Research Paper

Impacts of event-driven mega-projects on surrounding neighbourhoods

The case of the London Olympic Park

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Abstract

London won the bid to host the 2012 Olympic Games due to its focus on urban regeneration, aiming to drive jobs and investments, and improve skills and quality of life in East London. This paper conducts an empirical research to identify if, and how far these urban development goals have been met in the years after the games.

The spatial changes to the street and transportation network, that have been brought about as a direct result of the construction of the Olympic Park and the regenerative efforts in its immediate vicinity, are studied using space syntax methodology and compared to the changes in socio-economic indicators before and after the Olympics, including - population density, job density, income, house prices, health and well-being, housing and living environment, crime, and education. Direct causes and effects are identified through statistical regression, which are also tested within incremental distances from the London Olympic Park to identify the physical extent of the impact.

Through this study, it is identified that there have been significant changes to population, per capita income, living environment and crime around the park, which correlates directly to changes in the spatial environment. However, it is also identified that the extent of the impact is limited to the London Legacy Development Corporation (LLDC) limits. This indicates that the regenerative efforts stop with the facilities planned and built for the event and/or it takes a very long time for the benefits to trickle down to the surrounding neighbourhoods. Additionally, correlation with changes in population and income indicate that higher income residents have moved into the neighbourhood, in close proximity to the Olympic park who have been able to benefit from the development, with limited benefits to the existing residents of the area.

Keywords

Mega-events, Space Syntax, London Olympics, Impact Assessment, Urban Planning

1. Introduction

In the recent years, Mega-events such as the Olympics, FIFA Football World Cup or the World Expo are seen as harbingers of urban transformation for their hosts. As Müller defines it, mega events are "ambulatory occasions of a fixed duration that - attract a large number of visitors, have large mediated reach, come with large costs and have impacts on the urban environment and the population" (Müller, 2015). International events, therefore, are responsible not only for showcasing a city on a global platform but also play a significant role in bringing forth development at a local scale.

Since sporting events are reasonably short in duration, it can be argued that investments that go into preparing the city for the event are intended for the benefit of the city itself more than the event, with the event acting as an accelerant in bringing about this change is a time-limited, quick and efficient manner. Event governing bodies, such as FIFA or IOC, often require transformative impacts of the events to be outlined in the form of 'legacy' prior to the award of events (Müller, 2015), therefore the events work as triggers for local development and are responsible for bringing tangible benefits to the host city and country. Amongst these, mega-events are "catalysts for economic transformation, help upgrade urban infrastructure, strengthen the international image of the city and accelerate the implementation of desired urban policies" (Modak, et al., 2011).

