

Geospatial techniques for comparative case study of spatiotemporal changes in New Karachi and North Karachi parks

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Received: 5 March 2023 / Accepted: 31 March 2023

Abstract. The well-known fact is that parks play a significant role in sustaining the urban environment. Megacities like Karachi are developing rapidly with a simultaneous increase in the city area, putting immense pressure on open green spaces. The widespread built-up development is replacing the previously existing vegetative cover. The lack of green spaces is the main concern, and this problem will only worsen due to overpopulation associated with the rapid growth of cities. The lack of evidence-based planning contributes to the unbalanced spatial distribution of parks in quantity and quality. The present research aimed to compare and find out the quality and status of parks such as park areas under encroachment and temporal changes in the vegetative cover of parks in the predominantly low to middle-income residential areas of New Karachi and North Karachi Towns of Karachi metropolitan. Geospatial techniques have been used for mapping, assessments, and analyses. Results indicate that boundary walls are a good solution to stop or reduce park encroachments as correlation indicates the parks with boundary walls have a significantly lower percentage of encroachment in 2022. The existing work indicated that the number of trees has increased in most parks in both towns in 2022. The overall correlation results indicate that factors affecting park quality positively have a positive association with other positively affecting factors and a negative association with factors that affect park quality negatively. There is a dire need to implement better planning strategies to enhance the quality of existing parks and construct new parks in the study area.

Keywords: mega-city, urban environment, park quality, public health, correlation indices, planning strategy.

1. Introduction

Urban parks are open spaces, reserved for public use usually with high vegetation cover (Basu & Nagendra, 2021; Machar et al., 2022). Urban parks have proven to improve the living standards overall in

the world. The parks have many environmental, social, economic, and, health benefits for urban dwellers. Urban parks can be large or 'pocket parks' are usually smaller in size (Konijnendik et al., 2013). A well-planned urban area preserves nature and integrates it into cities to ensure sustainable urban growth. The parks have many environmental, social, economic, and, health benefits for urban dwellers. These benefits are largely affected by the park state, namely the presence and quality of vegetation cover and recreational amenities in the park area. Urban parks are generally be acknowledged in big cities because of its valuable role such as pollutants be absorbed by trees, regulate temperatures, biodiversity have been preserved and ecology of urban areas will be in balance (Klimanova et al., 2021).

Karachi has a population of over 21 million; with 4.5% per annum, growth lacks Open Green Spaces (OGS). Overall Karachi has 1256 open spaces including parks, playgrounds, and green belts (Anwar, 2013). The quantitative and qualitative spatial distribution of parks in Karachi is unbalanced (Azam et al., 2012). Park encroachment is a burning issue in the city. The parks all over Karachi are neglected and subject to negligence issue. There are many political, religious, and social reasons for OGS's introduction and increase in Karachi. Lack of maintenance and interest from the Government has led to a decline in public parks in Karachi. This deterioration of parks led to a negative perception of citizens of Karachi toward parks. There is a dire need to improve the condition of public parks (Anwar, 2013). Qureshi et al. (2013) conducted research to find the preferences of urban green spaces in people of different socioeconomic conditions and found that the public wants clean and safe areas with better lighting and facilities. People in Karachi mostly prefer trees but are least concerned about the diversity within plants, also ornamental features do not have much importance (Anwar, 2012). Interviews of 200 respondents, from DHA and Gulburg Town representing high and low-income neighbourhoods respectively found awareness about the ecological services provided by OGS is not highly related to socioeconomic factors. Visitations are mainly influenced by accessibility and the good quality of the environment. Citizens want better quantity and quality of green spaces are willing to also take financial steps (Anwar, 2012). This suggests that the park must be more accessible to locals and maintain a high-quality standard with recreational amenities (Kubal et al., 2009). States the importance of green cover in the limiting floods and confirms it in the case of Leipzig, Germany. Kaźmierczak and Cavan (2011) also stressed the role of green space in limiting flooding in their study of Greater Manchester they found the areas with less green spaces tended to be more vulnerable to surface water floods. Gill et al. (2007) studied Greater Manchester argues cities will be more resilient by adding more green space and storm water runoff can be significantly reduced. The authors also focused on mature trees important in the water cycle. Thus, in urban flood risk management, green parks should be taken into account. Particularly cities with high

densities are more vulnerable to floods. Generally, the environment and public health can improve by promoting environmental justice. The literature is presented on the environmental inequality is very uncritical and more research is required that correlates public health with environmental justice. The trends of environmental justice are improving (Crawford et al., 2008; Bakar et al., 2016; Brulle & Pellow, 2006). Gong et al. (2021) reported that the parking demand predicting and performance analysis have received enhancing attention in recent years due to their critical role in mitigating traffic congestion and considerate travel behaviours. Zhang et al. (2022) assessed that influence of urban spatial indicators viz., building density and building floor area ratio on the cooling effect of green spaces. The scientific questions of the present work are; how encroachment effecting the land-use and ultimately influenced quality of life? Up-to-date such intensive approach-based research have not yet to be executed for the study area as well as for Karachi. This research will be beneficial for such type of study area, which developed in the result of urban sprawl. It was hypothesized that the park conditions are expected to worsen with population increase, less park area under the encroachment and park being used for parking may probably expected to increase in in the both towns. Hence, the main objectives of the present study were to 1) locate the spatiotemporal changes in a public park area, determine the scale of change by comparing officially designated parking areas and tree counts on Karachi layout maps with areas under encroachment; mark these public parks either filled with sewage water or used as parking lots in the area of interest (AOI); 2) assess spatiotemporal changes in the quality of the park of AOI depending upon different factors such as positively impact (recreational amenities, trees, grass cover, and boundary wall) and negatively impact (encroachment, parking issues, sewage water accumulation, and garbage); 3) find association between different factors affecting the quality and average quality of Parks in AOI for the years 2004 and 2022, and 4) mark new parks which are not allocated on official layout maps in AOI.

2. Materials and methods

Both North Karachi and New Karachi towns (Fig. 1) are part of the central district of Karachi and are present in the north part of Karachi, located between the Lyari River, and the Manghopir Hills. The town's elevation differences are visible, the elevation is high on the Westside (Manghopir hills) and low on the east side because of the Lyari River. This slope led to flash floods in the towns (Fig. 2). The towns were formed after the 1958 coup d'état when Katchi Abadis (slums) were resettled here. Both towns have similar infrastructure compared to other towns in Karachi and mainly low to middle-income families reside in these towns. Residential land use is prominent, an industrial belt is located on the East side of North Karachi and Southeast in New Karachi along the Lyari River, and commercial areas are mostly

located along Shahrah-e-Usman the main road that goes straight through North and New Karachi (Fig. 3). Both towns are served by Greenline BRT (Karachi's only BRT), also runs along Shahrah-e-Usman. About 2.13% were the annual growth rate of these towns which was higher than the annual growth rate of central Karachi up to 1.41% and the literacy ratio was observed by 77.1% lower in the central Karachi district. In this paper, only 66 parks that are mentioned in the official layout maps are focused on 42 parks in New Karachi and 24 parks in North Karachi.

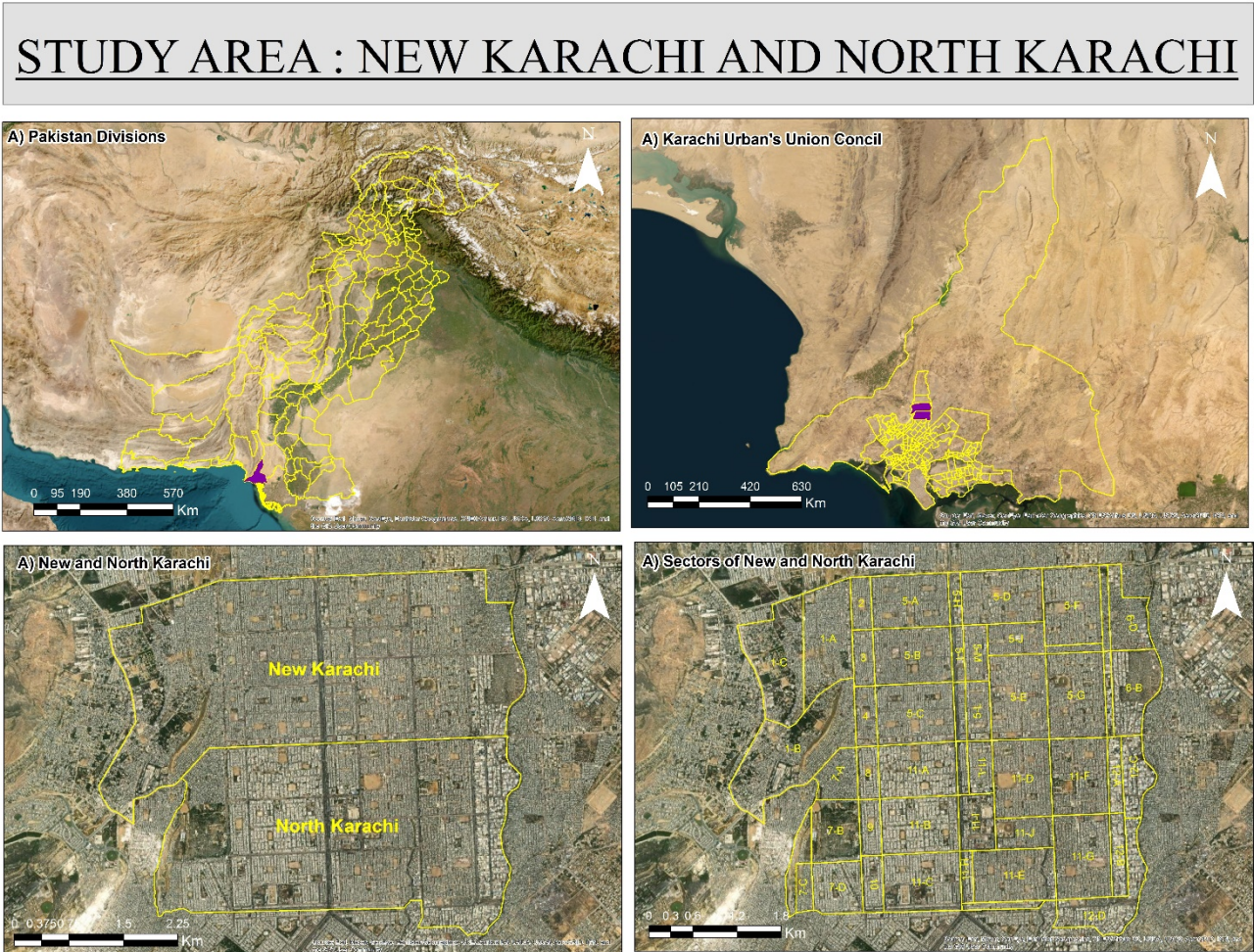


Figure 1. Study area

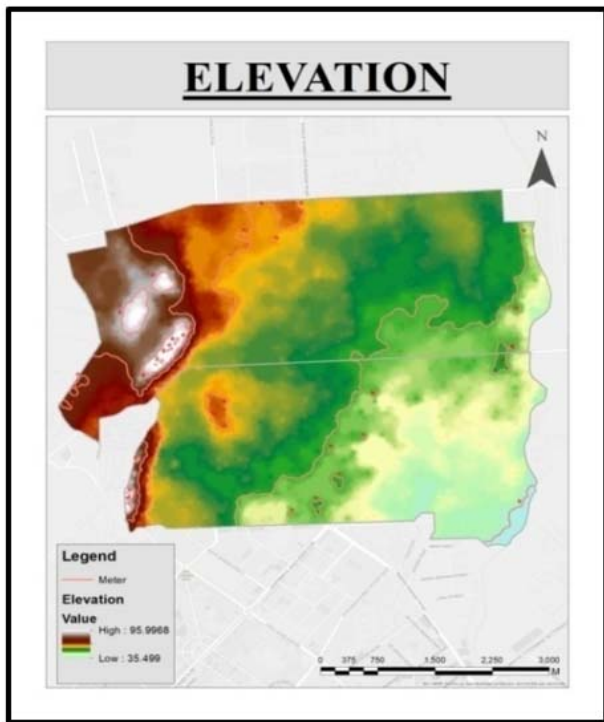


Figure 2. DEM of New and North Karachi

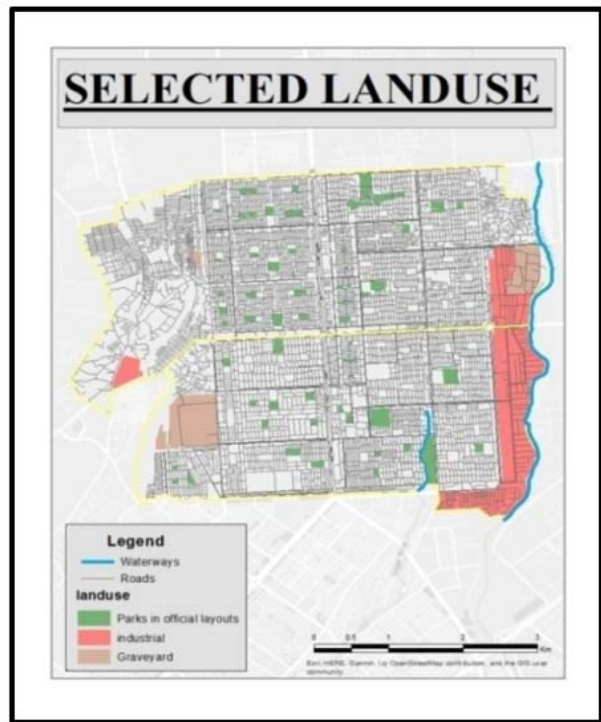


Figure 3. LULC of New and North Karachi

Data in (Fig. 4) shows depict population differences for the years of 1998 and 2017 and its general trend. Specifically, the population of New Karachi increased by 2.13%. In the study area, population density was 48,402.5 people per km² (Fig. 5). The literacy ratio of the study area was also calculated, and 77.03% residents are literate, which was less than any other part of Karachi (Fig. 6).

