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Comparative Study of Selected Greenfield Development Projects

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Abstract

Objectives: To compare Greenfield development projects that formed part of creation of smart cities, and thereby identify the variables that show correlation with the total area of the site developed. **Methods/Statistical Analysis:** Ten Greenfield development projects were chosen for data collection. Projects were so chosen that they are from different sizes. They vary from, as small as 0.36 sq. km to, as large as 150 sq. km. Data were collected from the respective project reports. Fifteen variables were compared. Correlation analysis was used as the tool to know how different variables exhibit relationship with increasing size of sites chosen. **Findings:** Variables such as population hosted, distance of the site to nearest city, commercial land use, provision of special economic zones, educational land use, wasted managed on a daily basis and lush greenery show significant correlation with the size of the project (with correlation coefficients respectively as 0.9627, 0.8421, 0.8556, 0.7847, 0.837, 0.8847 and 0.7323). When areas are reasonably large, their centroid will usually be located far away from the nearby major city. Such mega projects have additional provision of transport infrastructure to connect the site to the nearby city. It is also found that not all variables showed correlation with the area of the site. Employment, project cost and its duration are some examples (with correlation coefficients of 0.0532, 0.0637 and 0.5331 respectively). This is against normal intuition that when the greenfield development area is larger, it could cost more or it could provide more employment. However, findings above show otherwise. Such findings are helpful for urban planners drafting projects for smart cities to take into account the key variables that have correlation and carefully plan for the variables that show no correlation. **Application /Improvement:** Correlation analysis proves to be a simple and effective tool when applied in the comparison of Greenfield development projects, as smart city initiatives are increasing in the recent years.

Keywords: Greenfield Development, Land Use, Smart Cities, Satellite Towns, Urban Planning, Urban Sprawl

1. Introduction

Cities and urban areas within a country provide hope for aspiring migrants from rural areas who seek for a better employment as well as better living conditions. Cities in developed countries attract foreigners too, to live and work in better places. Urban areas hosted around 30% of the world population in the year 1950; it had increased to around 54%[1]. United Nations projects it to be 66% for the year 2050. Besides percentage-based statistics, it is also important for urban planners to note the actual number of persons moved to such urban areas in the same period (between 1950 and 2014). Statistics show that such urban population grew from 750 million to 4 billion.In the Asian context alone, it is projected that India will add 400 million people to its urban areas while China will add around 300 million by the year 2050. India needs to create or prepare its urban areas to host an additional 400 million people in say, 35 years. The '100 Smart Cities' initiative in India is perceived to be a strategic step towards tackling the anticipated urban population increase in the country[2].

The '100 Smart Cities' agenda involves creating one hundred cities and equip them with the latest technologies in order to enable them to be the key economic growth centres of the country. It is envisaged that urban areas will contribute around 75% of India's gross domestic product (GDP) by a projected urban population of 40% in the next fifteen years[2]. Towns that have potential to be developed as economic growth centres are chosen under 'smart cities' initiative.

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Smart cities essentially make use of state-of-the-art technologies in providing infrastructure, amenities and services. However, the underlying requirement of physical space to accommodate millions of people needs to be addressed. Two strategies are usually adopted[3]. The first strategy is to transform existing urban spaces or existing towns to tackle new incoming or growing population. The second strategy is to develop new areas, preferably as controlled extensions of existing cities. This enables planned expansion of an urban area rather than an unplanned urban sprawl. Transforming an existing space is often referred to as 'brownfield' development while developing new areas from typically vacant lands is referred as 'greenfield' development. Although acquiring or using vacant lands for the purpose of urban development had been in practice for centuries, the term 'greenfield development' is used when the vacant space is situated in, around or within the reach of an urban area. If such land is located far from city, suitable transportation must be provided to bridge the distance. The smart cities initiative in India includes greenfield development as one of the key strategies for managing the land requirement.

