Impact of Infill Approach to Sustainable Urban Environment the Development

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ABSTRACT:
One of the major problem facing cities in the developing countries of the world is growing number of population and urbanization that are characterize by urban sprawl and urban poverty, these phenomena gave birth to physical, social, economic and environmental consequences to the cities. This also goes with increasing demand for shelter, commercial and industrial activities in the cities. Infill development approach is the only alternative that can encourage optimal use of land, cut-cost of services and infrastructure provision; curb urban sprawl, and explore the highest and best use of land. Principle of infill development can contributes to the physical and economic growth and development of the cities.The paper examined the emerging infill development issues and problems. The benefits, types and the impact of the infill development in Unguwar Rimi GRA in Kaduna are assessed. Data were obtained through institutional survey and field survey in the study area. Data collected was analyzed using descriptive analysis and presented using percentage and frequency tables. Various impacts both positive and negative were identified, based on these impacts recommendations were offered for effective residential infill development in Unguwar Rimi GRA of Kaduna and Nigeria at large.
KEYWORDS: *infill, development, cities, urban sprawl, environment*

I. INTRODUCTION:

Given the uncontrolled expansion of Iran's cities, infill development is an effective approach. Focusing on the vacant and abandoned lands in cities, infill development could be seen as the simplest interpretation of internal development tries to load development on these lands. Moderate to high-income households generates most suburban growth, then infill development must be targeted to a more upscale housing market, which conflicts with the affordable housing goal (Razavian & Samadi, 2016; Steinacker, 2003). Cities development as complex and dynamic system the processes is, its development are always characterized by social, physical, economic, cultural and even sometimes political approaches. The growing urban population influences cities widespread developments. Due to the increasing urban population, especially the increasing population of metropolises, urban growth is unavoidable. The expansion of the city, called urban sprawl, is a phenomenon that has occurred in the last half-century, not only in developed countries but also in developing countries (Mokhtari, Hoseinzadeh, & Safaralizadeh, 2014). Due to above mention reason policy makers and urban managers looked at infill development as practical solution to urbanization associated problems especially in developing countries. (Abbasi & Nikniya, 2013; Chiroma, Adamu Harir, Bukar Abba, & Audu Gani, 2017; McConnell & Wiley, 2012; Mir moqtadaei, Rafieian, & Sangi, 2010; Razavian & Samadi, 2016). To reduce the dispersed development burden of lands; an infill development is used. The infill development causes the existing gaps in the community to be filled, and this development plays a vital role in utilizing the existing potential of the city and protecting pristine land and preventing urban sprawl(Abbaszadeh, 2016; Aliakbari & Akbari, 2018; Strunk & Ribikawskis, 2017). Indeed, infill development can be seen as a response to external development; a process that has led to the recession and the abandonment of the central regions of the cities from urban development(Steinacker, 2003). Currently, infill development in many metropolises has a significant share in the areas where construction is carried out. Many companies and organizations are moving towards infill

development, as they have realized the benefits of being close to the urban centers. Low cost of infrastructure and rental and sales costs to infill development projects helps these projects to be useful for developers, infill development projects to support the environment and increase the quality of life in cities(Rahimi, 2016). Also, paying attention to infill development (densification) without considering development policies can have disadvantages; For example, (Mustafa, Heppenstall, et al., 2018; Mustafa, Wei Zhang, et al., 2018)highlighted that the spatial planning policy oriented towards densification without expansion led to significantly higher flood damage.

Infill developments involve developing vacant land or under-used parcels within existing urban areas that are largely developed. Infill development is the process of developing vacant or under-used parcels within existing urban areas that are already largely developed. Infill development is the new development of vacant, abandoned, passed over, or underutilized land within built-up areas of existing communities, where infrastructure is already in place. The demolition of existing structures and building new structures or the substantial renovation of existing structures, often changing form and function. Infill sites could be divided into vacant lots which often become dumping grounds for waste, posing health and safety hazards, abandoned properties which requires maintenance and demolition costs or brownfields, which are usually lands where old industries, other businesses and warehouses were held (Aly & Attwa, 2013). Infill development has been defined in the literature in various ways; thus, urban infill is the practice of developing vacant or under-utilized properties within an urban area rather than undeveloped land in more rural areas(Sharpin, 2006). In addition,(Ooi & Le, 2011) described that infill development involves developing vacant parcels within existing urbanized areas that for various reasons has been passed over in the normal course of development. They include redevelopment opportunities where new and more expensive buildings are constructed in place of the old buildings or vacant sites.