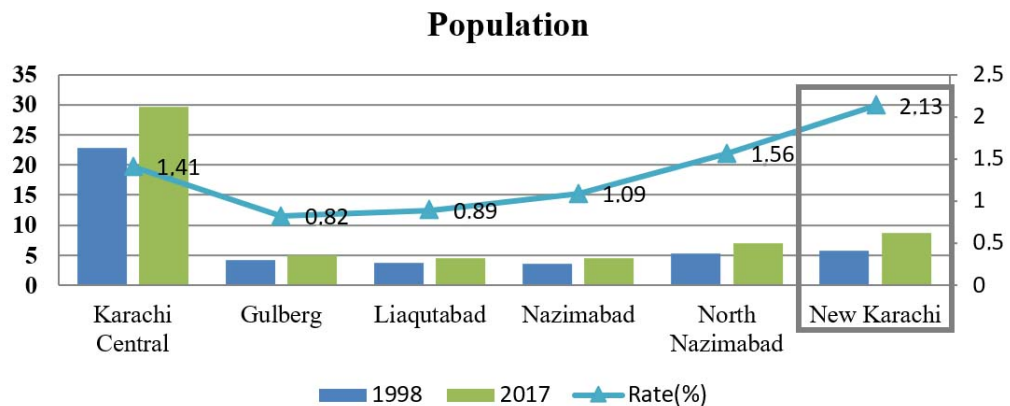


Figure 4. Human population

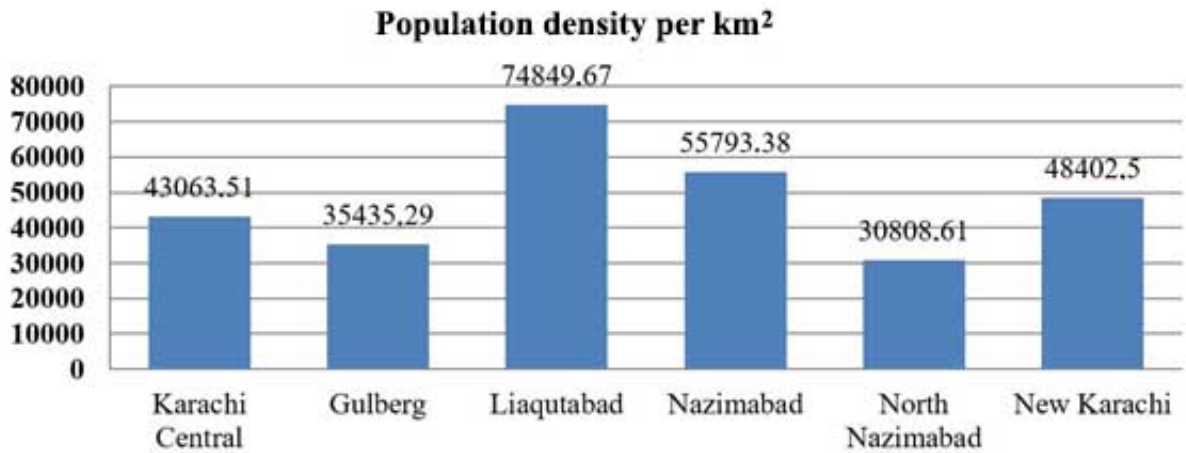


Figure 5. Human Population Density

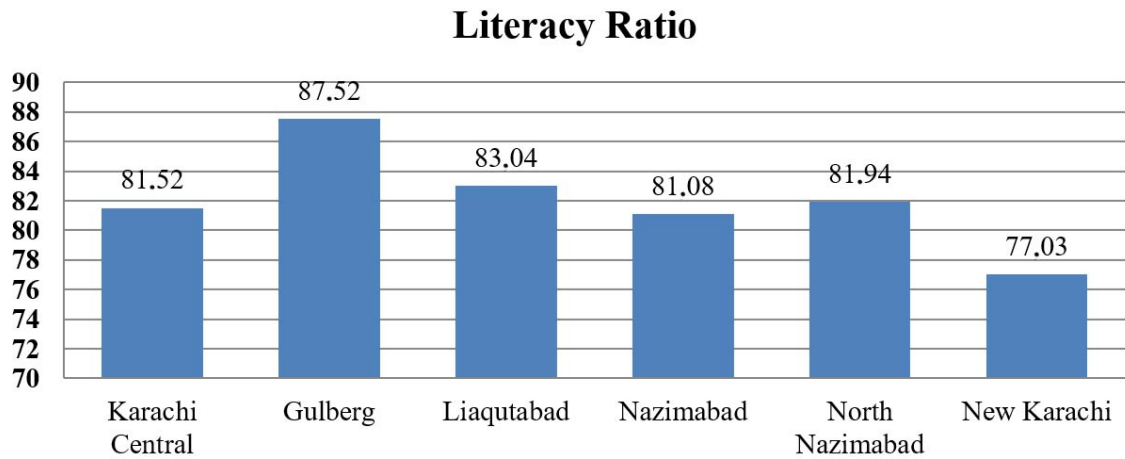


Figure 6. Literacy Ratio

2.1. Data collection and processing

The satellite images have been used for assessment. This data was further processed and analysed using GIS processing on ArcMap 9.8 and Google earth pro. The details of each process are following (Fig. 7).

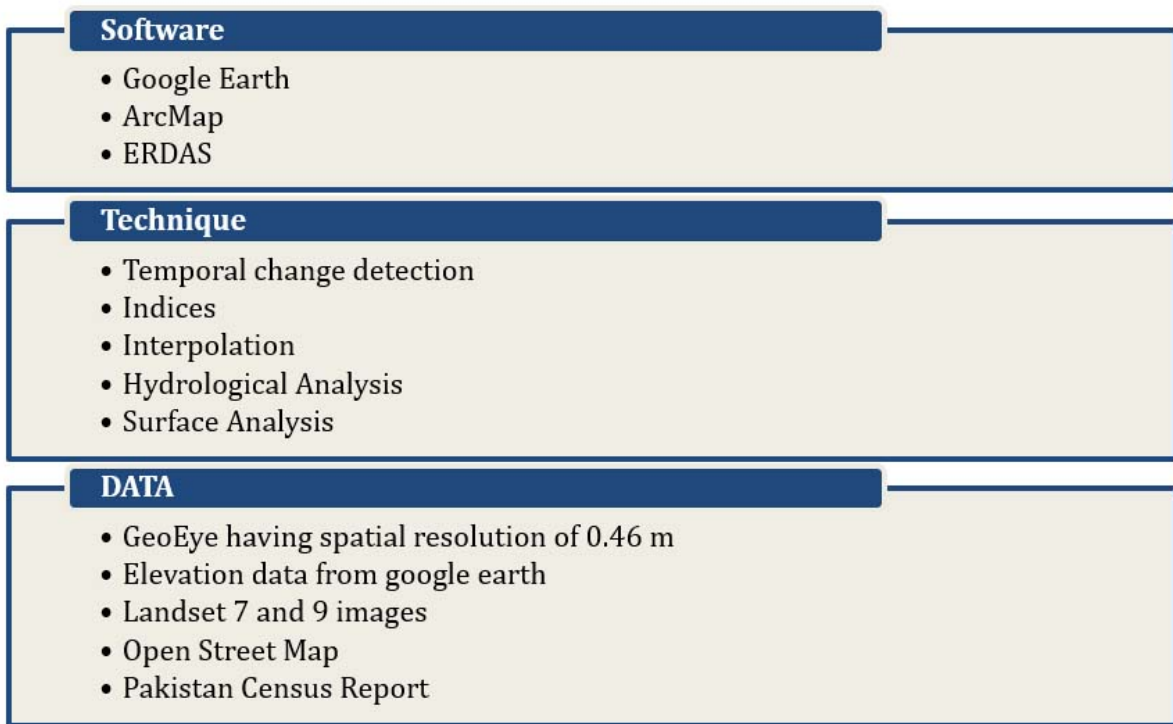


Figure 7. Data acquisition and processing

2.2. Google Earth Pro

Google Earth Pro, is a 3D mapping application produced by Google that allows users to access satellite images and aerial photography having high spatial resolution ranging from 15 meters to 15 centimetres. In Google Earth, we can view the area of interest and obtain geographical data about it. One of the important features of Google earth pro is a historical tool that allows user to view their area of interest back in time with historical imagery. GeoEye's satellite images provided by Google Earth Pro having high spatial resolution were used to collect a large amount of data. Multiple polygon Kmz and Kml files were developed on these high-resolution images, which were converted to Shapefiles in ArcMap using the conversion tool. The historical tool was used to monitor temporal changes. These high-resolution imageries were used to find out the total number of trees, verify if the parks mentioned in the official layout maps are present, and find the total parking area under encroachment, and the condition or quality of parks. The Historical tool was used to monitor changes from 2004 to 2022 in factors that affect the park quality. Elevation data was also collected from Google earth pro which after processing was used in the Hydrological and Surface analysis.

2.3. ArcMap 9.8

ArcGIS a product of Environmental Systems Research Institute (ESRI) is a common geographic information system (GIS) software. ArcMap, the primary component of ArcGIS, was mostly used in this research for compiling geographic data collected from various sites, analysing mapped information, discovering geographic patterns, and creating maps.

2.4. Web sites, newspapers, research articles, and reports

Different research articles, reports, websites, and newspapers were the source of information about the perspective of people over the entire globe belonging to different socioeconomic classes and the importance of urban parks in the life of urban dwellers. This information was mostly used in the literature review. In addition, Pakistan census reports were used to find the population growth in the different districts of Karachi.

2.5. Open street map (OSM)

OSM is a free global editable geographic database. OSM is an open data source usually used for navigation and as a base map. The OSM information can be quite accurate with around 80% of roads overlapped. The data was imported from the OSM website and was converted into a feature dataset using an Open Street Map toolbox in ArcMap. After conversion, data was further edited with the help of high-resolution imagery to remove any presented errors. Then this data was used for land use land cover map the data was also used in other layout maps.

2.6. Landsat 7 and 9 satellite images

Landsat imagery was obtained from the U.S. Geological Survey and NASA Goddard Space Flight Centre. The Landsat satellite record stretches from 1972 to the present. Landsat provides data with high spatial resolution and multiple spectral bands. These bands target a specific area of the electromagnetic spectrum. In this research paper, imagery provided by Landsat 7 and 9 was used to run different indices related to land cover. Two images were used to monitor temporal changes Landsat 9 image is on March 2022 and Landsat 7 image is on March 2003 instead of March 2004 as the Landsat images of 2004 have high scan line errors.

2.7. Indices

Indices are effective and simple algorithms that use different spectral band combinations for different purposes obtained from remote sensing, which are helpful for qualitative and quantitative evaluations. Due to the complexity, no one indices are fit for all applications for one attribute. Thus, many algorithms have been developed. In this research, paper indices were calculated in ArcMap using the Raster calculator. (Table1) contains the list of indices that were used in this study.

Table 1. Indices

| S# | Indices | Formula | Uses |
|----|--|--|--|
| 1 | Normalized Difference Vegetation Index | $NDVI = \frac{(NIR - RED)}{(NIR + RED)}$ | NDVI is the most commonly used vegetation index to detect active plant biomass. However, is very prone to atmospheric effects and soil brightness. |
| 2 | Normalized Difference Moisture Index | $NDMI = \frac{(NIR - SWIR)}{(NIR + SWIR)}$ | NDMI detects the moisture differences in vegetated areas. NDMI is applicable in drought monitoring. |
| 3 | Normalized Difference Water Index | $NDWI = \frac{(GREEN - NIR)}{(GREEN + NIR)}$ | NDWI outlines the open water areas and evaluates their turbidity. NDWI is used to detect flooded areas and wetlands. |
| 4 | Normalized Difference Built-up Index | $NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)}$ | NDBI highlights built-up areas. |
| 5 | Built-up Index | $BU = NDBI - NDVI$ | The build-up index indicates build-up and barren land and is used for urban pattern analysis. BU provides better results than NDBI. BU uses NDBI and NDVI. |

2.8. Hydrological analysis

The hydrological analysis uses elevation data to obtain information about the hydrological system. It can be used to predict the direction of runoff, geomorphologic changes in the course, and find the areas susceptible to flood. In ArcMap Hydrological and Surface analysis go hand in hand.