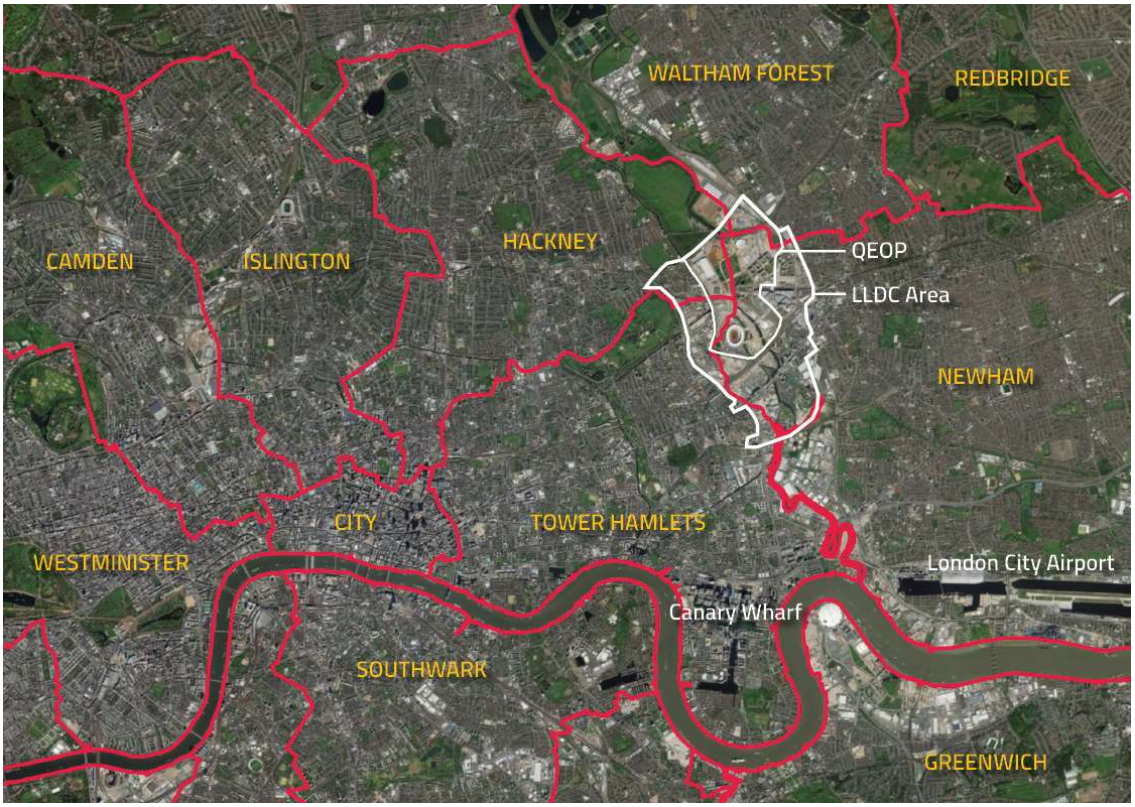

Figure 1 Map showing London Boroughs and the position of the Queen Elizabeth Olympic Park at the boundary of four boroughs

However, the extent to which these objectives are met are often forgotten or overlooked. It is in this context that this paper investigates the Olympic Park development in Stratford, London, which hosted the 2012 Summer Olympics. Despite being the frontrunner in the bid for the 2012 Olympics, Paris lost to London in the last round of voting. The success of London's bid was attributed to its focus on the regeneration of East London (Poynter, 2009). As a highly deprived area, in the heart of the city, Stratford

and its surrounding areas were already slated for regeneration, but hosting the Olympics meant this would be accelerated. Located at the boundary of four London boroughs (Figure 1), this area was chosen to be a catalyst for development in all of them. The Site of the Olympic park itself was a wasteland prior to the Olympics, with the games aiming to transform this area and its surroundings into a new hub for the city.

Mega-event driven developments have impacts on all aspects of society and the city. They are drivers for improvements in infrastructure, mobility as well as harbingers of social and economic change for its surrounding neighbourhoods. By following a comparative analysis approach, comparing conditions before the Olympics to those after the Olympics, which are then studied in relation to spatial changes brought forth by the Olympic park development, this research aims to study the spatial, social and economic changes brought about by the Games and their relationship to one another. While there have been studies on the impacts of the London Olympics previously, their degree and extent have not been quantified and is unclear. This research aims to fill this gap in knowledge.

The Stratford Metropolitan Masterplan (Newham London, 2011) outlines the intention of the creation of a new centre for London in Stratford by improving services and infrastructure. By using the space syntax methodology, one is able to investigate if these intentions have, in fact, materialized by studying the changes in the spatial configuration of Stratford, in the context of the entire city, in addition to the changes to the transportation connectivity, which can be analysed using multi-modal analysis within the space syntax framework.

In addition to spatial & accessibility impacts, there have been significant socio-economic impacts (Thornley, 2012). Therefore, the question arises, if the socio-economic conditions of the area have seen an improvement between 2005 and now, how is it a result of the mega-event development and how far-reaching is its impact?

2. Anticipated and Realized impacts

2.1 Anticipated impacts

The Olympic Games aimed to transform one of the most deprived areas of London by creating a new centre through the improvement of services and community infrastructure as well as by driving new jobs, skills, and investments (Hansard, 2005). With a tight deadline, the games were expected to expedite infrastructural development in the area and improve transport connections to and from the area (Poynter, 2009, p. 311). Additionally, improvements in amenities and public spaces were expected to bring new land uses to the areas and increase economic activity (Bernstock, 2009).

In spite of anticipated positive results in the case of London 2012, precedent cities that hosted mega-events had shown that there are risks associated with this large-scale quick investment, including the host city running up too many debts, the event benefiting only prosperous citizens and creating disadvantages for the poor. In the past, mega-events have often brought only temporary employment to the areas, most of which are part-time and low-paying (Silvestre, 2011). In parallel, such events create a rise in the cost of living that do not decline after the Games are concluded (Burton, 2003).