Today, about 50% of the world population or three and a half billion live in cities but it is expected that by 2050, the urban population of the world increases by 84%; namely, 3.6 billion people (Buettner, 2015). Also (Connor, 2015) observed that out of the 7.3 billion people in the globe, 54% live in cities; and this is projected to be 8.5 billion (66% urban dwellers) and 9.7 billion (about 90% urban) by 2030 and 2050, respectively. Although population growth is the primary cause of the spread of cities but the same irrational distribution or horizontal expansion and new construction around the city caused socio-economic damages and destruction of environmental resources in the cities and surroundings. Due to a substantial effect of the form of a city on its stability, it is necessary to know study, understand its dimensions, and guide it to achieve sustainable development (Anderson, Kanaroglou, & Miller, 1996). After 1970s and the World War II, severe reactions to uncontrolled growth of cities began. The reactions led to the formation of the movements such as smart growth, new urbanism, compact city and so forth. At smaller levels, the movements suggested some types of development, of which support of the transport-based development (TOD), mixed use development and the infill development can be, mentioned (Sharifian, 2010).

The population of Nigeria as at 2006 census is 160 million people. The more people countrywide undoubtedly mean adding pressure on urban area, and as a result, urban sprawl has become a development phenomenon in this country. Common explanations to this pattern of city growth include rising household incomes, lower commuting costs and cheap land cost in the suburbs. Such decentralization process, nevertheless, give rise to common problems associated with urban sprawl such as traffic congestion, increased infrastructure costs, and loss of rural and resource land (Ooi & Le, 2011). Most of this projected massive population growth is to be expected in Asia and Africa. Nigeria is currently the 7th largest country in the world and is the most rapidly growing, to become the 3rd largest country in the world by 2050 (Connor, 2015). India, China, and Nigeria are also projected to have the largest urban population growth that will account for 37% of the growth between 2014 and 2050[2]. By 2015, Nigeria is estimated to add 212 million urban dwellers alone, at an estimated urban population growth rate of 5% (FMH&UD, 2007; Jiboye, 2011; Millington & Cleland, 2017).

Associated with the spread out patterns of growth that have predominated in recent decades, increased traffic congestion, overstretched public facilities and increased infrastructure costs, loss of agricultural lands, open space and other resources. Some cities, however, are implementing progressive alternatives to suburban development in the face of increased population pressures, alternatives that are to slow the effect of sprawl and encourage infill developments to accommodate new growth.In the study area vacant developable land is limited, however, if we do not find space for future residents, housing will become even less affordable, more people will commute longer distances to work and employment and economic opportunities will suffer.In this paper, we defined infill development as new residential development on vacant, abandoned, and under-utilized property within built-up areas of existing communities, where infrastructure is already in place. Following are some of the reasons why infill development is important in Nigerian urban centers:

Types of infill development

According to 'Maryland Department of Planning (2001) and Northeast Midwest Institute (2001) USA' infill development include the following types:

i.　　　**Residential Infill:** This is the most common type of infill development. It takes place within residential neighborhoods of towns and cities. The scheme mostly take place in low-density residential areas e.g GRA. It can occur in places zoned for commercial or civic uses where it is aimed at blending housing with retails, entertainment and/or office functions or development (i.e. mix- uses).

ii.　　　**Commercial infill**: this practice take place predominantly in the Central Business Districts (CBD), down towns or places zoned and designated for commercial activities. It also takes place in some residential neighborhood of town and cities, mostly along access roads. Here new structures are either built on vacant lots or medium and high-rise ones for enhanced economic activities.