In this research high-resolution elevation data generated from Google earth pro was used after running interpolation to create a surface on which some hydrological analyses were run in ArcMap such as flow direction, flow accumulation, watershed, stream order to find flood-prone areas, and if any open green spaces were present in those areas (Fig. 8).

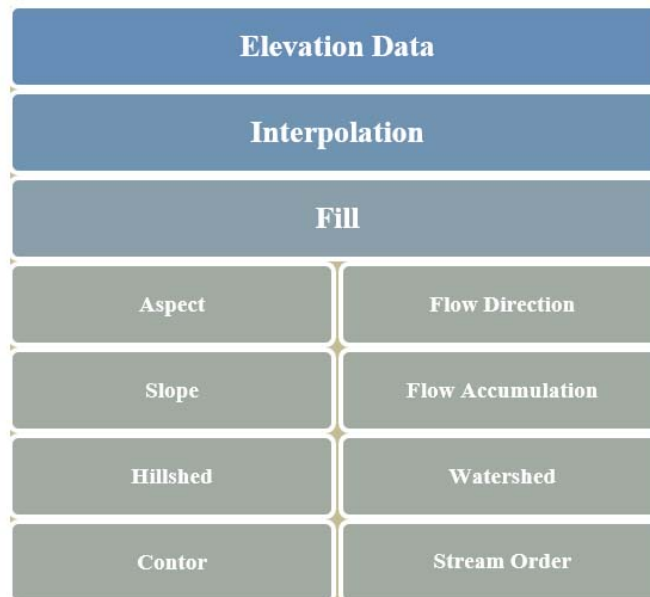


Figure 8. Surface analysis

Surface analysis is often known as terrain analysis. Allows users to analyse complex surface features and patterns generated from the existing elevation data and surface. Different types of Surface Analysis tools are present in the Spatial Analyst toolbox in ArcMap that generate information related to elevation. In this research paper, the surface tools such as aspect, slope, contour, hill shed, etc., were used on the high-resolution elevation data generated with the help of Google earth pro.

3. Result and Discussion

3.1. Land cover of study area

The following maps show temporal changes in various land covers from March 2003 to March 2022 through different indices. NDVI: In 2022 (Fig. 9), the intensity of vegetation is higher but the vegetation distribution is lower than 2003. In both years, vegetation in graveyards and Manghopir hills are visibly prominent and is relatively higher in 2022. In 2003, vegetation cover is well distributed throughout both towns but, in 2022 vegetation cover is only present in small patches that are higher in North Karachi than in New Karachi and within North Karachi, West Part has more of these patches. Gascon et al. (2016) indicated that NDVI could be a beneficial greenness metric liable on the assumption and area of study.

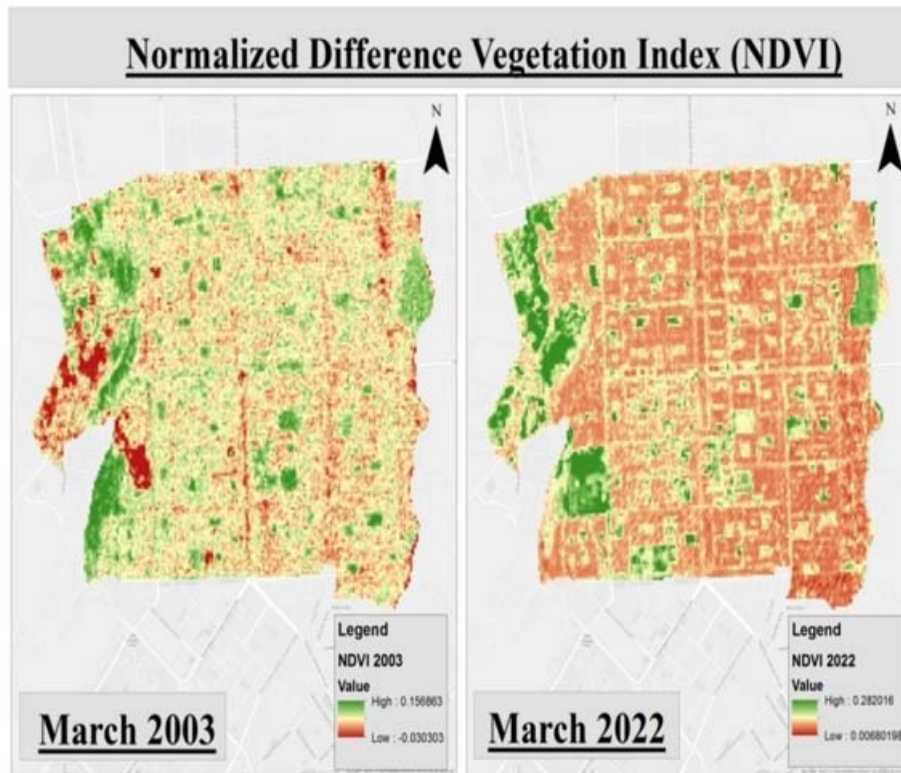


Figure 9. Normalized Difference Vegetative Index (NDVI)

NDBI: NDBI has significantly increased from 2003 to 2022 (Fig. 10). In 2003 the NDBI value is significantly higher than the rest of the area. Which are very unlikely and when these areas were checked in higher resolution imagery it was found that the areas were covered with some type of black soil which interferes with the NDBI of 2003. In 2022, NDBI values near Manghopir hills, the graveyard of North Karachi and some small patches have high build-up index values that are parked or open spaces without any vegetation cover thus having high reflectance values. Dai et al. (2018) revealed that the influence superficial temperatures, spatial regressions are essential to capture neighbouring effects, and higher-order polynomial functions are more appropriate for capturing the effects of NDVI and NDBI.

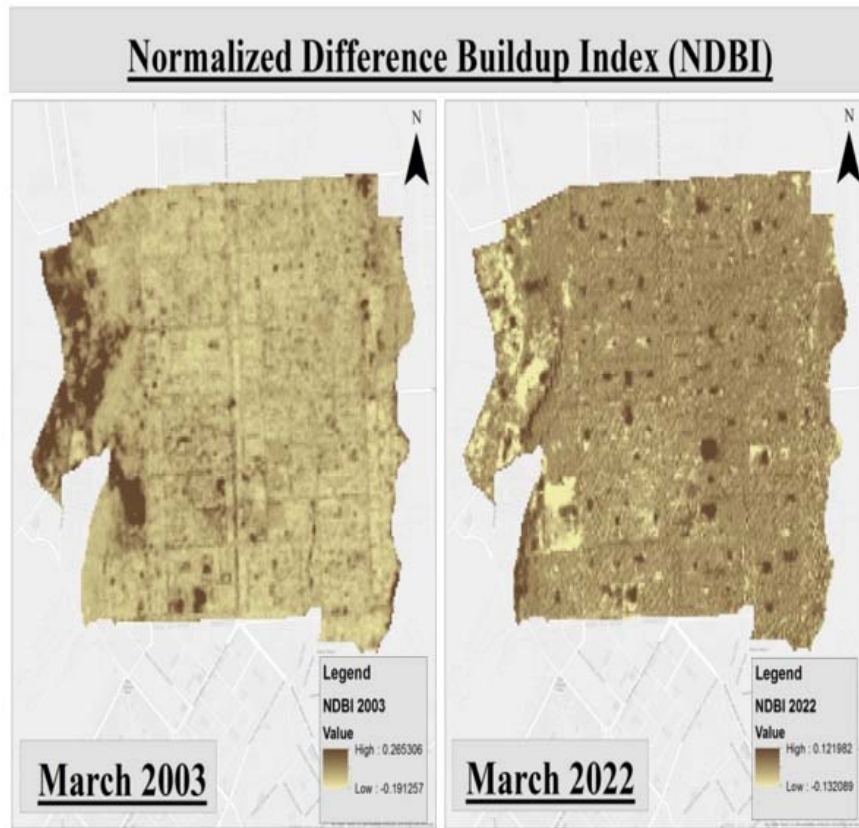


Figure 10. Normalized Difference Build-up Index (NDBI)

BU: For the build-up, index (Fig. 11) NDVI was subtracted from NDBI. The results at first seem the same as NDBI but in the build-up index, vegetation cover was removed from the build-up area and the results are better than NDBI. In 2022, the build-up area is in purple. Sun et al. (2015) assessed the accuracy and repairability of combinational build-up index (CBI) through qualitative and quantitative methods, and found that the proposed method is able to assist as an actual impervious index and can be applied widely. Huang and Zhang (2011) reported that the morphological build-up index (MBI) is a newly urbanized method for automatic indication of buildings in high-resolution images.

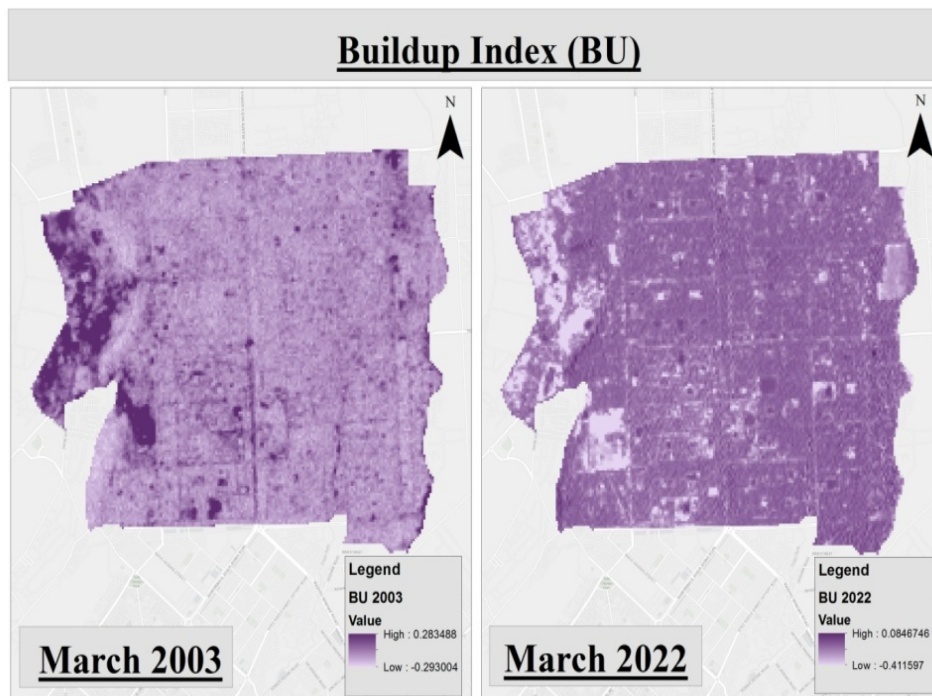


Figure 11. Build-up Index (BU)

NDWI: In 2022, Water Index values are significantly low indicating moderate drought-to-drought conditions. In 2003, values are higher than in 2022 and the range indicates humidity moderate drought conditions (Fig. 12). Water content is higher in that showed higher vegetation concentration on NDVI map. Ali et al. (2019) stated that the urban surface water bodies augmented about 129.8 ha spread frequently in Manggala area, because of fast built-up expansion viz., housing, makes the urban runoff intent in lowland and generates huge swamp in addition to an urban wetland.

