GIS FOR ELECTRICAL UTILITY AND RESOURCE ANALYSIS IN AN URBAN PERSPECTIVE: A CASE STUDY OF NORTH NAZIMABAD, KARACHI

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ABSTRACT: The roots of modern urban planning and urbanization originate from late 19th century. The term sustainable development emerged as a desirable outcome for achieving planning goals Karachi has become a megalopolis and ranks 7th among highly populist cities of the world. North Nazimabad is one of the best planned areas of Karachi. It was designed in the late 50's by Italian planners Carlo Scarpa & Aldo Rossi, but overpopulation and over exploitation has overburdened its service distribution capacity. This study has been conducted to exploit geospatial technologies to perform functional land-use classification, develop address-based geodatabase of North Nazimabad and to examine the actual design vs. implementation strategies for some basic utilities and to propose reconsideration and reallocation factors. GIS based Electricity load analysis model has been developed for energy load optimization and for proposing resource reallocation factors. GIS maps prepared during this research may serve as a potent analytical and planning tool for policy makers for taxation, emergency response and utility management.

Keywords: IBC, Geodatabase, KE, GIS, PMT, DTS ID, KDA.

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INTRODUCTION

Systematic urban land-use planning is the key that leads towards sustainable development of a city (Brown *et al.,* 2014). The pace of urbanization in Pakistan and its growth has boosted during the past five decades. Karachi is now a megapolis with a population of 18.1 million along with other megapolis cities like Mumbai, Kolkata, Jakarta, Nairobi, Manila, Lagos and Cairo. North Nazimabad is the most planned area of Karachi. Various master plans have been designed for Karachi but most of these plans failed in qualitative and quantitative terms at the implementation phase since the spirit of the proposal was not translated precisely into the desired state, resulting in unplanned urban growth which led to failure in fulfilling social needs, illegal land claims and land encroachment, thus culminating in the degradation of the urban environment (Azra *et al.,* 2007). It is here that the issue of post implementation urban assessment assumes importance.

Urban activity is land use function and there is an absolute interaction of cause and effect relationship between landuse and its services (Chandio *et al*., 2011). The concept of neighborhood originates from New York region to provide urban luxuries and services to its residents (Scholten *et al.,* 2013). Multidisciplinary and integrative tools are very significant in order to manage development in the City.

The total area of North Nazimabad is 2591 acres. The scheme was planned to provide residential accommodation to middle to high-income groups (Azam *et al*., 2012). North Nazimabad is considered as one of the best planned residential town consists of 20 residential blocks identified with alphabets from A to T. The objective of the study was to identify overburdened utility resources with specific attention to electricity and to propose reconsideration and reallocation factors using GIS based electrical energy load anticipation model.

Study Area: The extent of study area covers six blocks of North Nazimabad i.e. Block I, J, K, L, M, N.