Mega-events between 1987 and 2007 have also displaced approximately two million people, with the displacement disproportionately affecting minority groups, the poor and the homeless (Centre on Housing Rights and Evictions, 2007) (Poynter, 2009). With such evidence of detrimental effects of mega events such as the Olympics on the poor and vulnerable in the past, there is a high risk associated with the London Olympics as well.

Similarly, while house prices going up is good news for owners, it is bad for renters. East London has traditionally been a source of affordable housing which is threatened by the Olympics. Despite having goals

of 30 % affordable housing in Stratford, there is a high risk that this might not materialise (Bernstock, 2009, p. 210).

2.2 Realized impacts

The London Olympics enabled dramatic changes in the transport facilities and accessibility to the area, which has, in turn, made the area attractive for investment and development (Thornley, 2012, p. 209). This has contributed to the development of massive shopping centres such as the Westfield mall providing employment to nearly 15,000 people (Volterra, 2011). A detailed study of the Impacts of the Olympics, conducted by the University of East London on behalf of the IOC, indicates an improvement in Poverty and social exclusion parameters, decrease in crime levels and an improvement in community facilities - particularly, sport facilities (University of East London, 2015).

However, at the same time, extensive research conducted by Watt (2013), indicates that regeneration schemes have caused large scale displacement, with 30,000 households being added to waiting lists for social housing alone between 2005 and 2011. The improved services and connections, as well as the Olympic legacy, as he suggests, is beneficial to the new people moving into the area and not for the benefit of the long-term residents of Newham and Stratford. Gentrification is a key issue discussed in literature around such mega developments, with similar occurrences in Beijing, Sydney & Athens (Centre on Housing Rights and Evictions, 2007).

With the Literature review indicating that there have been both positive and negative impacts of the development, an empirical study is conducted to evaluate the actual changes brought about.

3. Methodology

This research follows the outline in Figure 3. It uses a comparative approach by investigating the conditions before and after the Olympics. With the Olympics taking place in 2012, the 'before' case is taken to be in 2007, 5 years before the Olympics and just prior to when works for the Olympics began on site in Stratford and 2017 is considered to be the 'after' case, 5 years after the Olympics took place. In cases where data is not available for 2017, the most recent data is used and in these cases, the 'before' data is taken 10 years back from this date, however, no 'before' information pre-dates 2005, which was when the Olympics was awarded to London, and no 'after' information is later than 2018.

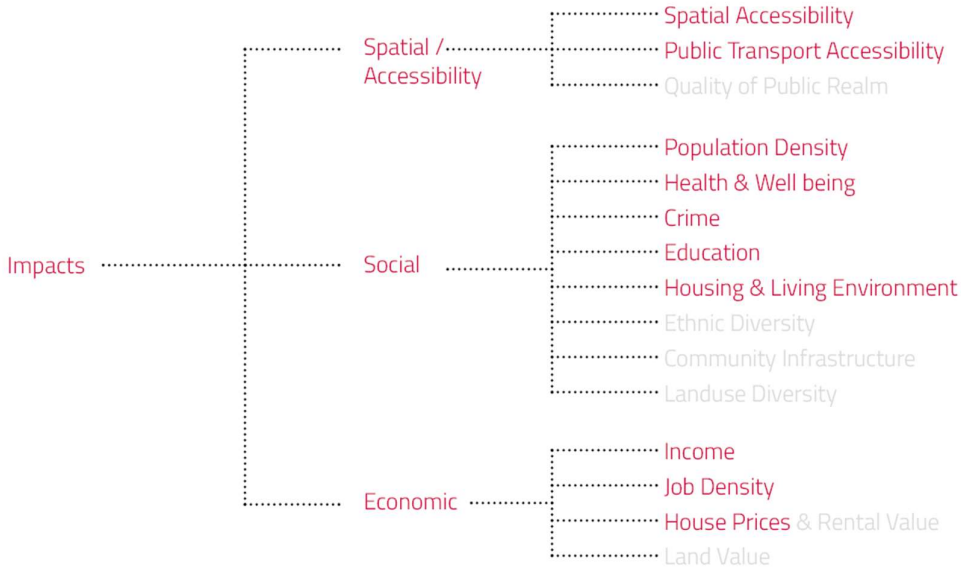

Figure 2 Spatial, Social and Economic parameters investigated in this paper, highlighted in red.

The spatial, accessibility and socio-economic parameters that are relevant to the impact study are indicated in Figure 1Figure 2 and include both quantitative and qualitative measures. However, due to the unavailability of micro-level data, only those highlighted are investigated in this paper.