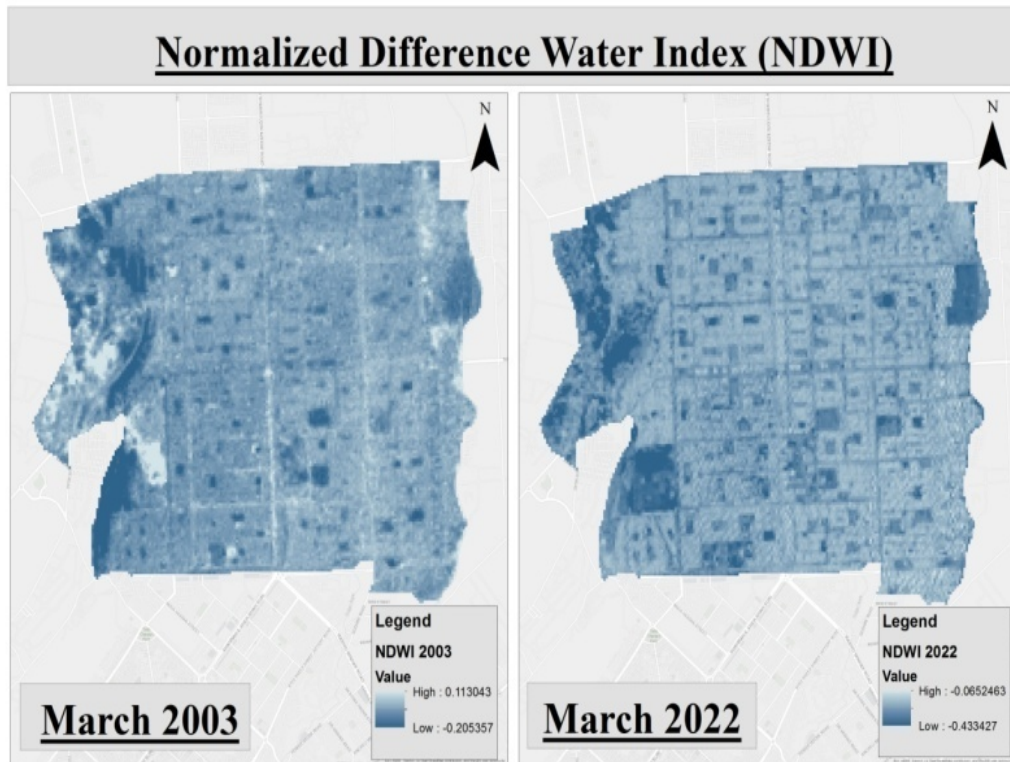


Figure 12. Normalized Difference Water Index (NDWI)

NDMI: The master index was higher and significantly distributed throughout the area in March 2003 (Fig. 13). Unlike 2022, where the moisture is only high in some parts of Manghopir hills and North Karachi's graveyard. In 2022, the most areas with high values of NDVI also have higher NDMI values. Rahman and Mesev (2019) observed the land use and/or land cover variations were precious by both an enhance in precipitation in 2010 in addition to a substantial reduction of precipitation in 2011 subsequent in the disturbing rapid drought. Sabah and Afsar (2020) explore the soil moisture content relies on climate change, urban heat island, and population.

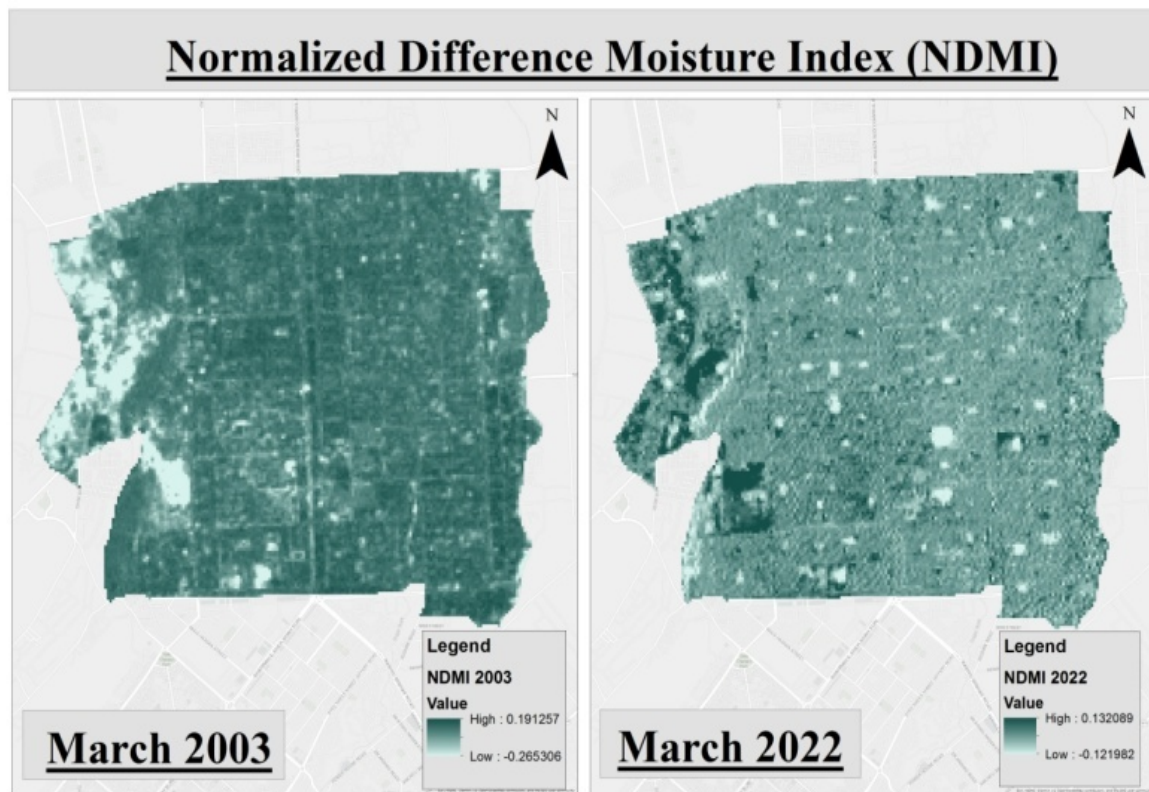


Figure 13. Normalized Difference Moisture Index (NDMI)

3.2. Spatiotemporal changes in parks quality of new and North Karachi

Temporal changes in the condition of parks were monitored from 2004 to 2022. Some attributes were selected each attribute had a score. Attributes having positive impacts such as the number of trees, boundary walls etc., had positive scores and attributes having negative impacts on the condition of parks such as sewage and garbage had negative scores are all combined for the final score. According to the layout plan map of Karachi, New Karachi has 42 parks having a total area of 380,424 m² and North Karachi has 24 parks with a total area of 371,297 m². Mahmud et al. (2011) stated that the expansion and variation of the prevailing water bodies should reflect the natural hydrological circumstances.

3.3. Spatiotemporal changes in encroachment

The illegal occupation of land is known as encroachment. Encroachment violates the rights of property, whether public or private it is the unwanted intrusion on the land that is not assigned to the intrusive activity. Encroachment is a big problem in the urban areas of developing countries. Unfortunately, encroachment was found in parks of both towns (Fig. 14). Approximately, 15 out of 42 parks in New Karachi and 11 out of 24 parks in North Karachi are facing Encroachment issues. With the increasing

population, the encroachment percentage has increased in both towns. But this increase was very significant in North Karachi in 2004 most of the encroachment was below 30% and only one park was 100% encroached located in the 11-E sector of North Karachi that increased to 4 parks with 100% encroachment in 2022. A park in the 11-B sector did not have any encroachment in 2003, and increased to a hundred percent in 2022. Another park from North Karachi sector 11-F in 2003 had 11% of their land encroachment that increased to 100% in 2022. This park was fully converted into a government school although the number of trees has increased In 2022 the encroached park area has more than 100 trees, but this area was no longer accessible to the general public as all of it is converted into a Government school. Compared to North Karachi encroachment in New Karachi has not increased significantly. Mahmud et al. (2011) reported that the land filling and encroachment were documented to be the main causes for a reduction of the wetlands in the city.

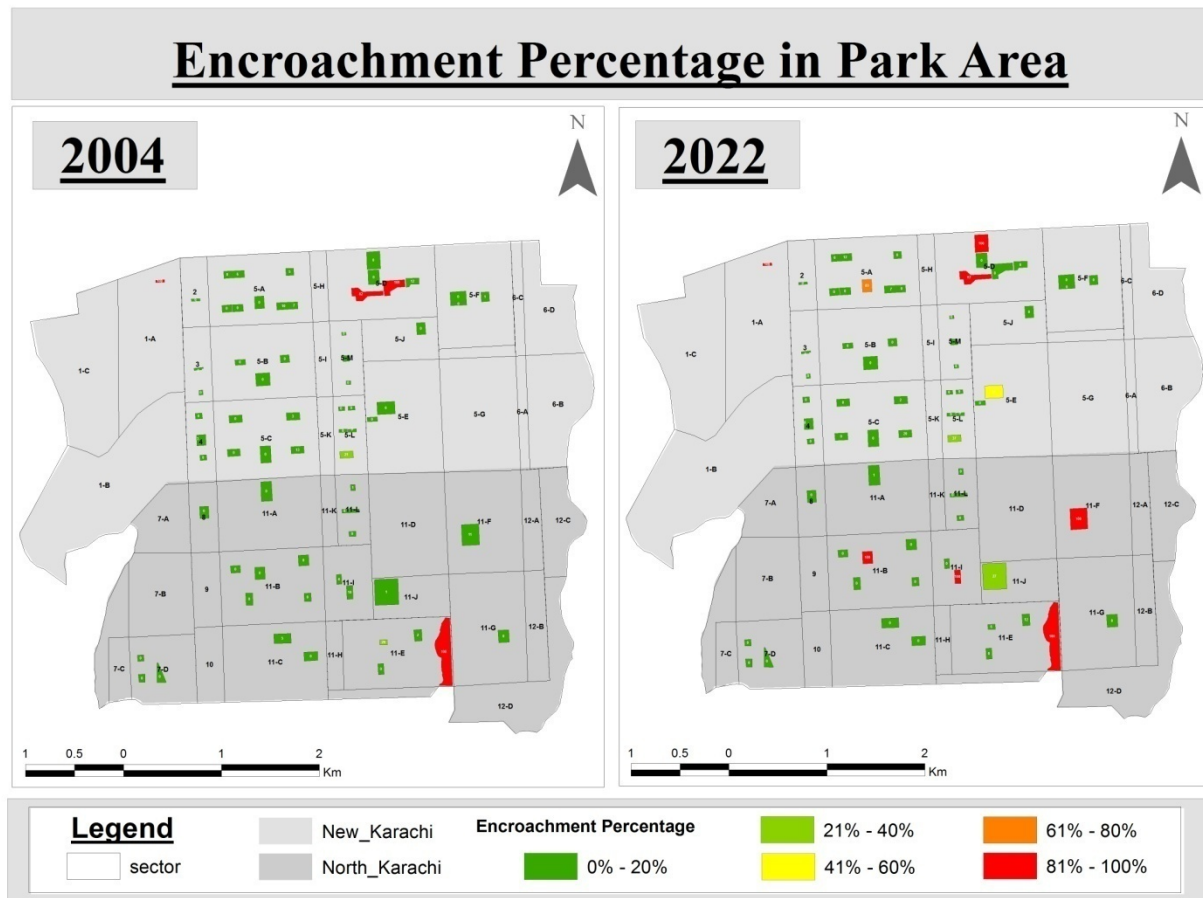


Figure 14. Encroachment percentage

Only one park of sector 5-A in New Karachi has a significant increase in encroachment in 2004 only 10% of the area was encroached that increased to 80% in 2022. Two parks in sectors 1A and 5d have 100% encroachment, and another park in sector 5-D has 82% encroachment in both years thus not having any temporal change. In the year 2004, 52,473 m² (13.8%) of New Karachi's park area was under encroachment that increased to 101,052.4 m² (26.5%) in the year 2022 (Fig. 15). North Karachi in the year 2004 had 87,976 m² (23.7%) of the area under encroachment, which increased to 157,701.8 m² (42.5%) in 2022 (Fig. 16). Park areas that have been encroached on may have some new plantation or parking issues etc., even if, the selected attributes are present in the encroachment area they are not included in the final score/ranking. As this area is no longer the part of the park.