iii.　　　**Industrial infill**: This scheme is common in industrialized nations such as United Kingdom (UK), United State of America (USA) etc. it normally occurs along industrial corridors. In most cases, the scheme involves the redevelopment of heavy manufacturing facilities into industrial districts with production activities that are appropriate to the surrounding and accessible to community residents who work in them.
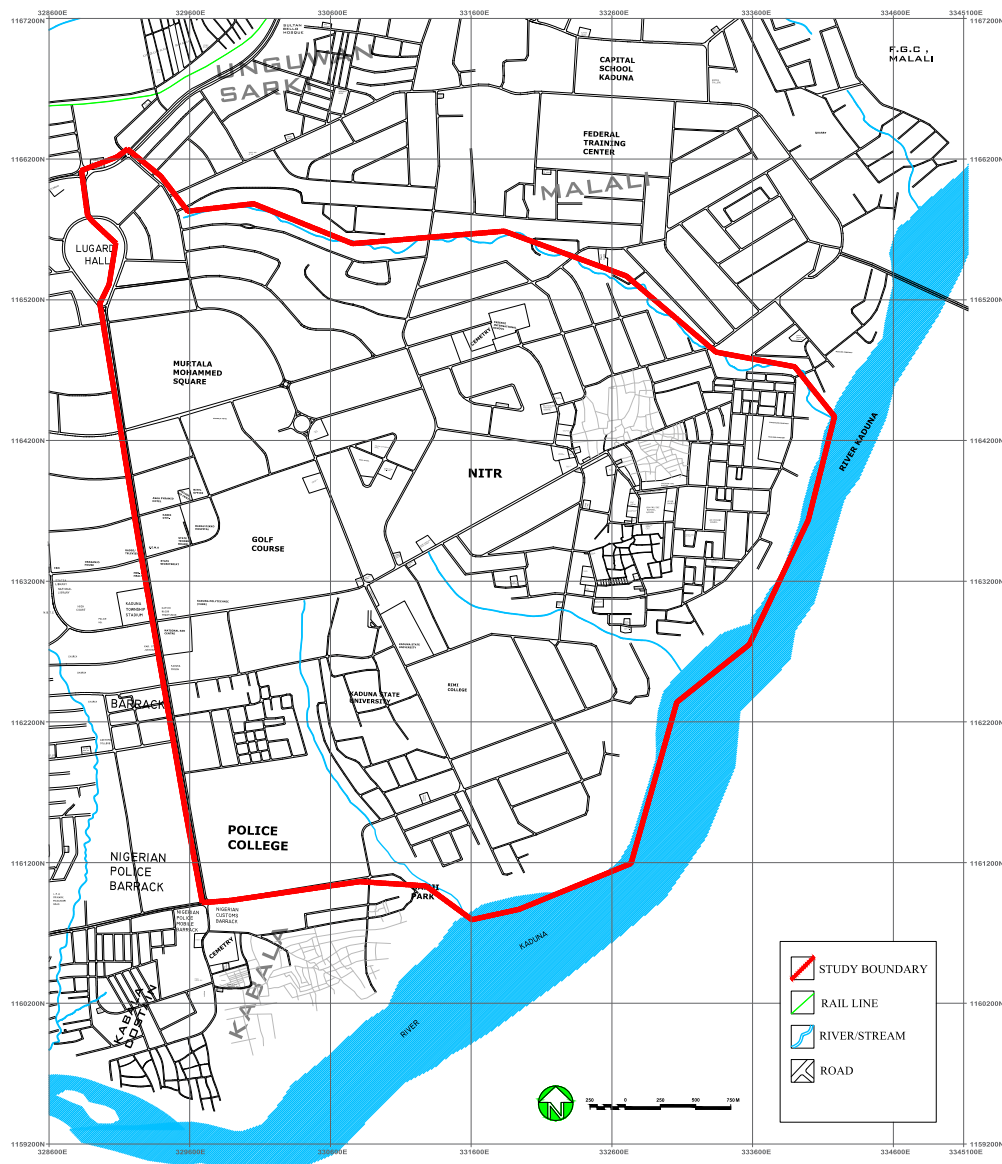
II.　　　METHODOLOGY

The Study Area

Figure 1. Unguwan Rimi, Kaduna.