The spatial analysis is based on space syntax methodology (Hillier & Hanson, 1984). The spatial network of the city is analysed for closeness centrality and betweenness centrality, namely, integration and choice. Through the theory of natural movement (Hillier, et al., 1993), we understand that integration is used to identify the centres within the network and can be used as a proxy to understand 'to movement' within the city, whereas, choice is used to identify the most travelled routes and is a proxy for 'through movement'. Space syntax analysis can be applied to understand the centralities of the complete network, i.e., the city. At the same time, it may be limited to smaller radii to understand more local phenomena.

To study the spatial impact of the development on London, as a city, the space syntax models for London (Space Syntax Laboratory, 2018), for both before & after the Olympics, are updated based on Google Earth underlays from March 2007 and July 2017, and analysed at the scale of the city, radius n (Rn).

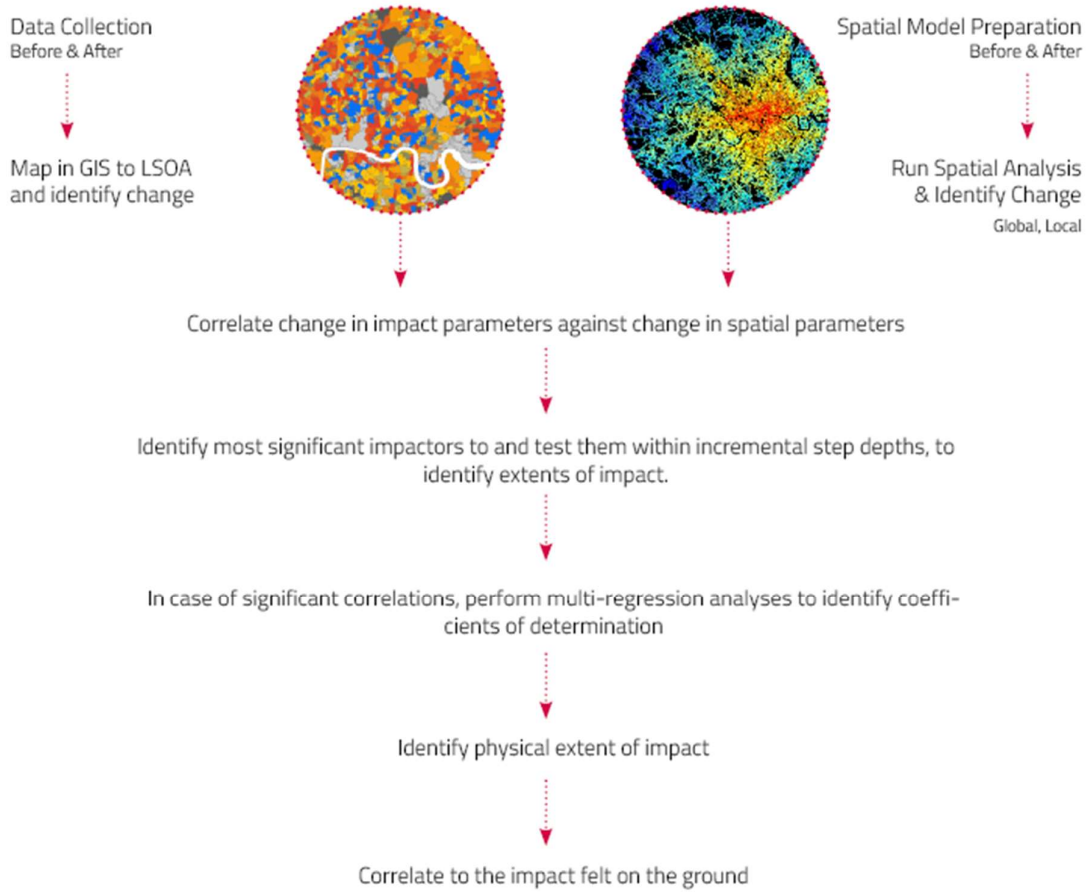

Figure 3 Outline of Research Methodology

Whereas, to understand the socio-economic impact of the Olympic park development on the surrounding neighbourhoods, a smaller scale of analysis is needed which accounts for people on foot and those on cycles. This is to understand the impact of the spatial and accessibility changes on the Socio-economic parameters. Space Syntax analysis is conducted at local radii (800m, 1600m, 2400m) to study the local impact of the development.