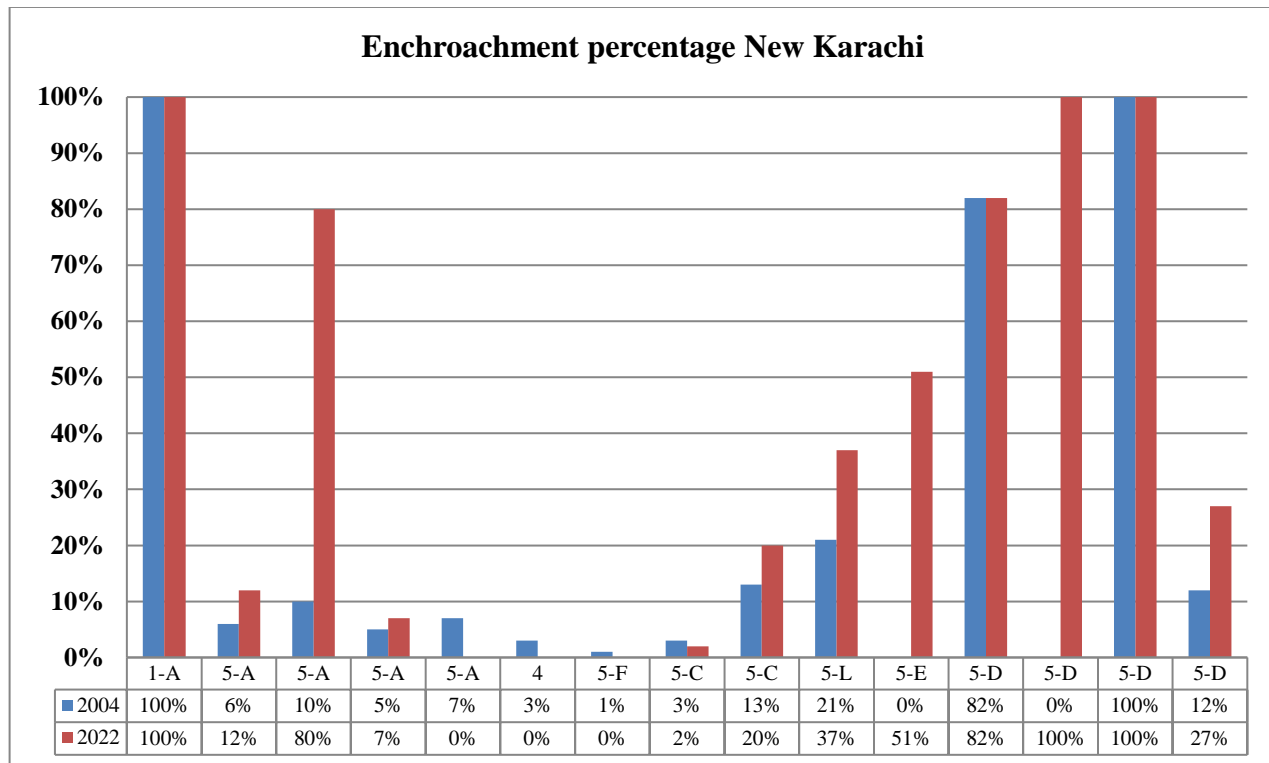


Figure 15. Encroachment percentage of New Karachi

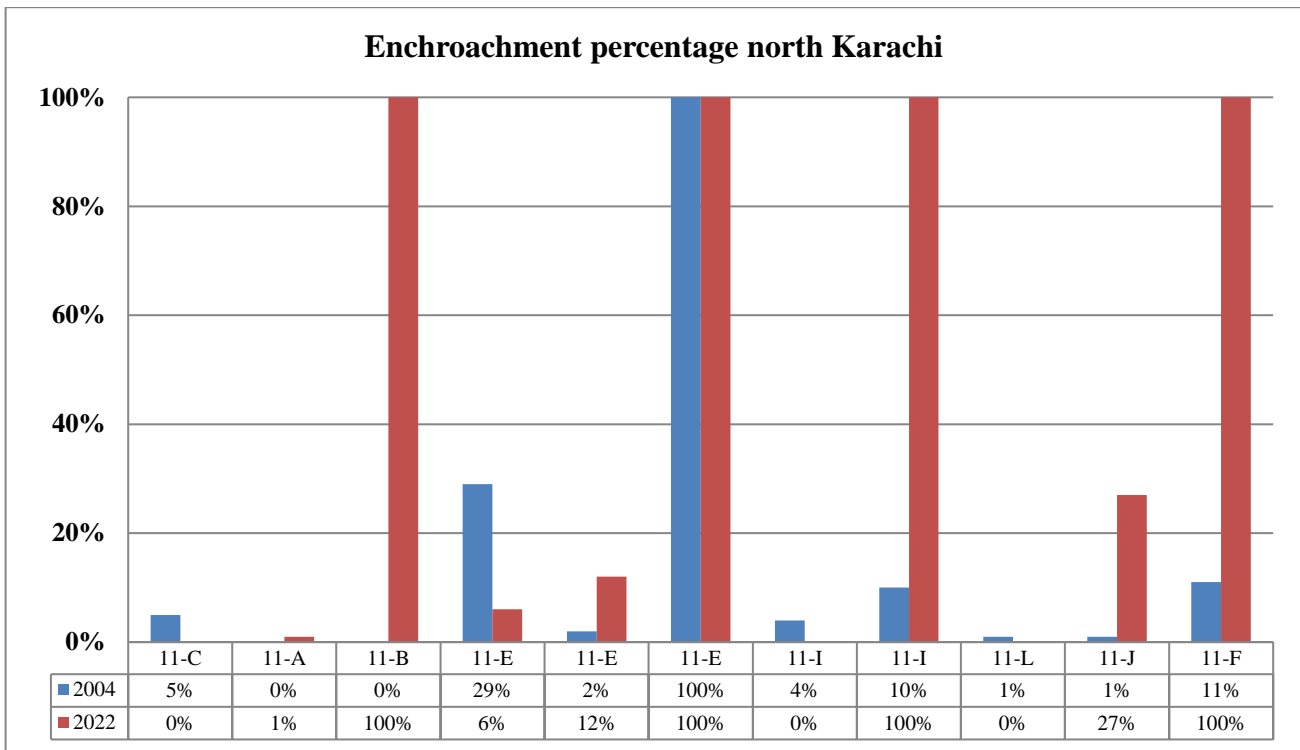


Figure 16. Encroachment percentage of North Karachi

3.4. Spatiotemporal changes in number of trees

The number of trees has increased from 2004 to 2012, in almost all parks located in this study area (Fig. 17). In New Karachi, the number of trees has increased in 34 out of 42 parks and decreased in only 2 out of 42 parks from 2004 to 2022. The number of trees has increased in 13 out of 24 and decreased in 8 out of 24 parks in North Karachi from 2004 to 2022. Sector 5-B (Fig. 18), has the highest number of trees in North Karachi town. In other parks, there was no change. In New Karachi parks, highest number of trees are present in sector 5-C (Fig. 19). The increase in the number of trees is not as prominent in New Karachi as in North Karachi (Figs 18, 19, 20). Most trees in 2022 are small in size. In both towns, a number of trees are higher on the Westside of Shahrah-e-Usman. Trees that are present in encroached part of the parts are not added in this, as they are no more part of the Park or available to the general public. The correlation data in (Table 2) shows a weak association is present between the number of trees in 2004 and 2022 in the parks of North Karachi and moderate association is present in the number of trees in New Karachi parks in 2004 and 2022. This means more trees are planted in the parks where trees were already present in New Karachi. Zhang et al. (2022) found the significant correlation between building density (BD), and building floor area ratio (BFR) around the green space and the cooling effect of green space. Xing et al. (2018) stated that comprehensively considerate of the spatial and sequential dynamics of the

urban green space, and also assistance policy makers and engineers to steadiness economic development and green preservation. Niu et al. (2022) reported that the large areas of tree-shaded places and pavilions, and suitability trails were more favourable to long durations of ex-situ activity.

