including road networks, turning absorbent surface into impervious surface. Decreased of open space, forest and agricultural land decreased quality of water sources caused by nonpoint source pollution and sedimentation. Increased of impervious surface also increased water runoff and risk of flash flood (Yang & Zhang, 2018; Archer et al., 2019). Increase of impervious surface particularly built up areas caused urban heat island, temperature differences and microclimate change. An example in Quebec Canada as studied by Siles et al., (2018), where urban sprawl causing fragmentation and loss of wetland area are affecting biodiversity and their ecosystem such as specific wildlife and birds. Another example by Manjunatha et al., (2019) where Chicago's aggressive extension and sprawl of its commercial district have become an environment threat to Illinois basin and Mississippi River, resulting in habitats loss along major rivers threatening the sustainability of wildlife populations.

The loss of arable and agricultural land has been considered as a serious threat to agricultural productivity and food security. In the case of Changchun-Jilin Economic Zone (CJEZ), the fertile land knowns as the place for world best golden maize and other high-quality crops was transformed into rapid urbanization and periphery residential expansion as studied by Li et al., (2018). The encroachment causing a serious environmental degradation and a threat to food security. Even Nile Delta located along Nile River was not spare by poorly planned urbanization and sprawl as studied by El-Ramady et al., (2019) where soil fertility and food

security for 90 million Egyptian was threatened. Uncontrolled development and sprawl were claimed to cause climate change, flash flood, soil pollution, topsoil erosion, reduction of soil fertility and salinization. However, bad things have to happen before good things can. In the case of Moscow Region, the urbanization has cause soil organic carbon stocks replacement as studied by Demina et al., (2018). It turns out the soil sealing and excavation of topsoil for building construction has converted infertile area with carbon-rich topsoil that suitable for vegetation and improved ecosystem.

Lack of mixed development in urban sprawl cause longer and more frequent travel that eventually would inevitably create private transport dependency. Private transport dependency can further trigger traffic congestions, traffic delays, increased accident risk, and increased vehicle miles travel (Khan et al., 2018). Higher degree of sprawl would have tendency of more than one passenger vehicles to meet with transportation vis-à-vis trip needs. A study of transportation sustainability in Huntsville, Alabama by Khan et al., (2018), discovers that urban sprawl creates private transport dependency, quoting land use models forecast without considering underutilized roadways causing urban sprawl. A sustainable transportation only can be achieved if potentially urban expansion forms a polycentric pattern with moderate densities and continuous land development, except for open spaces. Uncontrolled urban expansion promotes low accessibility, consume more energy, increased private transport use and carbon emission. The study recommends promoting transportation sustainability via planning mixed development and compact cities using available resources instead of planning road network only to cater for land use forecast model.

Urban sprawl also associates with fragmentation of natural trail and habitat causing ecosystem disruption including imbalance ecological food chain and species endangerment. In Sri Lanka, a study by Tella et al., (2020) on overhead electric powerlines that supply energy in scattered urbanized region become power traps causing population of animals at risk. The powerlines were built right in the middle of natural habitat of mixed forests kills animals by electrocution and fragmented their trail. Forest and infrastructures show very low levels of ecological connectivity because infrastructures damage environmentally fragile natural trail and habitat and risk of wavelength and electricity to animal in this case is excessive. Continuous encroachment of urban periphery into agricultural and forest land increased carbon emission that desecrate the stratospheric ozone layer causing global warming.

Conclusion

Urban sprawl has been and remains a global prominent issue and a threat to sustainable urban growth and development. Based on its characteristics, clearly urban sprawl is a disparaging urban phenomenon. Urban sprawl discourages the use of public transportation and promote the use of private automobile that consume higher fossil fuel and increased carbon emission. Dispersed and low-density development of urban sprawl elevate rural and agricultural land being transformed to urban use which reduced scarce agricultural land. Spatially segregated land use created greater pressure on land resources and decreased traditional rural-agricultural productivities and socioeconomic deprivation. Large single-use development hinders walkable leisure and retail activities and reduces functionality and efficiency of urban land use system. Polycentric development does not have structuring growth and disproportionate rate of

population growth and urbanization. The characteristics of urban sprawl are the overwhelming evidence of urban sprawl is a threat to sustainable development.

The consequences of urban sprawl to sustainable social, economic, political and environmental development also has been thoroughly discussed. The study found that social well-being, social inequality and suppressing social interaction arises from spatially segregated land use, intensified fiscal disparities and long commutes, which caused by urban sprawl. The study has also discovered some evidences on economic consequences connecting urban sprawl with reducing economic agglomeration and productivity in the core urban area and undermining the socioeconomic of poverty-stricken population. The study also found a strong link between urban sprawl and local political fragmentation, allowing intervention policy such as land use planning and fiscal incentives to permit suburban development in the periphery. Last but not least is the consequences to environmental degradation which among others are: reduces open space, forest and agricultural land, decreased quality of water sources, increased risk of flash flood, urban heat island and a serious threat to agricultural productivity and food security. Notwithstanding of how urban sprawl is defined, theoretically distinct, characterized and measured, sprawl response often to disorienting sets of social, economic, political and environmental consequences. Thus, the government and the concerned people have to provide more effort toward mitigating the adverse effect of sprawl.

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