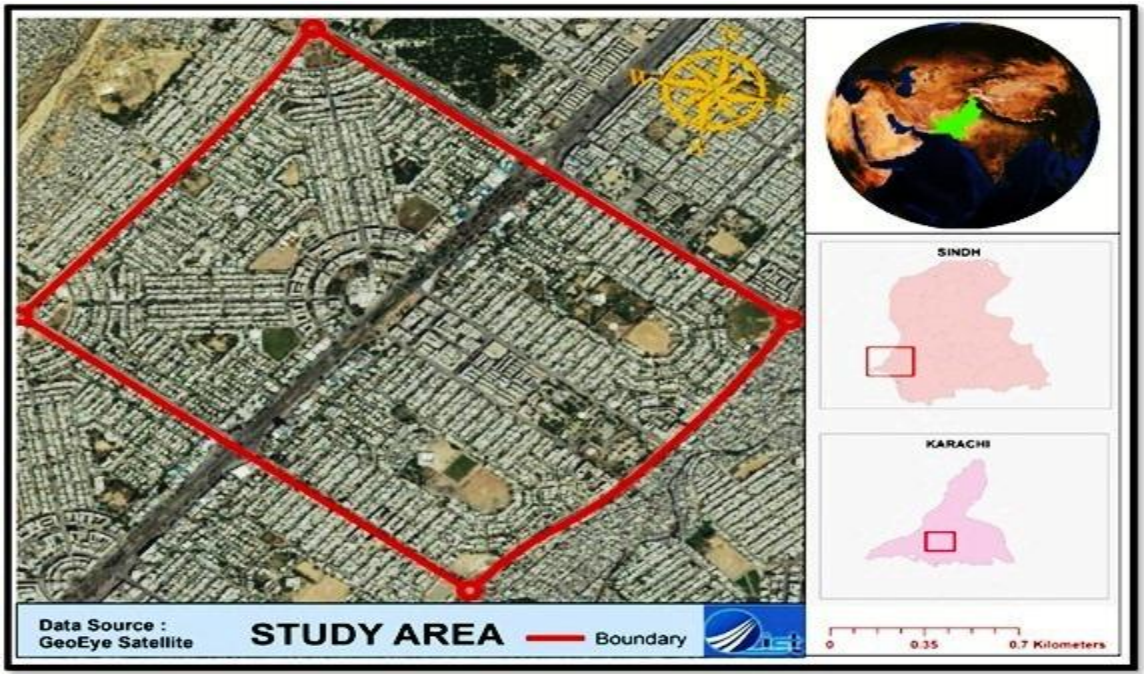

Fig-1: Map showing study area

METHODOLOGY

A land-use survey of different areas of North Nazimabad was conducted. An area of 10 sq. km was selected as an Area of Interest (AOI). A number of sites were sampled in the area.

GIS can be helpful for making the master plan of urban town in order to achieve long term planning goals (Kahila-Tani *et.al*, 2016)

Pioneering in the field of urban development many local governments are using GIS for transformation of traditional records to digital geodatabases (Gilfoyle et.al, 2016).

Land record area maps from Karachi Development Authority (KDA) and high-resolution satellite imageries were obtained from Google earth and digitized for land-use delineation.

The pattern of land use was studied along with the functional classification of various urban activities and the recorded data was transformed through various process of digitization with different data layers to prepare informative GIS based maps.

The rise of digital mapping has the potential to monitor landuse and to analyze urban growth trends with visualization of digital layers (Rissman *et.al*, 2017).

Remote sensing & ground trothing were used as input for GIS data. ESRI products were used for representing and overlaying different data sets into a single platform.

Data collected and generated from different platforms and formats were integrated to develop GIS based geodatabase. In analytical phase, results and findings of the study were entertained and report writing was performed.

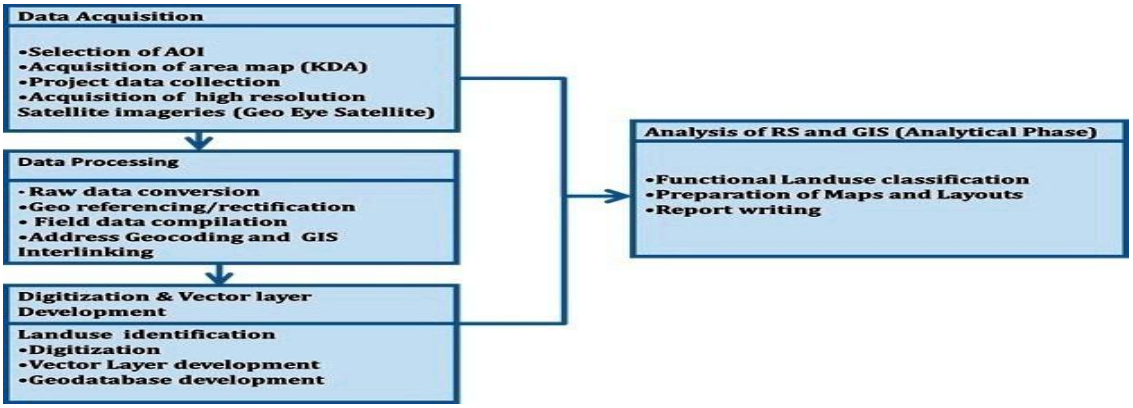

Fig-2: Methodological framework

RESULTS AND DISCUSSION

A scanned town map was acquired from Karachi Development Authority (Fig-3) which was used as a reference for digitization and database development along with Google imageries.