The results of this spatial analysis are then joined to the LSOA (Lower Layer Super Output Areas) Census boundaries. Socio-economic parameters are obtained for LSOAs (only socio-economic parameters where a minimum of LSOA level of detail is available is included in this study). These socio-economic parameters are then statistically tested for correlations against the changes in Normalised Angular Integration and Normalised Angular Choice at different local radii are tested to identify if these changes in socio-economic parameters follow a spatial logic.

They are also tested in relation to their metric and angular step depths from the park to identify the impact of the park on the socio-economic conditions of the neighbouring areas. Metric step depth is the shortest distance between any two points through the network, whereas angular step depth is calculated as the shortest number of turns between any two points in the network, with a 0^o turn being assigned as 0 turns, 90^o turn being assigned as 1 turn and intermediate angles being assigned valued between 0 and 1.

By testing linear correlations between changes in socio-economic conditions and changes in spatial conditions within incremental radii from the Olympic Park Development, the extent of impact of the Olympic Park is determined. Once the significant correlations are identified which are then tested for linear regression to identify the coefficients of determination. Additionally, the impact of all spatial parameters is tested in a Multi-regression analysis in order to understand their combined effect.

4. Spatial & Accessibility Impacts

Angular Segment Analysis at a global radius 'n' identifies the spatial impact of the Olympic park development on the Greater London Area as well as the change in global prominence of local areas. Normalised Integration (Figure 4, Figure 5) & Choice (Figure 6, Figure 7) at Radius 'n', are compared between 2007 and 2017. The Integration and Choice maps do not show significant changes to the spatial network of the city as a whole as a result of the Olympic Park development. This is consistent with the fact that there has been minimal change in the street configuration of the surrounding neighbourhoods, with network changes mostly limited to the park itself, which would have more local impacts than global ones.

While the change of the street network has been minimal, at the scale of the city, there has been a significant change in the public transport network of London between 2007 and 2017, with the addition of the Overground, new routes on the DLR and the Tfl Rail, all of which are connecting at Stratford. In order to assess Public Transport accessibility, a multi-modal spatial model (Law, et al., 2012) is prepared for the Greater London Area, which accounts for Tube, Tram & Rail lines based on Transport maps (Transport for London, 2018). Space Syntax analysis of the multi-modal spatial model is performed to identify changes in public transport accessibility as seen in Figure 8 and Figure 9. A visual comparison of the figures shows a clear improvement in the public transport accessibility in the East & South-east of London, with Stratford clearly identifiable as a public transport node. Detailed findings are discussed holistically further in the paper.