Traditionally, satellite towns were planned and created nearby cities that could not handle any further increase in population or cannot provide more opportunities for economic activities. Even ancient city planning methodologies did follow such mechanism[4]. The trend in the past decade had been however to use existing land spaces in and around a city, which were intentionally left vacant or being designated as parks and green spaces in previous master plans, and develop them. The physical extension or areas of such greenfield lands vary significantly from project to project. Every other characteristic such as residential land use, commercial land use and other factors also vary correspondingly. In this study, it is intended to find how different land use and economic variables relate to the size of greenfield developments. Ten projects were chosen for this purpose. Projects are so chosen to represent different sizes and population characteristics. The smallest is 0.4 sq. km in area and the largest is 150 sq. km. in area. Correlation analysis is used as a tool to analyse data collected for these ten greenfield development projects. First, a brief introduction on the projects are presented.

2. Greenfield Development Projects for Analysis

Due to the well-pronounced commercial nature of smart cities and related land development projects, their data or information are available mainly in the mainstream media such as websites, newspapers or magazines rather than peer reviewed articles. Relatively fewer works are available in peer reviewed journals and conference proceedings. Projects chosen for comparison are tabulated in Table 1.

Individual projects are introduced here:

Malta Smart City[5]: Malta Smart City is reported as a joint venture between the Government of Malta and the consortium called Smart City Dubai. Strategic location

Table 1. Greenfield development projects compared

Sl. No.	Project	Site Area (sq. km)	Population hosted ('000)	Population density (Population /Area, persons/sq. km)	Nearby City or Urban Area	Country
1	Malta Smart City	0.4	25000	69444	Malta	Malta
2	Hafen City	2.4	12000	5000	Hamburg	Germany
3	GIFT city	3.6	50000	13966	Ahmedabad	India
4	Songdo International Business District	6.0	60000	10000	Inchean	South Korea
5	Masdar City	7.0	50000	7143	Abu Dhabi	United Arab Emirates
6	Konza Techno City	20.0	250000	12358	Nairobi	Kenya
7	Purbachal	25.0	350000	14068	Dhaka	Bangladesh
8	Putrajaya	50.0	330000	6692	Kuala Lum-pur	Malaysia
9	Clark Green City	95.0	1200000	12698	Manila	Philippines
10	Caofeidian Eco-City	150.0	1500000	10000	Beijing	China

of the island of Malta in the Mediterranean Sea gives an added advantage to the development planned for catering the markets of Europe, North Africa and the Middle East. The project includes 11 business parks providing 50000 jobs. The area is relatively smaller, extending around 0.36 sq. km. Some of the sustainability features are rainwater harvesting, water-efficient landscaping and the use of solar photovoltaic powered Light Emitting Diodes (LED) lights.

Hafen City[6]*:* Hafen City was created on maritime area with archaic port and industrial land parcels, near the harbour of Hamburg City in Germany. Investments were around 8.5 billion Euros from the private sector and around 2.4 billion Euros from the public sector (including around 1.5 billion Euros from the sales of plots). Built-up area constitutes only 31% while public and private open spaces cover 45%. Within the built-up area, 30% is dedicated for residences and the remaining are for offices, retail and educational purposes.

Gujarat International Finance Tec-City (GIFT) city[7,8]*:* It is located in India. It extends to an area of 3.58 sq. km, located between two major cities Ahmedabad and Gandhinagar. This is a classic example of orderly extension or controlled urban sprawl, especially between two existing urban areas. Focus is more on equipping the new place with the state-of-the-art Information and Communication Technologies (ICT). Issues such as location of mobile communication towers for minimum disruption of service are also addressed[9]. Residential land use is relatively low (4%) due to hosting of mainly commercial and social facilities.

Songdo International Business District (Songdo-IBD)[10]*:* It is located at Incheon Metropolitan City in South Korea. It extends to an area of 6 sq. km. Green space is given importance and hence 40% of the total area is kept greenery. It is a 35 billion US dollar project creating 60000 jobs and hosting 36000 residents. Around 1000 retail businesses and 1600 domestic and global companies are located. Four Universities are also located within the developed area.