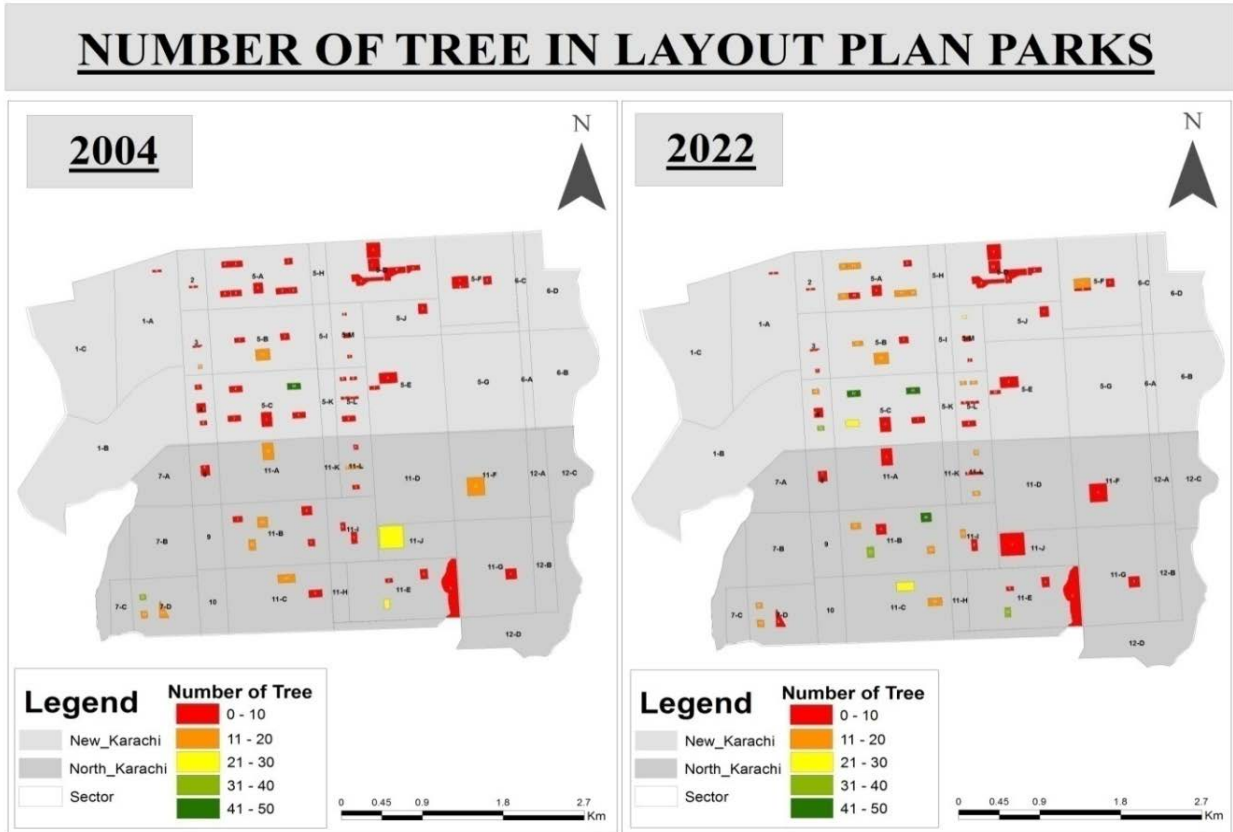


Figure 17. Number of trees

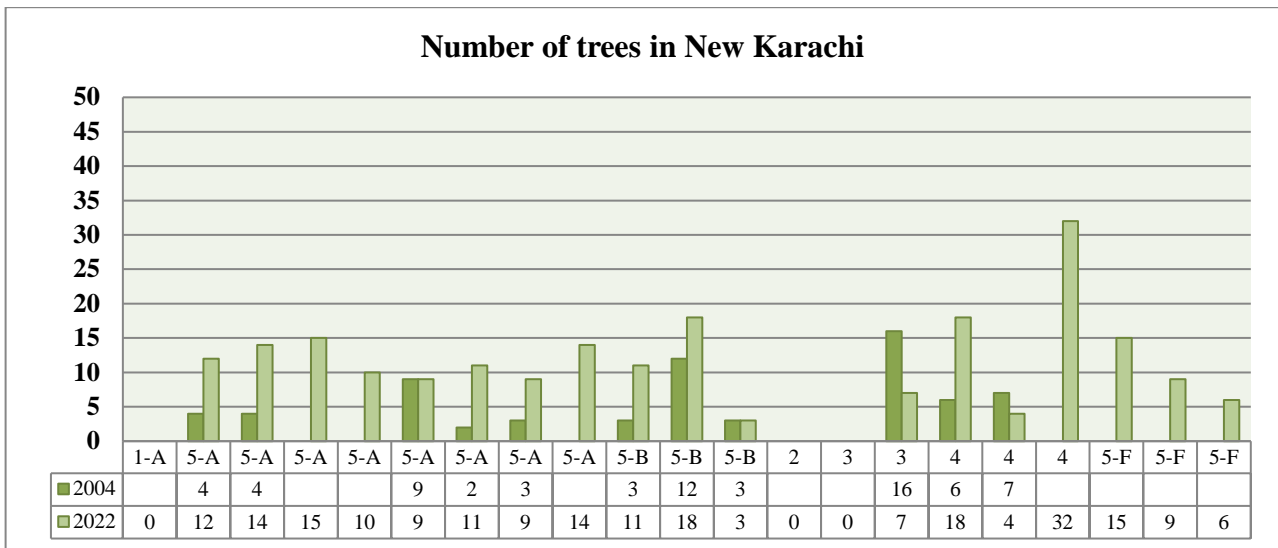


Figure 18. Number of trees in New Karachi

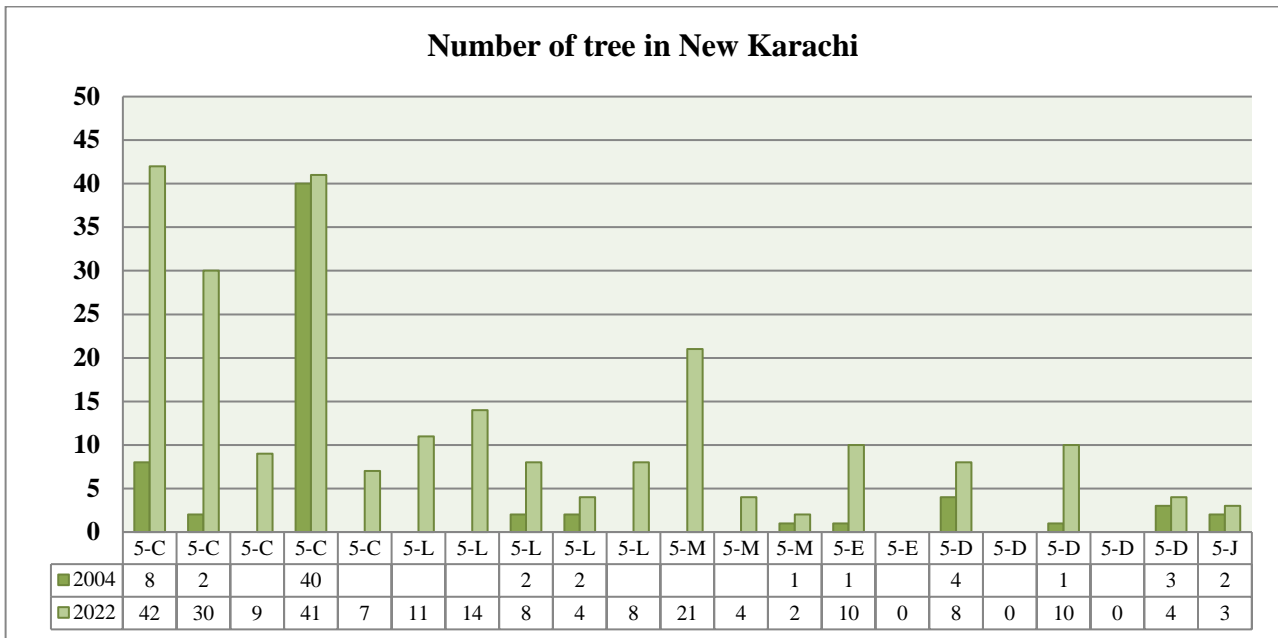


Figure 19. Number of trees in New Karachi

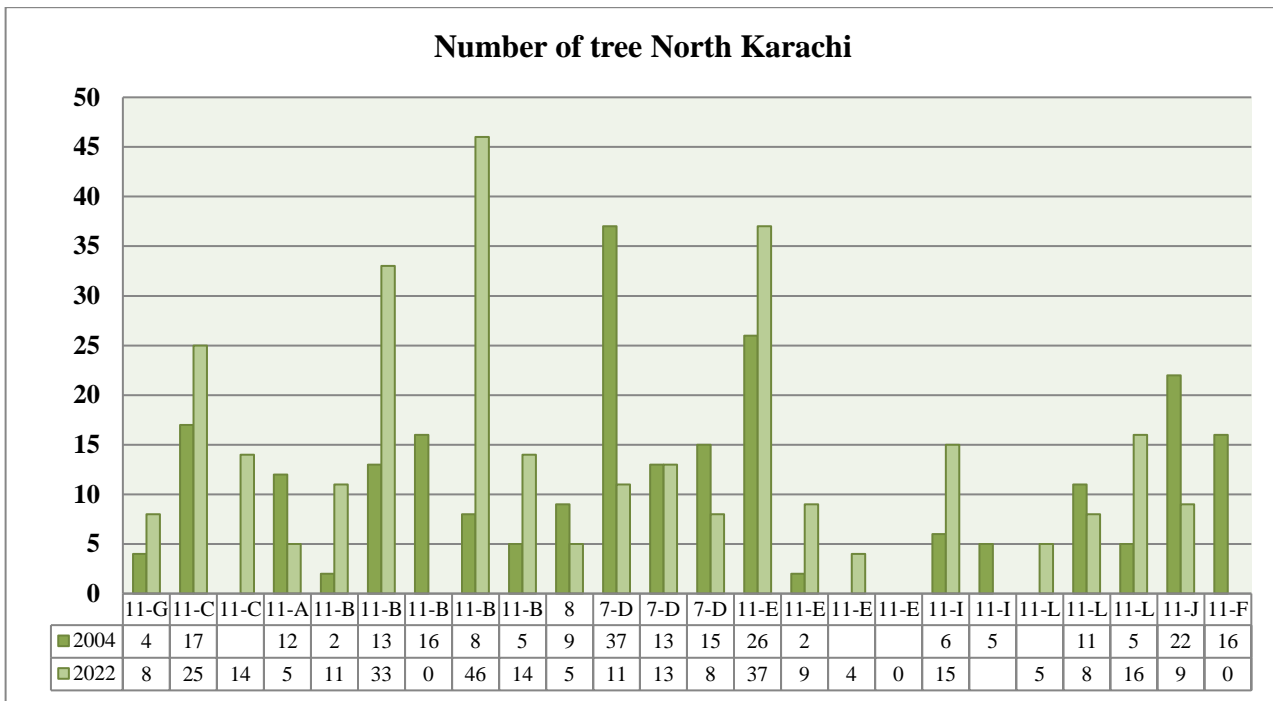


Figure 20. Number of trees in North Karachi

Table 2. Correlation of parks between North Karachi and New Karachi

| Correlation Between | North Karachi | New Karachi |
|----------------------------------|---------------|-------------|
| Number of trees in 2004 and 2022 | 0.226499325 | 0.50365 |

3.5. Spatiotemporal changes parking issues in parks

The owing to the population growth, urban build-up land is increasing in urban areas leading to parking problems, as previously left vacant land is no more vacant. Leaving no place for residents to park their vehicles. This has led to the unfortunate situation in New and North Karachi where public parks are being used as parking lots (Fig. 21). In some parks, the vehicles are parked along the boundary wall If that is the case the parks are given a negative 1 score as these vehicles do disturb the games and activities within parks but do not stop them. In some parks, the condition is even worse where vehicles are parked in the centre of the park converting parks into parking lots completely stopping the game/activities or having a major negative impact on the recreational activities of the parks. In such a case -2 scores are given. The conversion of parks to parking lots have increased with time. The parking problem is more prominent in New Karachi than in North Karachi as more parks are facing these problems (Fig. 21). In 2004 only four parks were being used as parking lots where vehicles were parked along the boundary walls within the park two of these parks were in New Karachi town and the other two were in North Karachi town also sector 4 parks of New Karachi were being used only as a parking lot. In 2022, 12 parks in New Karachi

have a -1 score and 9 parks have a -2 score in parking issues. In North Karachi, 2022 four parks have a -1 score and one park has a -2 score in parking issues. These numbers have increased significantly due to the annual growth rate of 2.13% in both towns. Wu and Ma (2022) found an average on-street parking occupancy in Hong Kong was up to 80% during the day, and three parking patterns are reliably identified by direct data imaging and clustering consequences.

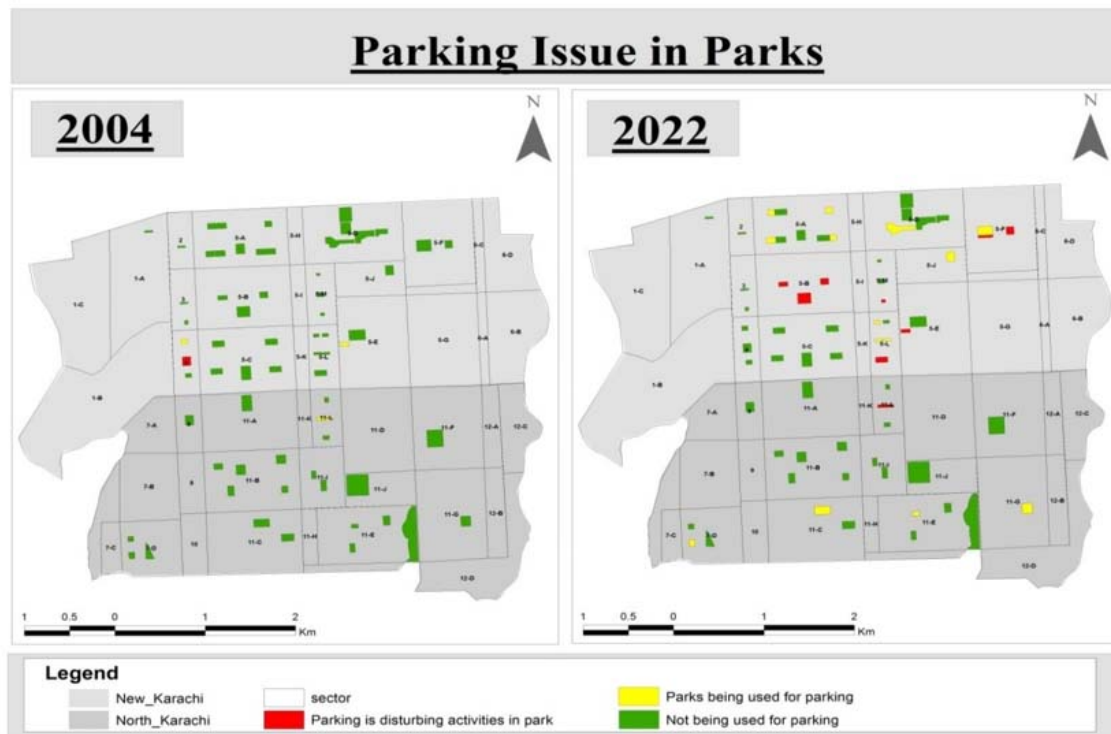


Figure 21. Parking issue

3.6. Spatiotemporal changes in sewage water accumulation

Sewage water accumulation is also a big problem for the citizens of Karachi. To find which parks were more vulnerable to sewage water accumulation six months of data were analyzed and if within this period sewage water was found within the park area. The park was given a negative one score. In 2004 (Fig. 22), 29 out of 66 parks had sewage water accumulation from which 22 out of 42 parks in New Karachi and 7 out of 24 parks in North Karachi were facing sewage water problems. In 2022, 16 out of 42 parks in New Karachi and 5 out of 24 (Fig. 22), parks in North Karachi are suffering from sewage water accumulation. There was no clear association between the natural watershed and the park with sewage accumulated (Fig. 23). All of the parks of New Karachi are located in the watershed and around half of them are facing sewage water accumulation issues. In North Karachi half of the park is located in the watershed and they

are not more likely to have sewage water accumulation than those that are not located In the watershed area. Mahmud et al. (2011) reported that area of wetland and rivers & Khals in Dhaka city reduced ominously since last 3 decades by 76.67% and 18.72% respectively Because, this varying trend of marshlands marks into the drainage system of Dhaka City vulnerable, producing water logging issues and their consequences.