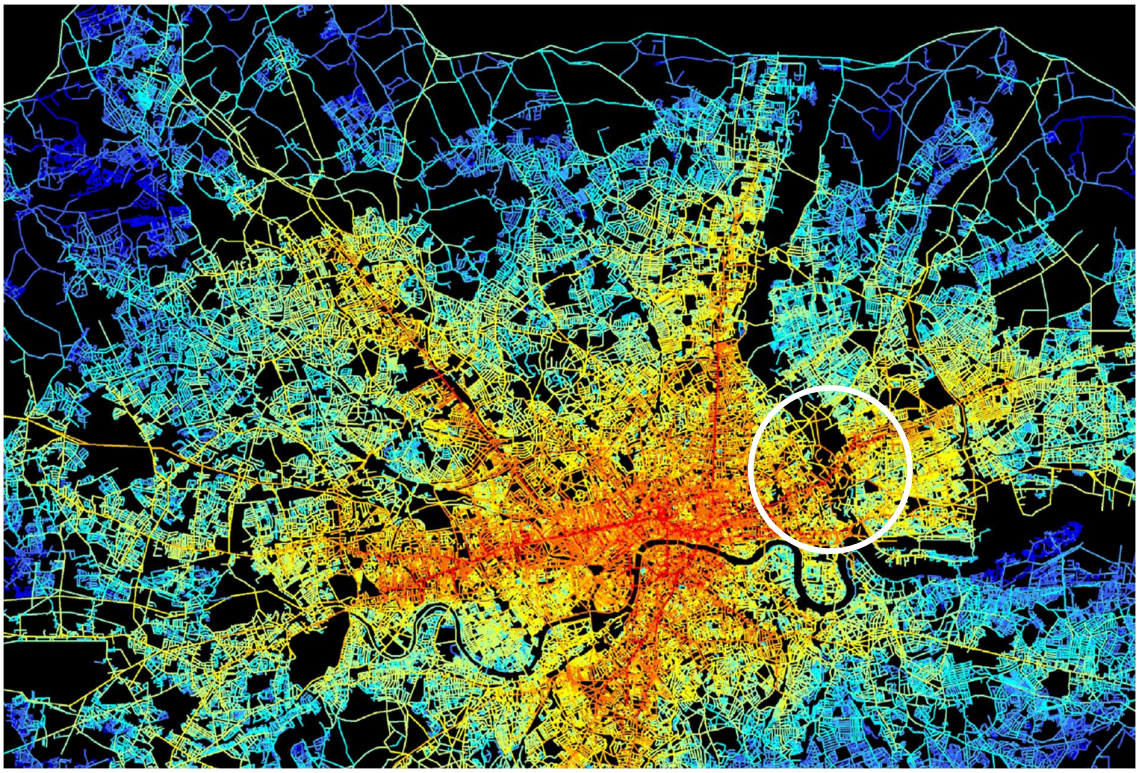

Figure 4 Normalized angular integration at radius n for London before the Olympics (2007)

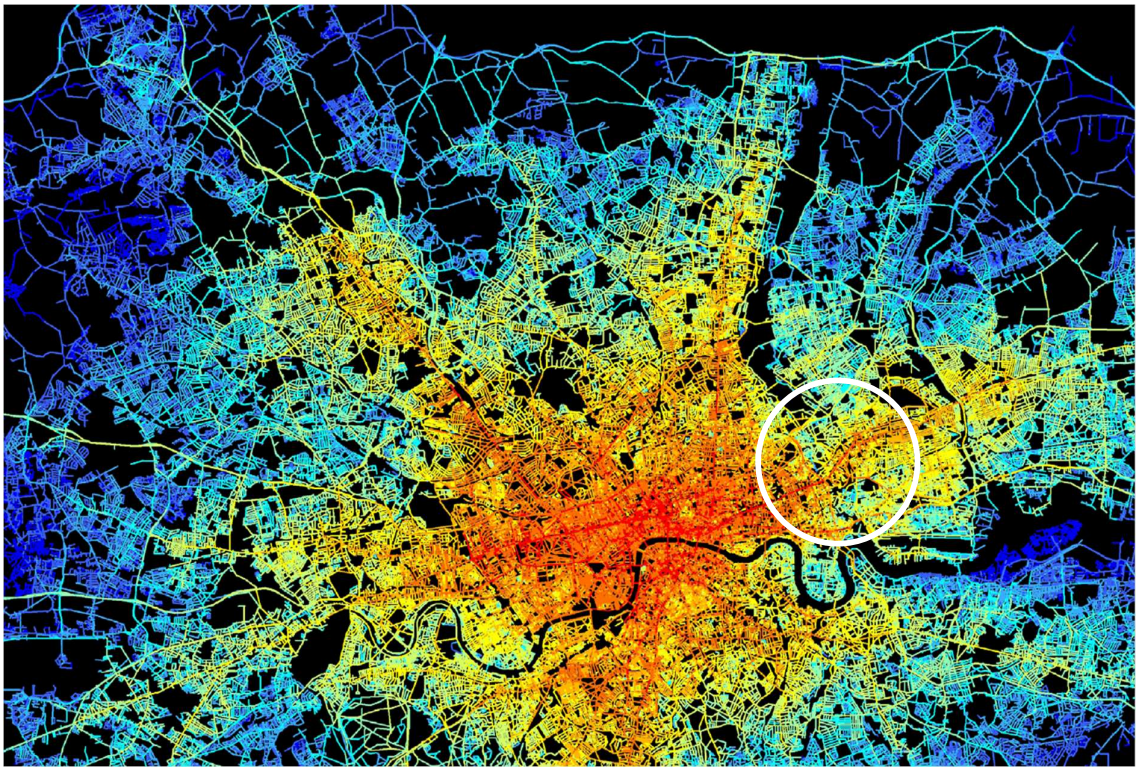

Figure 5 Normalized angular integration at radius n for London after the Olympics (2017)