Unguwar Rimi is located in Kaduna north local government area of Kaduna state Nigeria. It covers a land area of approximately 908 hectares and population of 41,510 people (2012). Malali bound it to the north, Kabala Doki to the south, River Kaduna to the east and Independence way to the west.

The study area that is Unguwar Rimi GRA is a low-density residential neighborhood, which was formerly known as European Reserved Area (ERA) planned and developed by the colonial masters. The plot sizes of the ERA was 1.6 ha or 16,187 m^2 as being appropriate for each senior service residence. The area was the first to be fully developed and occupied by the colonial administrators. Each house is situated on a generous portion of land surrounded by trees and gardens. It is gratifying that this section of the city remain as it was during the colonial days except the house are now occupied by government officials.

Methods

The data used for this research were obtained through primary sources, such as government files, maps, records, and publications. Survey was also conducted of the study area in order to collect information about infill development in Unguwar Rimi GRA. Data was also obtained through secondary sources, such as academic journals, periodicals and government reports. The data collected was analyzed using descriptive analysis and presented using percentage and frequency tables. Out of the total infill plots, only 165 plots were used for the analysis due to unavailability of design data.

Land use allocation of Unguwar Rimi GRA

The land use allocation in the study area revealed that residential land use have the highest percentage of 53.3%, this is followed by public open spaces with 31.1%. The government, military and public buildings has 5.9%, while educational institutions and circulation occupied 7.4% and 2.1% respectively. The least land allocation is that of commercial land use with 1.2% as shown in table 1. It revealed a stable low-density neighborhood commonly found in Nigerian cities. In other words, neighborhood levels across a large suburban area and often describe as low density or GRA.

Table 1: Land use allocation in U/Rimi GRA

Land use	Percentage
Residential	53.3
Public open spaces	31.1
Govt. buildings	5.9
Educational institutions	7.4
Circulation	2.1
Commercial	1.2
Total	**100**

Source: Max Lock Kaduna Master Plan (1967-2017)

Distribution of Infill plots over ten years

The trend in the distribution of infill plots over ten years, indicate that 2007 has the highest figure which suggest that apart from professional consideration, politics have influenced the large scale infill plots in the GRA, due to the fact that it was an election year. As such, out of the number of infill plots, only 165 plots were used for the analysis.

Table 2: distribution of Infill plots over ten years

Year	No of Plot	Percentage
2001	53	18.3
2002	25	8.6
2003	27	9.3
2004	10	3.4
2005	11	3.8
2006	24	8.3
2007	64	22.2
2008	49	16.8
2009	18	6.2
2010	09	3.1
Total	**290**	**100**