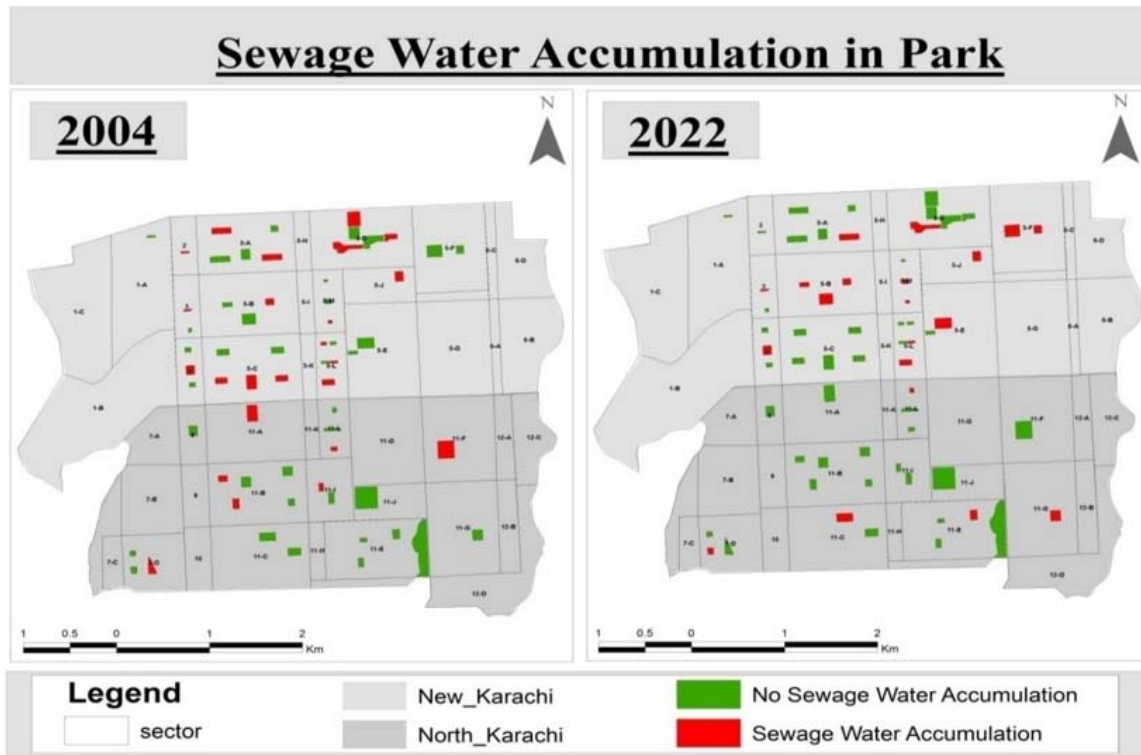


Figure 22. Sewage water accumulation in parks

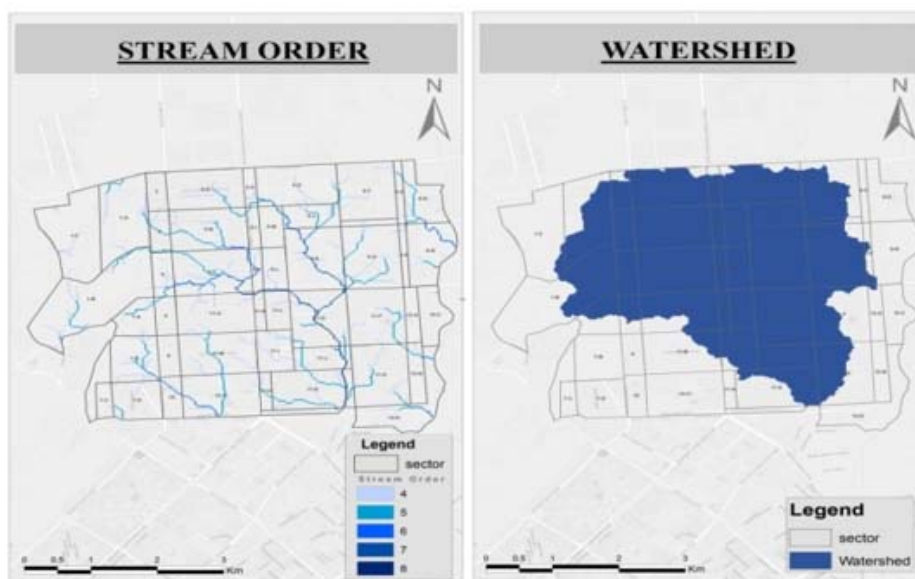


Figure 23. Stream order and watershed

3.7. Spatiotemporal changes in the quality of parks

For the final scoring/ranking of the park (Figs 24, 25). Approximately, 8 attributes were selected. 4 attributes that can improve the condition of parks (number of trees number, recreational amenities, boundary wall, grass cover) have positive scores. For number of trees, different scores were given to different range (1-10 trees = +1 and 11-20 trees = +2 score...). And 4 attributes that negatively impact the quality of the park were also included (sewage water accumulation, parking issues, garbage, and encroachment) had negative scores. Encroachment's negative scores were also associated with the percentage of area under encroachment (1-10%= -1, 11-20%= -2...). The parking problem also had two scores, if the parking within the park only distributes the park activities -1 and if the parking problem could stop the activity-2 score was given. The sum of these 8 attribute scores was used to calculate the final score of park quality.

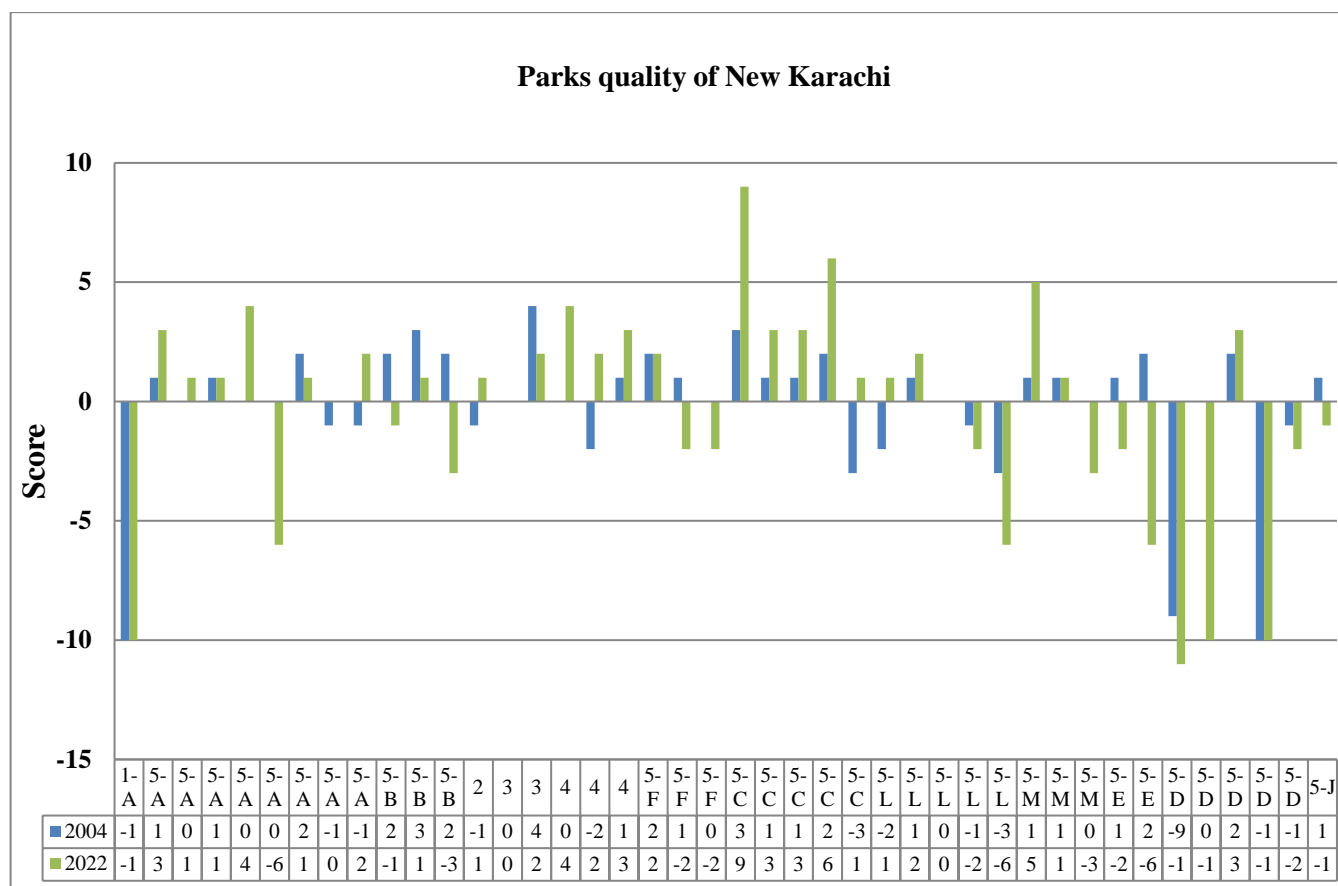


Figure 24. Temporal changes in park quality in New Karachi

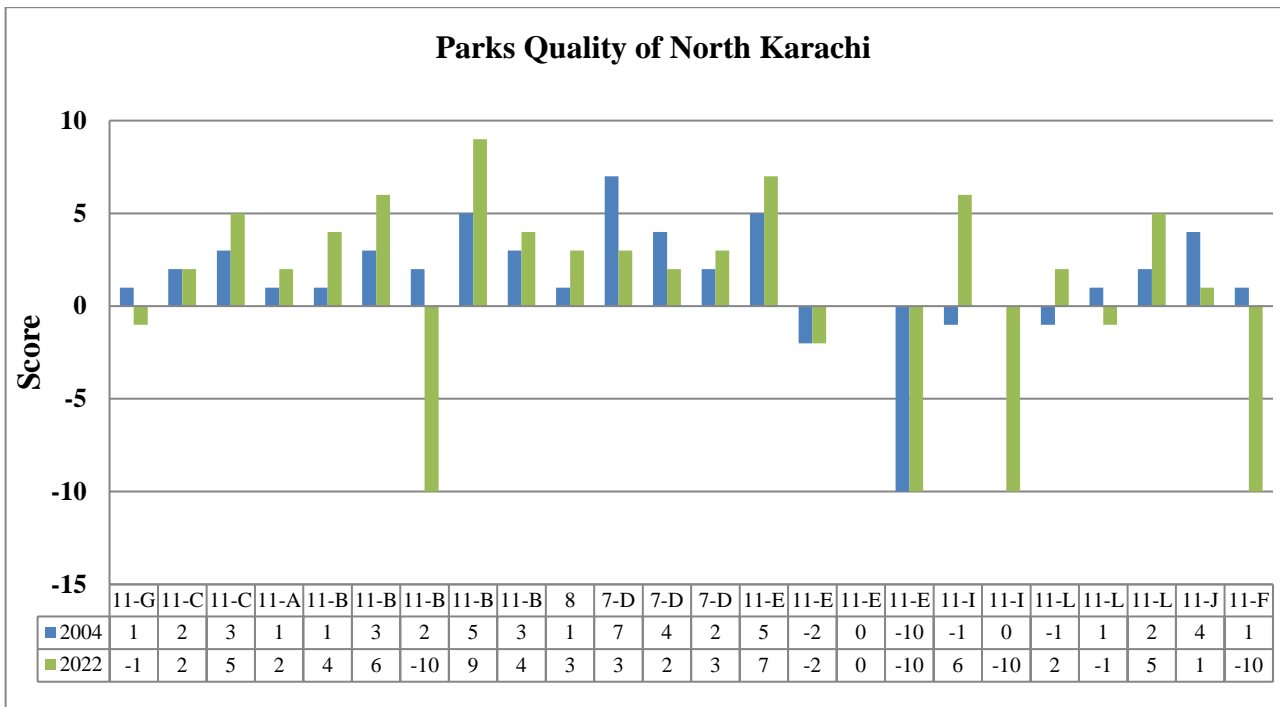


Figure 25. Temporal changes in park quality in North Karachi

According to the final score (Fig. 26) of park quality in New Karachi, 18 out of 42 parks quality improved from 2004 to 2022. 17 Park's quality decreased and the quality of 7 parks remained the same from 2004 to 2022. In 2004 sectors, 5D and 1A had the worst quality parts in New Karachi and sector 5B had the best park quality in New Karachi town. In 2022 sectors 1 A and 5D still have the worst park quality and now sector 5C has the best park quality in New Karachi town. In 2022 North Karachi's parks on the west side of Shahrah-e-Usman have much better quality than on the east side and in 2004 North Karachi Park has better quality than parks in New Karachi. Crompton and Kim (2004) examined the constraints change over time among a sample of state park visitor and changes in the magnitude of constraints influence visitation to state parks. As a result, seeming constraints on the time availability, personal and facility constraints, and weather magnitudes did change ominously over these time periods.

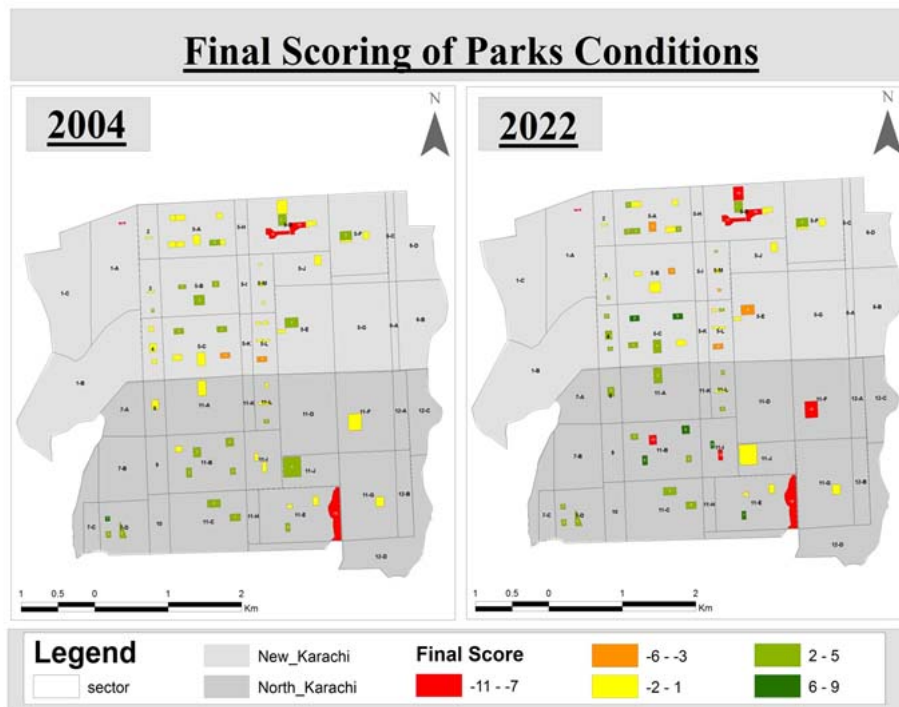


Figure 26. Temporal changes in park quality

AVERAGE PARK CONDITION IN EACH SECTOR



Figure 27. Temporal changes in park quality in different sectors

To better visualize the park quality patterns in both towns each sector was given a score depending on the average park quality scores of the sector (Fig. 27). According to the result in New Karachi park's quality has improved in 5 out of 13 sectors from 2004 to 2022, decreased in 6 sectors, and 2 out of 13 sectors saw no change in New Karachi. In North Karachi, park's quality has improved in 5 out of 11 sectors and decreased in 6 out of 11 sectors from 2004 to 2022. Overall, in 2004 park quality was much better in both towns than in 2022 if comparing both towns North Karachi's parks have better quality than the parks of New Karachi. Most of the parks where the quality of the park has improved from 2004 to 2012 are on the West side of Shahrah-e-Usman.