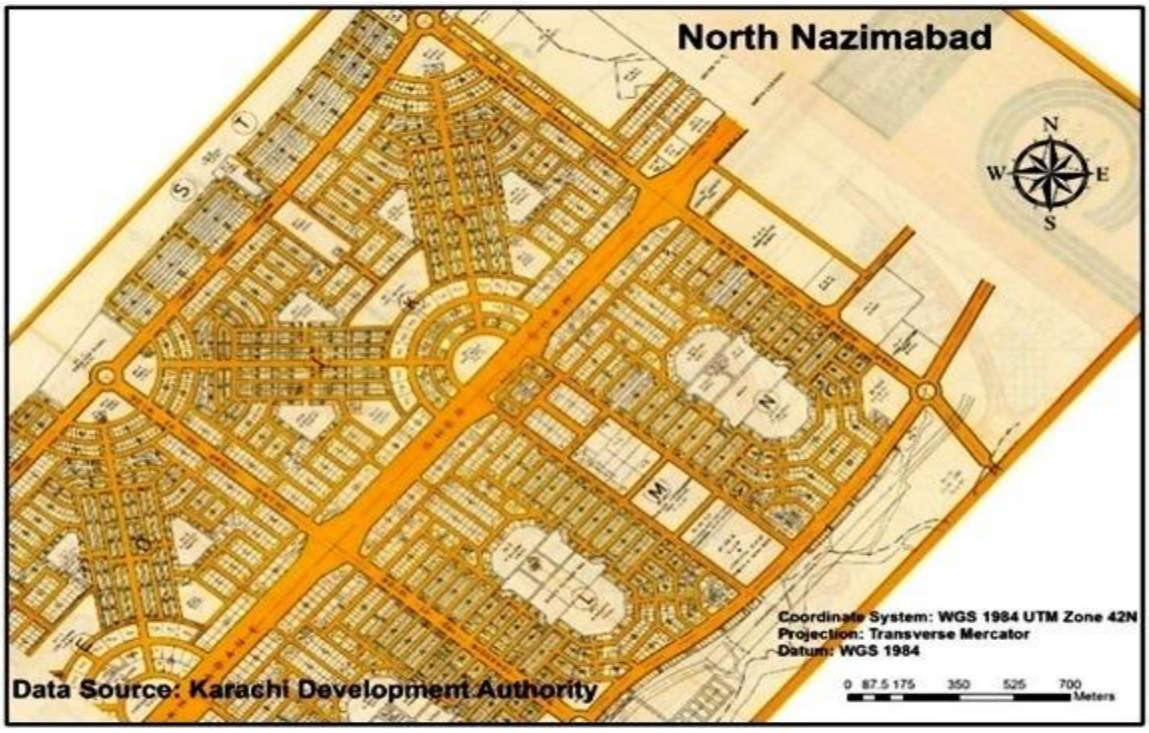

Fig-3: **Town map North Nazimabad**

With the prevalence of information technology, Geographic Information Systems (GIS) have integrated for a variety of applications in the electrical utility network and its distribution (Wolch *et al.*, 2014).

780 Land parcels were digitized for land-use delineation. The road network was also digitized for representing major and minor roads of the area. Fig-4 shows a glimpse of digitization and land-use classification.