Source: Kaduna State Urban Planning Development Authority (KASUPDA)(2012)
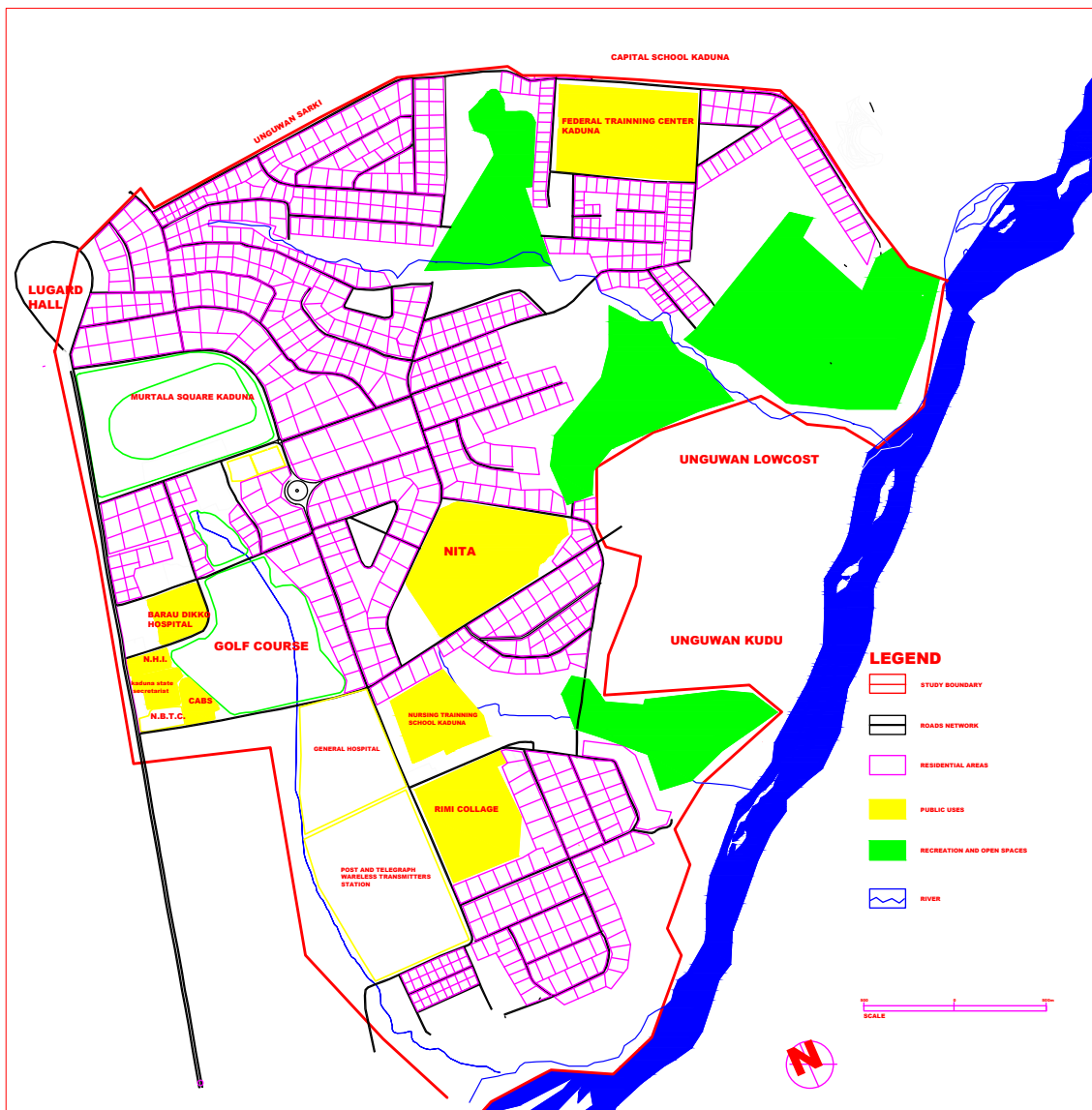
Figure 2. Unguwan Rimi, Before Infill.

Figure 3. Unguwan Rimi, After Infill.

Geometric Characteristics of the Infill Plots in GRA

       Examination of the cadastre sheets of the GRA reveals that majority of the original colonial plots were regular (rectangular or square). However, the subdivision embarked upon by the government agencies have produced infill plots of different shapes and sizes some of which are irregular and this can have many design implications. The problem is Max lock recommendations were not considered when subdividing the plots. Out of the 165 plots that were analyzed, only 16.4% were found to be regular (7.9% square and 8.5% rectangular), as shown in table 3.

Table 3: Geometric Characteristics of Infill plots

Shape	No	Percentage
Square	13	7.9
Rectangular	14	8.5
Deep	30	18.2
Dogleg	42	25.5
Irregular	66	40.0
Total	**165**	**100**

Source: Field Survey 2012

Infill Initiators in Unguwar Rimi GRA

There are two types of infill development found in Unguwar Rimi GRA; these are residential infill and commercial infill. The practice of these type of infill in Unguwar Rimi, takes different form based on who initiate it. Although they tend to follow the same process after the initial stage, these initiators are government and individuals.

a.   The government initiators: These are new developments in the GRA that are initiated by the government, within the government owned deteriorated or under- utilized properties, vacant or under-utilized land, the state government will identify these properties. Then a proposal for subdivision is prepared for both the residential and commercial uses, depending on the needs and the uses the area was meant for. After the subdivision of such properties, the allocations for these infill plots are based on the request to the authority.

b.   Individual initiators: This category of infill development as the name implies, emanated from the a situation where individual (private)apply to the state ministry of land, survey and country planning for the subdivision of privately owned properties, the ministry will send its staff for site inspection and the division of such plot follows after fulfilling all requirements. The certificate of occupancy (C of O) for the infill plots are then prepared in the name of the owner who then makes the transfer for either leasehold or sale agreement.