Masdar City[11]*:* Masdar is in Abu Dhabi, United Arab Emirates. It was started with an objective of creating a sustainable city and work began in April 2007. Estimated cost was 22 billion US dollars to accommodate 50,000 residents. Economy, environment and equity were the focal points of this development. Some of the strategies included waste-to-energy, zero cars, greenbelt of agriculture, and 80% water reuse capability among others.

Konza Techno City[12]*:* Konza Techno City is developed as a smart city near Nairobi, Kenya. The greenfield chosen for this development was around 20 sq. km, belonging to the Kenyan government. The development work is planned to be executed over 20 years since 2012 at a cost of around 7 billion US dollars. The project is expected to create around 200,000 jobs in Business Process Outsourcing (BPO) and Information Technology Enabled Services (ITES) during the 20-year period.

Purbachal[13]*:* Purbachal New Town is a planned township in Bangladesh. It extends for around 25 sq. km and around 39% is dedicated for residential areas. Open space constitutes around 15%. A total of 24 wetland cells had been carefully created based water levels.

Putrajaya[14]*:* Putrajaya was conceived as a Garden City spreading across 50 sq. km. More emphasis was given to keep green open space (around 37% of total area). The area was designed to host a population of 330,000 in 20 different areas or precincts. The area was so chosen that it acts as a strategic location within a growth corridor planned by Malaysian government, called Multimedia Super Corridor.

Clark Green City [15,16]*:* Clark Green City is relatively a large planned development extending around 100 sq. km and costing 10 billion US dollars. It has two seaports and three airports. Special attention is given in developing special economic zones. According to the report, resource management, accessibility, identity, leadership and governance, diversity and density, economic vibrancy and resilience are considered as key factors in this project.

Caofeidian Eco-City[17,18]*:* Caofeidian Eco-City development is a joint venture between China and Sweden. The area is significantly large when compared to other greenfield developments. Once completed, it will have an area of 150 sq. km. Initial plan is to develop 30 sq. km. According to the reports, energy efficiency, closed-loop economy, innovative knowledge applications, and efficient use of water and land areas some of the objectives behind this development. The project claims to have an eco-cycle model where water, energy, waste and material related issues are managed in an integrated fashion.

3. Analysis

Correlation between total land area and other variables are shown in Table 2. It is evident there are variables that show good correlation while some show very poor correlation. Variables and their correlation relationships are analysed in detail in the following sub-sections.

Table 2. Correlation between land area and variables

Sl. No.	Variable	Correlation Coefficient (R^2)
1	Population hosted	0.9627
2	Distance to nearest city	0.8421
3	Educational land use (area)	0.8370
4	Commercial land use (area)	0.8556
5	Special economic zone (area)	0.7847
6	Solid waste managed (weight/day)	0.8807
7	Lush greenery (area)	0.7323
8	Water features (area)	0.7226
	Poor correlation:	
9	Project cost	0.5331
10	Residential land use (area)	0.5185
11	Sewage treatment capacity	0.2808
12	Water supply (quantity/day)	0.1984
13	Project duration (years)	0.0637
14	Employment (jobs)	0.0532
15	Power generation (power units such as Megawatt/day)	0.0231

Variables that show good correlation are discussed first, followed by variables that show no or poor correlation.

3.1 Total Area and Population

With primary objective of developing a site is to accommodate increasing population, it is intuitive to see a strong correlation between the area of the site and the number of residents planned to be hosted there. This is reflected in Figure 1. Larger the area of the site developed, more the population being accommodated. This area-population relation is the strongest among all the variables analysed. However, population density, which is measured as persons/unit area, should not be expected to have the same trend. From Table 1, it is evident that population densities vary significantly across the projects compared. Songdo with 6 sq. km area and Caofeidian Eco-City with 150 sq. km area have same population densities of 10,000 people/sq. km. Projects developed in developing countries show an increased population density: Bangladesh, India, Philippines and Kenya with respectively around 14068, 13966, 12698 and 12358 people/sq. km.