Fig-4: **Showing digitized work and land-use attributes**

An address-based Geodatabase was developed for the area by embedding relevant attributes such as house address, building name, land-use function/type, block information and KDA land-use codes. An accuracy of geocoding has become more and more important in industries such as insurance, catastrophe risk and disaster managements, telecommunication (Hegazy *et al.*, 2015).

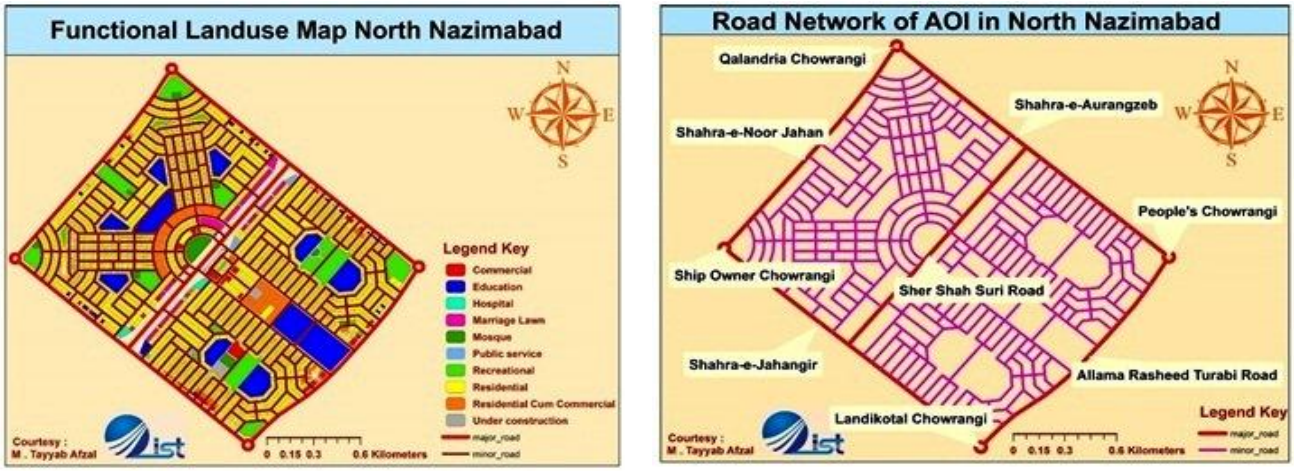

Fig-5: Functionally Classified land use and road network of study area

A GIS map of Area of Interest (AOI) was prepared and classified according to certain spatial features (major road, minor road, land-use, schools, colleges, clinics, hospitals, institutions, recreational places, commercial, residential etc.). International land use color codes schemes which is also followed by KDA for land use classification, were used for preparing GIS maps (Fig-5).

As a major test-case of the provision of utilities in the study area, electricity data from K-ELECTRIC (formerly known as KESC, Karachi Electric Supply Corporation) was acquired from its regional Integrated Business Centre (IBC) in North Nazimabad. The extent of study area is covered by North Nazimabad IBC. There are approximately 16886 KE registered consumers that are being facilitated through 162 PMT (Pole Mounted Transformers) and Substations. (Ground based transformers). The transmission is regulated through 12 feeders that are ensuring continuous supply and regular monitoring at significant level of utility distribution. Most consumers are connected through *Marhaba Galaxy* Feeder that covers 3365 consumers. The Geotagged consumers and the electrical network are shown in Fig-6.