Table 4 shows the characteristics of the various types of infill development by the plot sizes as obtained from the government and individual initiators of infill development.

Table 4: Characteristics of infill plots by size

Initiator	Type of infill	Plot dimension (m)	Area (ERA-CLIM2)
Government	Residential	30 x 30	900
		25 x 30	750
	Commercial	5.0 x 5.0	25
Individual	Residential	15 x 25	375
		15 x 30	450
		20 x 25	500
	Commercial	3.0 x 4.0	12

Source: Ministry of Lands, Survey and Country Planning Kaduna State (2012)

Impact Assessment of the Infill development in the Unguwar Rimi GRA

Since the creation of the new infill sites (curved-outs) and their development began on mass scale in 1999 to date in the Unguwar Rimi GRA, the area have received considerable attention and publicity because the controversies that usually surround infill developments, whether residential or non-residential.

Infill developments whether in theory or practice have always come with implications, some of these implications are positive while others are negative especially if the infill projects are poorly conceived, planned, and/or developed.

The study conducted in Unguwar Rimi shows that an infill development carried out in the GRA is done on an ad-hoc basis without any recourse to either the conventional or infill planning and development principles. This however, has come with several findings most of which have implications. The implications of the infill developments are as follows:

a.   **Changes in Land uses:** Different types of land conversion as well as changes in land uses have taken place simultaneously. As Kaduna expands the value of land in the GRA rises due to its proximity to employment centers and access to urban services. In response to this infill, there is a change in land use i.e the residential use has increased by 10%, commercial use increased by 5%, while circulation increased by 3% and public and semi-public increased by 3%, however, recreation and open spaces decreased by 20% as show in table 5. The implication is the serious reduction of open space, significant reduction in space between existing properties and breaching of established building lines. The reduction in open green space can have serious repercussions for the physical e

Table 5: Change in Land use

Land use	1999		2012	
	Area (Ha)	Percentage	Area (Ha)	Percentage
Residential	454	50	549	60
Commercial	22	2	62	7
Circulation	63	7	93	10
Public/semi public	76	8	96	11
Recreation/open space	293	32	108	12
Total	**908**	**100**	**908**	**100**

Source: KDPC Report (1999) and Field Survey (2012)

b.   **Change in residential density:** The study revealed that there is an apparent change in the gross residential density of Unguwar Rimi GRA the gross residential density of the areas before infill was calculated

to be approximately 1 dwelling unit per hectare (1DU/Ha), while on the other hand the existing gross residential density of the area after infill was calculated to be 5 dwelling per hectare (5 DU/Ha). The table 6 shows the comparism between the previous and the existing gross residential density in Unguwar Rimi GRA.

Table 6: Gross residential density

1999	2012
GRD = 956/908 = 1DU/Ha	GRD = 4702/908 = 5DU/Ha

Source: Field Survey, 2012.

Infill development also results to the change in net residential density in Unguwar Rimi GRA. The net residential density of the area before the infill was 4 dwelling unit per hectare (4DU/Ha), while the existing density was nine dwelling per hectare (10DU/Ha) as shown in table 7.

Table 7: Net residential density

1999	2012
NRD = 246/454 = 2DU/Ha	NRD = 4702/454 = 10

Source: Field Survey, 2012.

c.   **Change in demographic and dwelling Units:** Study into the demographic and dwelling units revealed that the number of dwelling and the population of the study area keeps increasing gradually from independence 1960 to 2010. This is due to infill development and natural population increase in the study area as indicated in table 7.The impacts of infill housing are directly or indirectly associated with two key aspects of any development, the degree to which it increases the average population density of the area and the quality of the design.