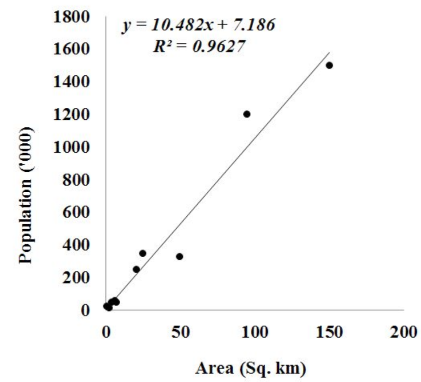

Figure 1. Relation between total land area and population.

Projects have different housing layouts and types of dwelling units. For instance, a project may provide only prepared land sites while the other may provide high-rise multi-storeyed apartment schemes. As such, a comparison between the total area and the residential land use area can be expected to not show a correlation. This is reflected in Figure 2. It shows that each project has its own unique way of providing housing facilities.

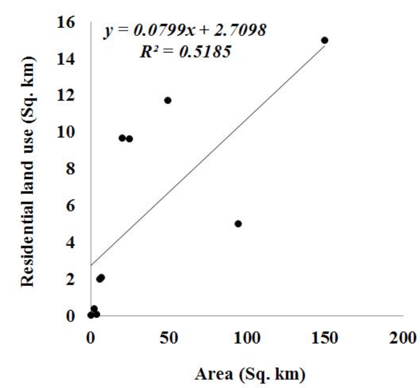

Figure 2. Relation between total land area and residential land use.

Greenfield sites should be large enough to accommodate the planned population but the provision of housing layouts or design of dwelling units is entirely up to the developer. As such, this will influence both population density as well as residential density. Hence, there is not a pronounced correlation between area and residential density.

3.2 Total Area and Distance to Adjacent City

The greenfield development projects investigated were conceived to serve as economic growth centres and/or planned extensions of nearby urban areas or major cities. As such, the distance between the site and the city is a crucial variable for people to migrate and settle. Commuting between residence and workplace is important for location choice. This warrants an improvement on the transportation sector to ease travel between the greenfield site and the city nearby. Figure 3 presents the correlation between area of the site and its distance to its nearby city.

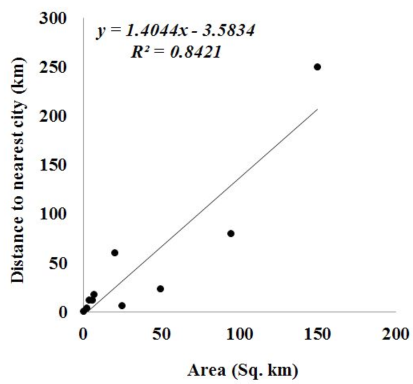

Figure 3. Relation between total land area and distance to nearby major city.

From Figure 3, it is evident that smaller sites are nearer to cities and larger sites are far away. Larger sites, due to the very reason being large, will have its centre or centroid far away from its boundary and hence, far away from the adjacent cities too. If the site is small, it could house fairly lesser number of people, unless a suitable multi-storeyed building is constructed to host the expected population. If the site is large, there will be a need to build suitable transport infrastructure for people to commute between the developed site and the main city where they could probably be working. In the same case of large sites, internal trips are also equally important. Developers and planners need to address local travel needs and provide a safe, economical and efficient transport infrastructure to attract the target population. Large projects invariably have one or more accompanying transport infrastructure projects associated with them. For example, greenfield development project in Philippines is accompanied by Clark Rail Transit System and Mac Arthur Highway System to connect the site to[15]. Similarly, Beijing-Tianjin-Tangshan intercity railway system was built in China, to partly handle travel demand between greenfield development at Caofeidian Eco-City and Beijing[19].