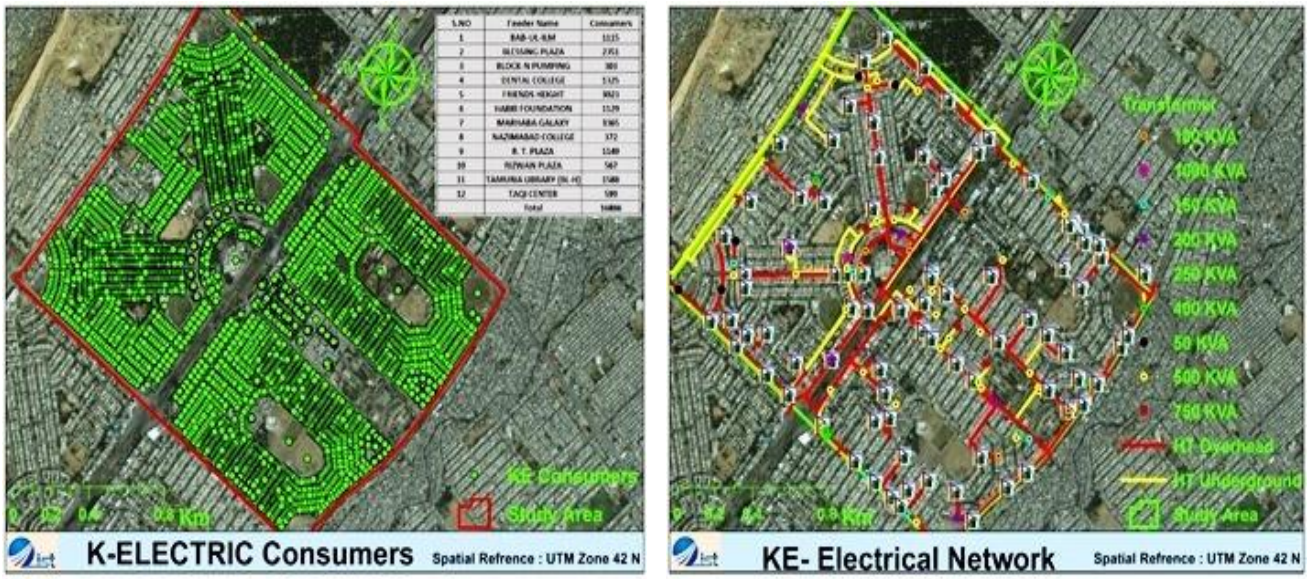

Fig-6: Geotagged KE Consumers and KE- Electrical network

Electrical Utility Data Analysis

Electrical network data provided by K-ELECTRIC was further analyzed for Electrical Supply-Demand Analysis. Data provided by K-ELECTRIC composed of consumer and transformer information (Fig-7).

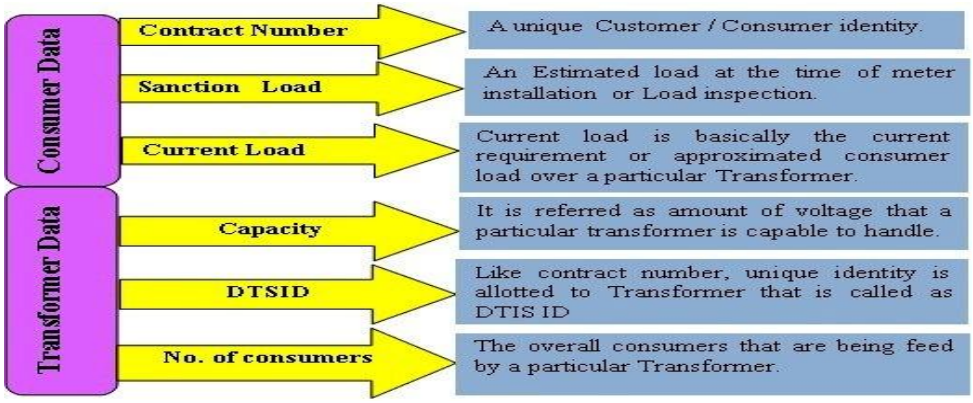

Fig-7: **Electrical utility data hierarchy**

Current Load on Transformer

Current load is the aggregate of all individual consumers' load against a particular transformer that is calculated using the following formula:

$$\sum_{n=1}^{n} load = c_l.n_1 + c_l.n_2 + c_l.n_3 + \cdots + c_l.n_n \quad \text{_____(1)}$$