3.8. Correlation between different factors of park quality

Correlation is used to find the association between two variables. In this research, correlation is used to find the association between different factors related to park quality. Data in (Table 3) shows that the degree of correlation between different Park qualities factors scores during 2004 and 2022 in New and

North Karachi town. It can be used to make sense of the correlation scores. According to the result in (Table 4), the moderate correlation in research within the selected factors is only found in North Karachi town in the year 2022. Encroachment and boundary wall in the North Karachi year 2022 shows the highest association with this research have a score of -0.68201 representing a negative moderate association meaning encroachment percentage is low in the parks that have on boundary walls. In addition, in New Karachi year 2022 has a weak negative association, also in the year 2004 both towns have a weak negative association between encroachment and boundary walls. The negative correlation scores have increased from 2004 to 2022 in North Karachi town means the park that has a boundary wall has significantly lower increase in the encroachment percentage.

In addition, boundary walls also have a positive association with recreational amenities. In North Karachi year, 2022 has a Moderate positive association, New Karachi has a weak positive association between boundary walls, and recreational activities this association is higher than the year 2004 in both towns as both towns had a negligible positive association between boundary walls and recreational amenities in 2004. This show the recreational amenities have decreased in parks where the boundary walls were absent. The recreational amenities also have a positive association with the number of trees present in the park. During, 2022 North Karachi has a moderate positive association and New Karachi has a weak positive association between recreational amenities and the number of trees present in the park. In 2004, the association was negligible in both towns. Furthermore, the number of trees has a weak positive association with grass cover and, also with boundary walls of park in both towns year 2022. This positive association has increased in the year 2022 as of 2004 both town's parks had a negligible association between the number of trees with boundary walls and the number of trees with grass. The overall correlation results indicate factors that affect park quality positively have a positive association with other positively effecting factors and a negative association with factors that affect park quality negatively. These associations have become stronger with time. Other than, the factors mentioned above there were no significant temporary and spatial patterns and trends between other park quality factors.

Table 3. Correlation between different park quality factors

| Correlation between scores of studied variables | New Karachi | | North Karachi | |
|---|-------------|----------|---------------|------------|
| | 2004 | 2022 | 2004 | 2022 |
| No of trees and parking problem | 0.098102 | 0.058622 | 0.163461 | -0.0467326 |
| No of trees and sewage water accumulation | -0.00388 | -0.21764 | 0.072635 | -0.00998 |
| No of trees and grass cover | -0.02638 | 0.482805 | 0.088561 | 0.468047 |
| No of trees and boundary walls | 0.051426 | 0.309308 | 0.235324 | 0.454808 |
| No of trees and recreational amenity | -0.19109 | 0.354631 | 0.201182 | 0.640241 |

| | | | | |
|--|----------|----------|----------|----------|
| No of trees and garbage | -0.02638 | -0.1557 | -0.26919 | -0.14666 |
| Encroachment and garbage | -0.06818 | -0.0725 | -0.07881 | -0.11987 |
| Encroachment and boundary wall | -0.37454 | -0.37103 | -0.33195 | -0.68201 |
| Encroachment and parking problem | -0.00121 | -0.25933 | -0.05522 | -0.23463 |
| Boundary wall and parking problem | -0.06024 | -0.30525 | -0.21654 | -0.22018 |
| Boundary wall and garbage | -0.33344 | -0.14587 | -0.02649 | -0.1382 |
| Boundary wall and recreational amenities | 0.201843 | 0.462556 | 0.247475 | 0.654654 |
| Recreational amenities and parking issue | -0.06632 | -0.30688 | -0.09091 | -0.33634 |
| Recreational amenities and sewage water accumulation | -0.08299 | -0.02148 | 0.055279 | 0.0431 |
| Garbage and sewage water accumulation | 0.146938 | 0.438529 | 0.071007 | -0.15467 |
| Boundary wall and grass cover | 0.141421 | 0.185695 | 0.204124 | 0.370479 |
| Grass cover and garbage | -0.07255 | -0.20672 | -0.31053 | -0.17408 |

Table 4. Correlation value and its association

| Range | Strength of association |
|------------------|-------------------------|
| 0 | No Association |
| 0 to ± 0.25 | Negligible Association |
| ± 0.25 to ± 0.50 | Weak Association |
| ± 0.50 to ± 0.75 | Moderate Association |
| ± 0.75 to ± 1 | Very strong Association |
| ± 1 | Perfect Association |

In many sectors, some parks are not present in the layout map of the town (Fig. 28). These parks were identified with the help of high spatial resolution images. Furthermore, the data in (Fig. 28) shows the number of parks that was not present in the official layout map of both towns.

In New Karachi 14 sectors, have parks that are not mentioned in the layout maps of Karachi. New Karachi had 37 unmentioned parks in 2004 that decreased to 27 in 2022. In 2004 sector, 5F had the highest number of parks that is 11 these reduce to 5 parks in 2022. In 2022 sector, 5G has the highest number of unmentioned parks that is 8 in New Karachi town. Temporal changes for New Karachi show the number of parks have increased only in 2 sectors and decreased in 3 sectors out of 14. In North Karachi, 15 sectors have parks that are not mentioned in the layout map of Karachi. North Karachi had 24 unmentioned parks in 2004 that increased to 32 parks in 2022. In both years, the highest number of parks is 8 in sector 11-A of North Karachi town. The second-highest number of unmentioned parks in a sector was 5. Temporal changes in parks of North Karachi show the number of unmentioned parks have increased in 5 sectors and decreased in only 1 sector. Most unmentioned parks are on the east side of Shahrah-e-Usman. Bahriny and Bell (2020) stated that the combination of influences in relation to the

quality of the parks viz., presence of facilities, presence of water and other special attractions, in addition to how well-lit they are, how well kept and safe they are, has a lot to do with their level of use.

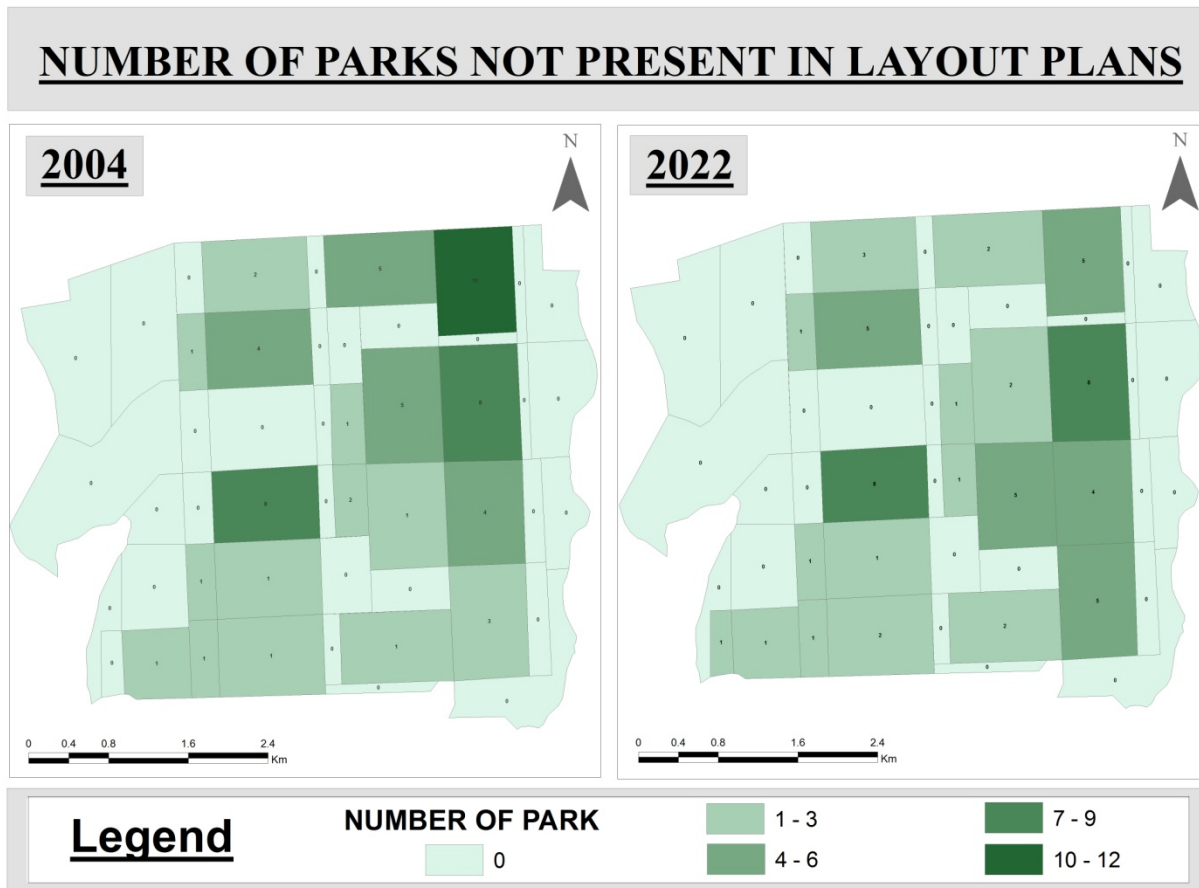


Figure 28. Number of unmentioned parks in each sector

4. Conclusion

It was concluded that, in both years the results of NDVI showed, vegetation in graveyards and on Manghopir hills is visibly prominent in 2022 as compared to 2003. The overall vegetation cover is well distributed throughout both towns in 2003 while in 2022 vegetation cover is present in small patches only. NDBI has increased noticeably from 2003 to 2022. In 2022, near Manghopir hills, the graveyard of North Karachi and some small patches have high build-up index values. Build-up Index (BU) showed results which prior seems similar in NDBI at but vegetation cover was removed from the build-up area and the results are better than NDBI. NDWI and NDMI results showed desertification and less moisture in 2022 vs. 2003. The spatiotemporal changes in parks quality of New Karachi and north Karachi are as follows: a) approximately, 15 parks among 42 (total parks) in New Karachi and 11 parks among 24 (total parks) in North Karachi are facing Encroachment issues, b) in 2004; Only one park was 100% encroached while 4

parcs with 100% encroachment in 2022 in North Karachi. While in New Karachi not a single park encroached completely, 3) in New Karachi encroachment increased from 26.5% (2004) to 13.8% (2022) while in North Karachi encroachment increased from 42.5% (2004) to 23.7% (2022). Overall North Karachi encroached more than New Karachi and d) since 2004; number of trees have been increased in 34 parks while decreasing in 2 parks among 42 (total) in 2022 in New Karachi Town. While in North Karachi Since 2004, number of trees have been increased in 13 parks while decreasing in 8 parks among 24 (total) in 2022. Due to rapid urban sprawl the unfortunate situation in New Karachi and North Karachi, where public parks are being used as parking lots. This issue is more prominent in New Karachi than in North Karachi. The issue of sewage water accumulation, got decline in both towns i.e., in 2004, 22 parks since 42 in New Karachi, while 7 parks from 24. While in 2022 16 from 42 in New Karachi and 5 from 24 facing such problem. The temporal changes in the Park quality scores indicate most parts in the year 2004 had an average score meaning the parks were in moderate condition in comparison to 2022. In 2022, most parks have a higher or lower score than the average score meaning most parks' quality have either improved or deteriorated 2022. The association between the different factors related to the Park quality has increased in the year 2022. The association between factors that similarly affect the park quality (e.g., positively or negatively) is positive. The association between the factors that differently affect the power quality (e.g., one positive and one negative) is negative. These associations are much higher in year 2022 than in 2004.

4.1. Future suggestions

- To enhance the number of visitors; there is a dire need of maintenance and improvement required to upgrade the condition of public parks. Authorities should have managed the official parks as the negligence has led to the deteriorating park condition in both towns.

- To ensure sustainable urban growth; A well-planned urban area preserves nature and integrates nature into cities, therefore the government should plan appropriate strategies and construct new urban parks in the study area, where the number and quality of parks are less and inapt respectively.

- Encroachment (violation of land utilization by influential residents i.e., public parks transformed into houses, transform parks into car parking) on parks must be removed immediately, as no concerned action has been observed and recorded by the Karachi Development Authority. In addition, well-maintained parks (including indigenous species of trees) with boundary walls and gates are required along with trained gardeners, security and surveillance facilities should have been introduced.

- The only solution is promotion of environmental justice (introduce more parks (green cover) while only a few parks in both towns have recreational amenities. The number of recreational facilities in

both towns should be introduced to promote physical activities, which brings positive impact on the health of the study area.

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