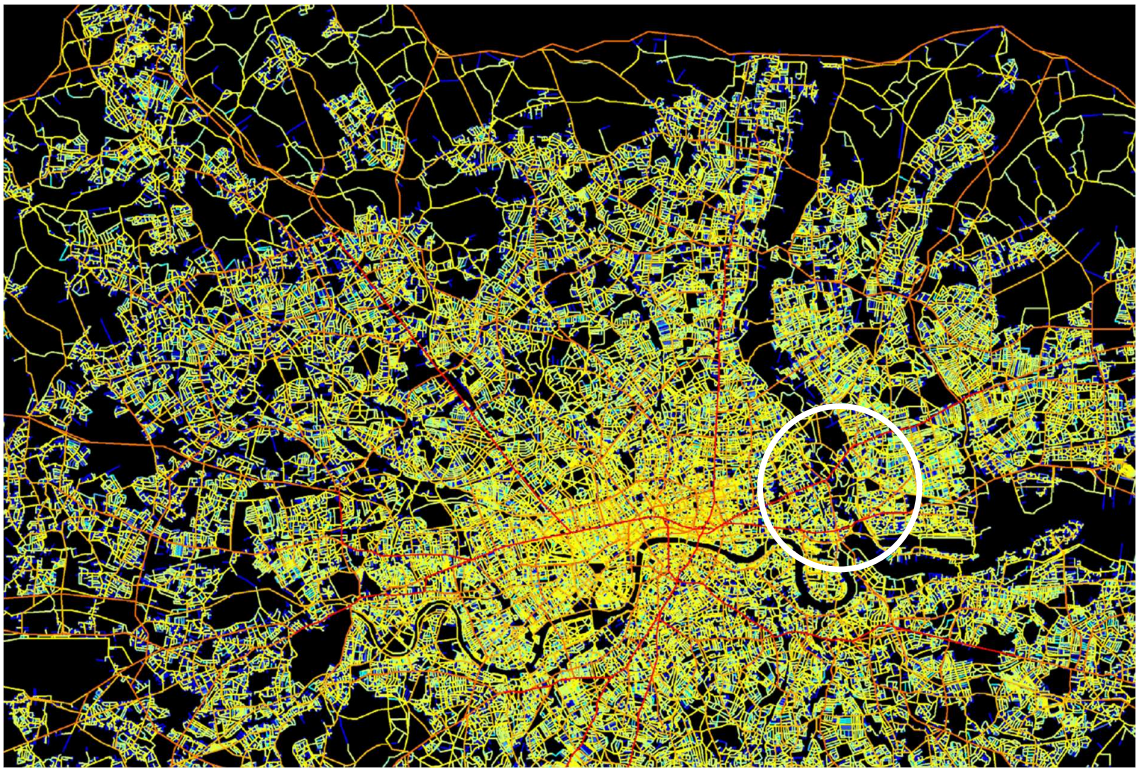

Figure 6 Normalized angular choice at radius n for London before the Olympics (2007)