Where: n Represent individual Consumer / Customer

c_l Represent current load measured in kilo-Volt-Ampere or kVA/hour

Load Difference: The load difference between supply and demand on the electrical network was calculated using the formula:

$$Load_{difference} = T_{capacity} - T_{Load} \quad \text{_____(2)}$$

$T_{capacity}$ Transformer Capacity

T_{Load} Transformer Load

Note: Both These quantities are measured in kVA/Hour

All the PMTs were individually computed for load and it was found out that some of the PMTs were being underutilized, i.e., they had more capacity than the load whereas other PMTs were at a deficit of electricity and were being overburdened. The PMTs were therefore spatially marked as *Surplus* or *Deficit* and further classified based the value of kVA (Fig-8).

Fig-8: Map showing PMTs in the study area

The overall capacity of the 141 transformers installed in the study area came out to be 44350 kVA whereas overall load on these transformers was 54065 kVA indicating an aggregate deficit / electricity shortfall in the study area of 9715 kVA.

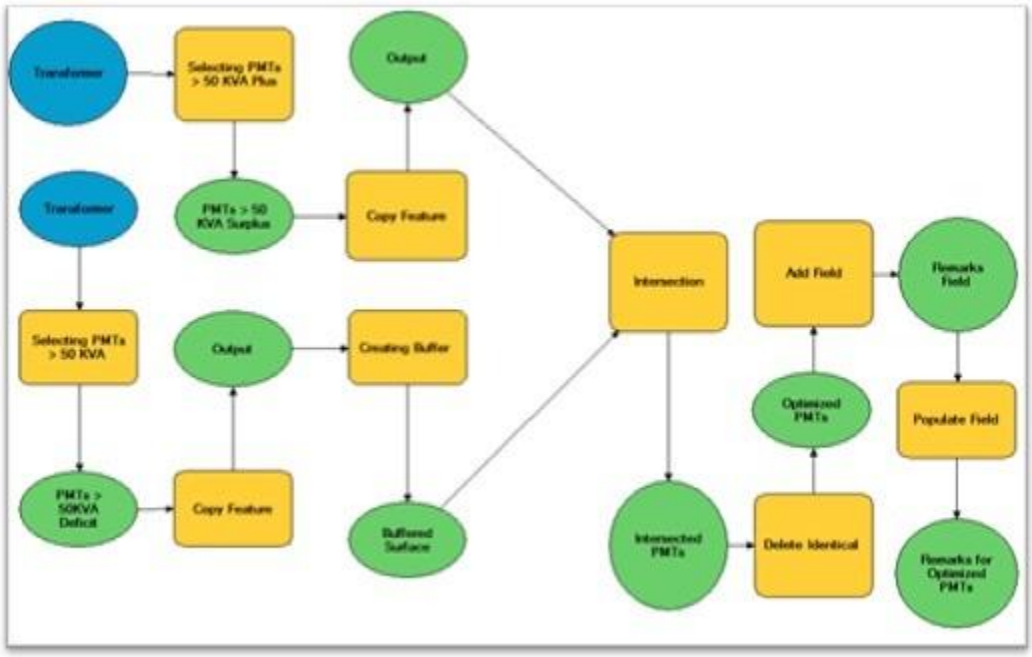

Fig-9: **Electrical load analysis model**

For performing electricity load reallocation, a GIS model was prepared (Fig-9). This model was prepared to perform electricity load analysis based on spatial proximity. The idea was to select PMTs whose deficit was greater than 50 kVA and also selects those PMTs having surplus more than 50 kVA from the feature class of PMTs. After selection various proximity buffers were created against deficit PMTs so that their extra loads could potentially be transferred to PMTs with surplus capacity via cabling. For this purpose, distances of 100, 200 and 300 meters were chosen. The total extra load was then divided amongst the PMTs with surplus capacity. The results revealed that the overall shortfall of 9715 kVA in the study area could be reduced by 41.53%, 57.18% or 96.08% by cabling and reallocating the load to PMTs within 100, 200 or 300 meters respectively (Fig-10, Table-1).