Table 7: Demographic and Dwelling Units Distribution in GRA 1960-2010

Year	No of Dwelling Unit	Population
1960	956	10,476
1970	1746	13202
1980	2013	15874
1990	2379	18177
2000	2702	23336
2010	4702	41510

Source: KadunaState Development and Property Company (KSDPC) and National Population commission (NPC)

Increase population density result from increased dwelling density, and are widely agreed to have both ecological and social impact, an increased population concentration can improve personal safety as natural, and informal surveillance is generated (Vallance et al, 2001). However, increased population in the study area has result in traffic congestion and demand for curbside parking. Both of these are known to reduce community safety levels, and for children in particular. In addition, congestion generated by increase traffic lengthens travel time and concentration of vehicle emission, causing environmental degradation and generate additional noise in a neighborhood.

d.   **Impact on urban utilities and services in GRA:** Urban utilities and services are among the basic needs of the society, without which production will not function efficiently. Hence its provision to meet the present and future demand becomes necessary to ensure orderliness and efficiency within the environment. Population of the area determines the demand for water and its measured based on per capita consumption or demand per day and the type of land use. The water supplied to Unguwar Rimi GRA was efficiently meeting the demand of the residence before the large scale infill development now the water supply cannot meet the demand of the existing population of the study area effectively.

Furthermore, increased in population due to infill development in the study area it led to increase in the generation of waste. Infill development in the area result in the increase in waste generation as the higher the population in particular area the more the waste generation.

e.   **Loss of established trees and vegetation:** As well as having ecological value, old trees or established vegetation add character and heritage value to an area. Unfortunately, they are often causalities of infill housing construction. Loss of individual trees, particularly along boundaries, can reduce privacy of existing houses. This will also leave the study area at risk of erosion, and the exposed the area to strong wind.

f.   **Increase hard surface:** Hard surfaces tend to replace open space and vegetation when infill housing is constructed. As a result, the ability for surfaces to absorb water is reduced. This increases runoff, which can cause flood, erosion and pollution.

III. CONCLUSION AND RECOMMENDATIONS

It has been deduced from the survey findings that there was no any guiding principle or an established policy laid down for carrying out infill development in the GRA. All infill schemes were based on ad-hoc proposals and of political matters.Secondly, it has been observed that infill development generally in principles and practice goes beyond Lock's fundamental objectives of maximizing the use of colonial site areas in the GRA through the sub-division of large sites, which was achieved through recommended approaches. The recommendations, which were predicted on the assumption that the GRA would continue as residential area for senior civil servant, come out to be a basis for un-coordinated, un-planned and haphazard development that diverges completely from the conventional planning principles. Thus bot Max locks vision of increased housing density and the haphazard developments in the GRA fall short of infill development principles, standard and practice.Thirdly, as the practices continues, more plots are allocated, more buildings comes up and pose challenges in both the net and gross residential densities of the area, demand for utilities and services also increases as the overall population of the area increased. Yet, to date since the large scale practice from 1999 there is no efforts towards reducing its negative consequences on the physical environment.

However, the general planning implications of the infill development include changes in the pattern and form of the city, hence distort the city image, it makes future planning very difficult due to high demand variation, reduce the rate of urban sprawl, encourages compact development, ease cost of new infrastructural provisions, provision of housing for the growing population and regeneration of urban areas. In view of the mentioned implications, creative and technological measures are hereby recommended.Based on the assessment of the infill development of Unguwar Rimi GRA it was concluded that infill development could reduce development pressure on the outlaying farmland and open space. This can only occur when infill development is done with good planning and link with appropriate improvements in infrastructure and public services. The following are recommended to solve identified problems associated with infill development in GRA.

- Estimating the potential of the sites to accommodate additional housing at appropriate densities.
- Use existing database and parcel attribute and location information to identify appropriate sites for infill development.
- Density control through regulation plot sizes, ratio between developed and undeveloped portion of the plot and the floor area ratio.
- Improve provision of infrastructure to the increased demand due to infill development.
- Proper site inspection and development control, through enforcement of development control guidelines over all infill development.

In addition, urban planners, managers as well as project developers to engage the public or the community in proper consultation planning and participation as well as development control authority.

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