3.3 Education Land Use

Provision of land use space for education purposes depend upon project objectives and scope. For smaller sites that are intended to act as business districts, the need for an exclusive educational land use can be waived. It can be assumed that people living there could access schools and colleges in nearby cities. Previous correlation showed that smaller sites are located nearer to major cities. However, large areas hosting significantly higher population will demand provision of exclusive educational facilities to cater to the local needs. Children cannot be expected to walk or commute for long distances. Educational institutes such as schools and colleges will require sufficient land space. A comparison is hence made to know whether educational land use is provided in accordance with total land area of the site developed. The comparison is shown in Figure 4.

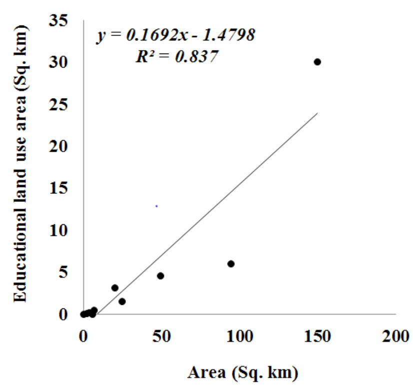

Figure 4. Relation between total land area and educational land use.

Small sites show provision of relatively smaller areas for educational land use. Large areas such as Caofeidian Eco-City have educational land use of around 30 sq. km (20%). This is total educational land use area allocated for the entire site. There could be several schools and colleges located at different locations within the site depending on population concentration and other transport accessibility factors.

3.4 Commercial Land Use

Smart city development invariably involves allocation of commercial land space for opening retail businesses that cater to the needs of people living inside the site as well as those living in surrounding areas. Figure 5 shows correlation between the two variables, namely the total area and the extent of commercial land use provided. Unlike residential facilities, not all commercial facilities can be provided as high-rise structures with an intention of reducing land area required. Most of the commercial entities need ground-level access to loading and unloading goods. They also need parking facilities for container and other forms of trucks. These requirements impose restriction on how tall the commercial facilities can be. Hence, as the total area gets bigger, an increase in commercial area can also be expected.

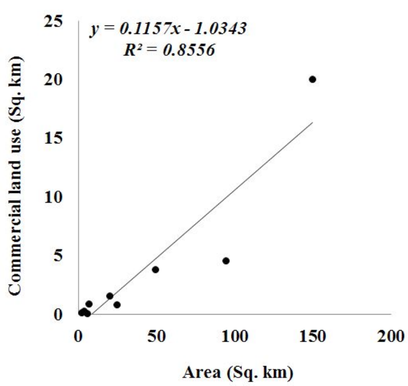

Figure 5. Relation between total land area and commercial land use.

Furthermore, large sites could have more than one commercial site. In such cases, data on total commercial area are used for analysis.

3.5 Special Economic Zone

A Special Economic Zone (SEZ) is an area provided exclusively for setting up industries. Such zones are provided with amenities such as suitable access roads (for large and heavy vehicles), uninterrupted power supply along with high voltage lines, and most importantly, subsidies for individuals or groups of companies to setup their manufacturing plants in that specific area. The zones can also accommodate small firms. A major manufacturing company would then want to locate its premises in SEZ to get a just-in-time support from smaller companies around. Figure 6 shows correlation between total area of greenfield development and the area allocated for SEZ.

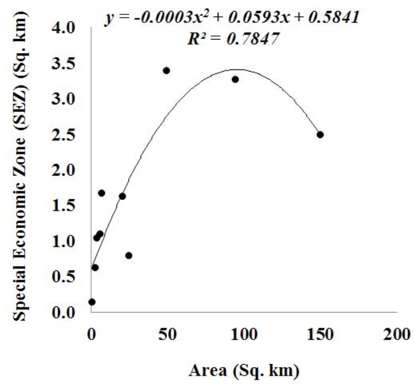

Figure 6. Relation between total land area and special economic zone land area.

Figure 6 shows a pattern where a linear increase in SEZ cannot be expected as the greenfield development size increases significantly. As total area increases, it can be expected to have a proportionally large SEZ area. However, it is found that very large greenfield developments need not necessarily have large SEZ areas. The size of SEZ relies more on how many industrial plants can be sustainably run at one place. An unusually large SEZ area would require special attention on power requirement, waste management and intra-zone travel capabilities. Hence, a non-linear variation fits well for the relation between site area and SEZ provision.