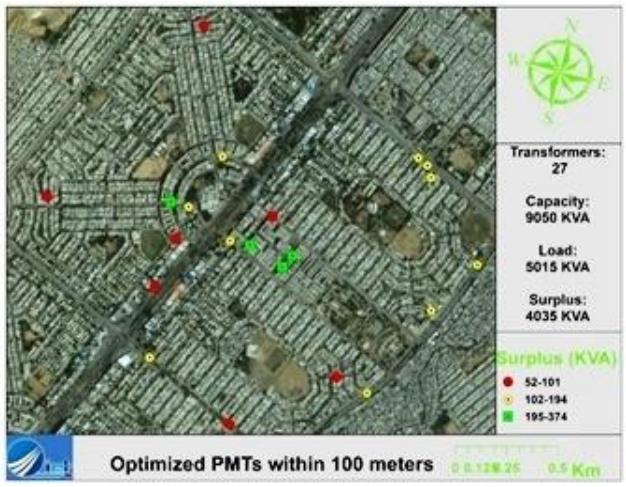

Fig-10: Deficit PMTs optimized within 100, 200 and 300 meters

Following are the results obtained by this model for the Criteria of 100, 200 and 300 meters.

Table-1: **Results obtained from GIS Model.**

	Buffers (Meteaawrs)	No. of Surplus PMTs	Transformer Capacity (kVA)	Transformer Load (kVA)	Surplus Available (kVA)	Total Deficit (kVA)	Losses Covered %age
1	100	27	9050	5015	4035	9715	41.53 %
2	200	44	13950	8395	5555	9715	57.18%
3	300	56	20650	11315	9334	9715	96.08%

The developed GIS Electricity load analysis model gave promising results for all the given criteria and may be effectively used to analyze electric network system capacity and load and to propose reallocations where possible. The model can also be used for analyzing and suggesting reallocation possibilities wherever networked utility services are involved.

Wind / Sunlight Corridors: During several field visits, building floors were recorded and then integrated with GIS for 3D representation of study area. The 3D image of six blocks of North Nazimabad that is converted to 2D for representation purposes is shown in Fig-11.

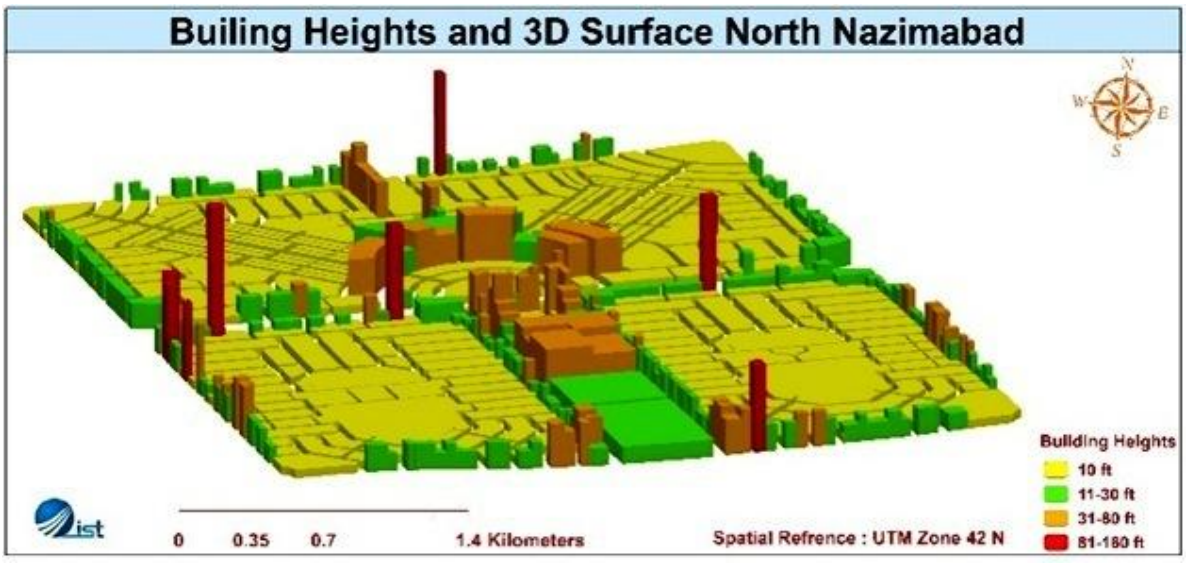

Fig-11: **Map showing 2D cum 3D representation of the study area.**

Since it was beyond the scope of this study to physically measure every building in the study area, only the number of storeys / floors were counted. From the above map it can be observed that building with floors ranging from 1 to 16 exist in the study area. On the basis of number of floors buildings are then categorized using GIS platform. As per international standards, for every building with number of floors greater than 5 there must be an emergency exit whereas it has been witnessed that there is no significant emergency exit and emergency passage for fire and disaster conditions which is highly prone to any hazard cum disaster. Height for a single floor was assumed as 10 feet. Based on that assumption building heights in the area vary from 10 feet up to 160 feet with most of the high-rise buildings constructed along the peripheries, surrounding each block ranging from 70 feet up to 160 feet.

Most of these buildings are semi commercial with apartment complexes. North Nazimabad was initially planned to provide residential accommodations with a building range of Ground + 1 to Ground + 2. However, the current trend in vertical construction has created a *Wall Street* effect in the area. Therefore, these high-rise buildings obstruct view, ventilation and sunlight for the small houses and buildings adjacent to them.

Geotagging and Field Data Integration with GIS: Geotagging refers to assigning the raw image/ photograph the geographical information i.e. latitude and longitude coordinates so that it can be overlaid on the actual location via internet (Luo *et al*., 2011). Following are some places that have been reported and geotagged during this study and then are integrated with google maps for overlaying (Fig-12).

Fig-12: **Geotagged places in the study Area**

Parks play a vital role in developing a healthy urban environment (Lee *et al.*, 2011). From the above map it is clearly seen how illegal construction and garbage dumping has destroyed the green space of park in block L. Open street garbage throwing is also a very negative aesthetic and health factor.

GIS can be effectively used for Optimization of municipal solid waste management system development

which highlight shortest path for vehicles to collect garbage (Nguyen-Trong, 2017).

Drain channels were also blocked by garbage dumping and due to lack of regular clearing could result in urban flooding in case of torrential rains.

GIS based approach for developing sustainable urban drainage system (SUDS) in urban environment is a useful tool for improvement and management in deficit in the existing infrastructure (Mguni, Lise Herslund et.al, 2017).

Electrical wire spaghettis were also geotagged in Block M of the study area. These haphazard wirings could also potentially result in short-circuiting and fire and also result in line losses. Open street garbage was again found to be an issue in Block M degrading the urban environment and creating sanctuary for number of vulnerable diseases.

Block N is one of highly populist Blocks in North Nazimabad Scheme. Open street garbage burning was observed as shown in the above map which is highly unacceptable for any planned society of the world. The *Sakhi Hasan* water hydrant is yet another famous place in Block N. It is a source of potable water distribution in North Nazimabad and adjacent areas. In the above map plenty of water tankers can be seen lined up for filling purposes. This is an evidence that tanker mafia and culprits are not willing to provide the available water freely to the residents via the pipeline distribution network. There is no choice left for the residents of this town to pay high prices for these tankers for their water needs.

Conclusion: The GIS maps can be useful as analytical and planning tool for policy makers to monitor taxation and relevant purposes and can be used for quick response in emergency conditions.

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