3.6 Waste Managed

The amount of solid waste generated from a greenfield developed area varies with the total area as shown in the Figure 7. There is correlation between the two variables. When area increases, the amount of waste in tons/day also increases. Solid waste management is critical for a city's sustainable development[20]. This is also critical from planners' point of view, as whether to manage the waste generated within the area developed or to manage it elsewhere by engaging suitable transportation. This in turn could cause pressure on providing better transport infrastructure as well as treatment infrastructure located elsewhere.

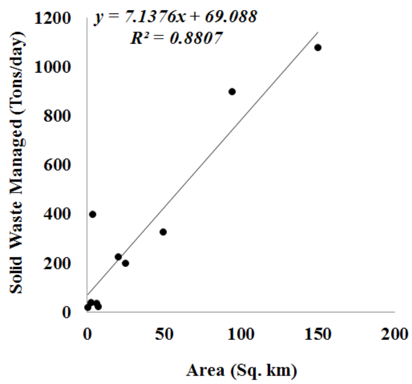

Figure 7. Relation between total land area and solid waste managed.

3.7 Lush Greenery

One of the arguments often posed against greenfield development is that it could be a threat to environment, especially causing destruction of natural habitat for flora and fauna[21–23]. Threat to agricultural lands being converted to residential or commercial lands had also been addressed by environmentalists. For these reasons, developers often choose greenfield areas that are mostly vacant or sparsely occupied. In addition, exclusive green belts or green areas called 'lush greenery' is purposively planned as a part of greenfield development. Figure 8 shows correlation between total area of the development and the area allocated for lush greenery.

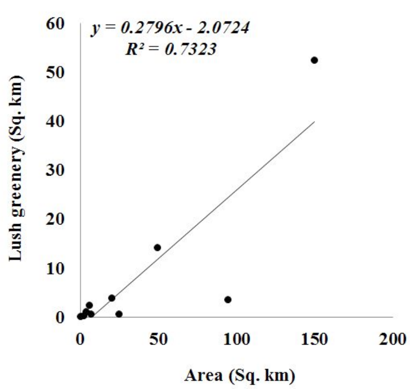

Figure 8. Relation between total land area and lush greenery area.

The lush greenery areas are not necessarily located in one place, especially when the area developed is large. Project planners often plan in such a way that suitable green space is naturally made available between industrial and residential or central business district and other areas. As the total area available increases, planners tend to provide more room for lush greenery.

3.8 Other Relations

Comparison of other variables showed no or feeble correlation. Such variables include: water features (catchment and storage tanks), power generation within the area, employment (jobs created), project cost and project duration. These variables are unique to individual greenfield projects. If greenfield development is to host residential population and serve as an orderly extension of an existing urban area, employment or other variables such as power generation cannot be expected to vary across projects proportionally. A general expectation would be to have increase in cost and duration as there is an increase in the area chosen for development. However, costs are unique to each project since the entities and facilities provided can also be unique. The same is true for project duration as well. Hence some factors show no correlation (as shown in Table 2).

4. Conclusion

Greenfield development is one of the strategies along with brownfield development, in planning smart cities in India as well as other countries. Ten successful greenfield projects were chosen for comparing how different variables are related to each other. Variables such as total area of greenfield development, population hosted, residential and commercial land uses, extent of special economic zone, environmental aspects such as waste generation and lush greenery were compared across the projects chosen. Strong correlation is seen between the total area developed and the following variables: population, distance to nearby city, commercial land use, special economic zone area, educational land use, lush greenery and waste managed. Residential area allocated does not seem to vary linearly across different projects. This is because residential types are unique to each project. Other variables such as water facilities and power generation were also found to be unique to the projects and hence did not show any correlation with respect to the total area or population. Further research could involve economic factors such as employment, project duration and project cost, which require more data that are yet to be reported in by greenfield developers across the world.

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