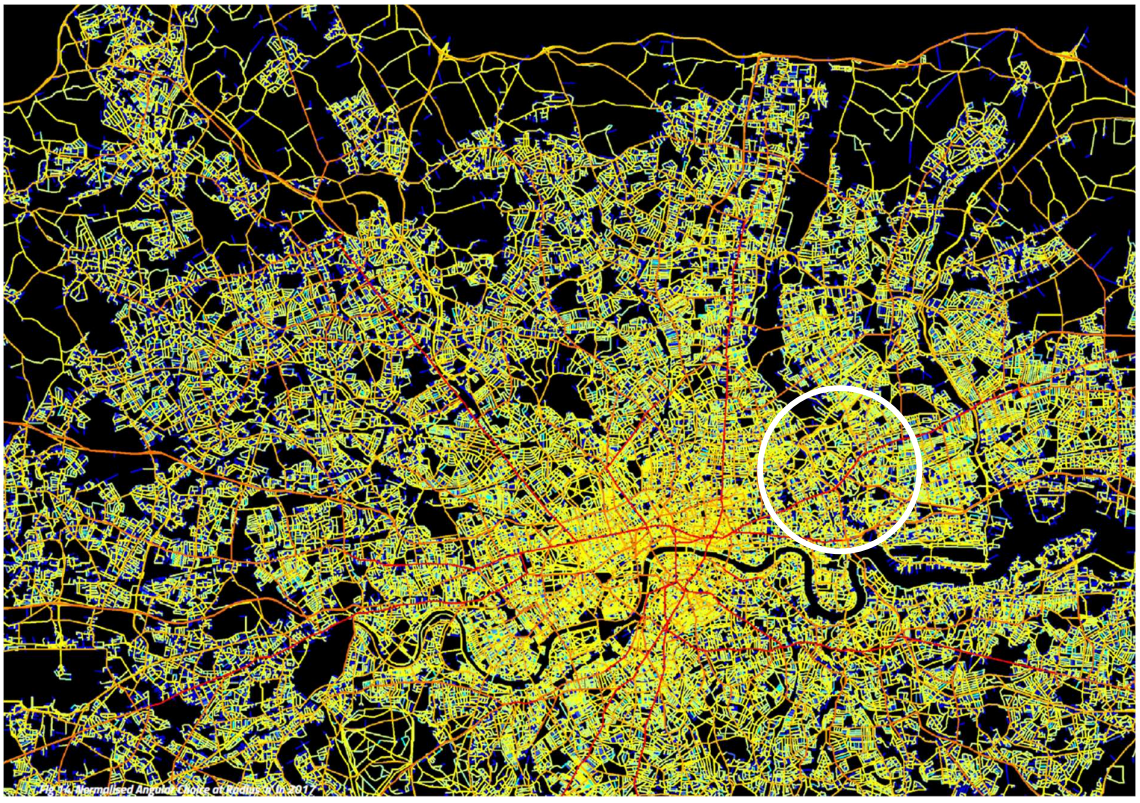

Figure 7 Normalized angular choice at radius n for London after the Olympics (2017)

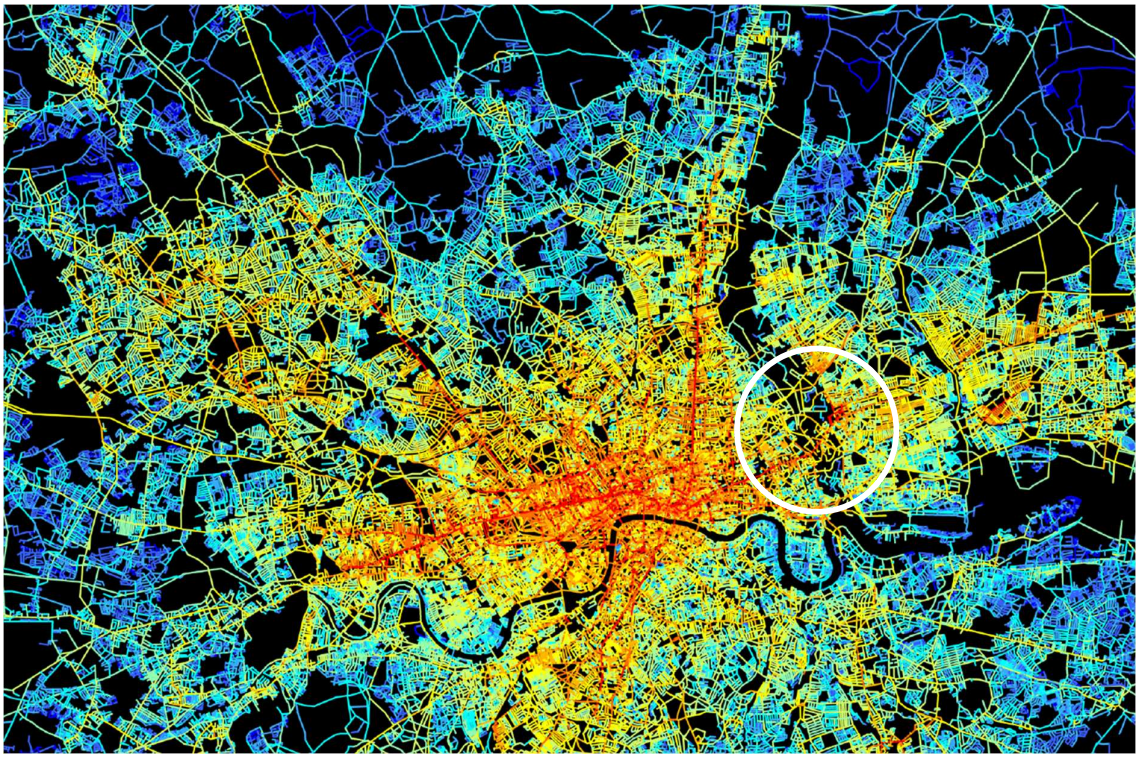

Figure 8 Multi-modal Integration Analysis at Rn of London in 2007

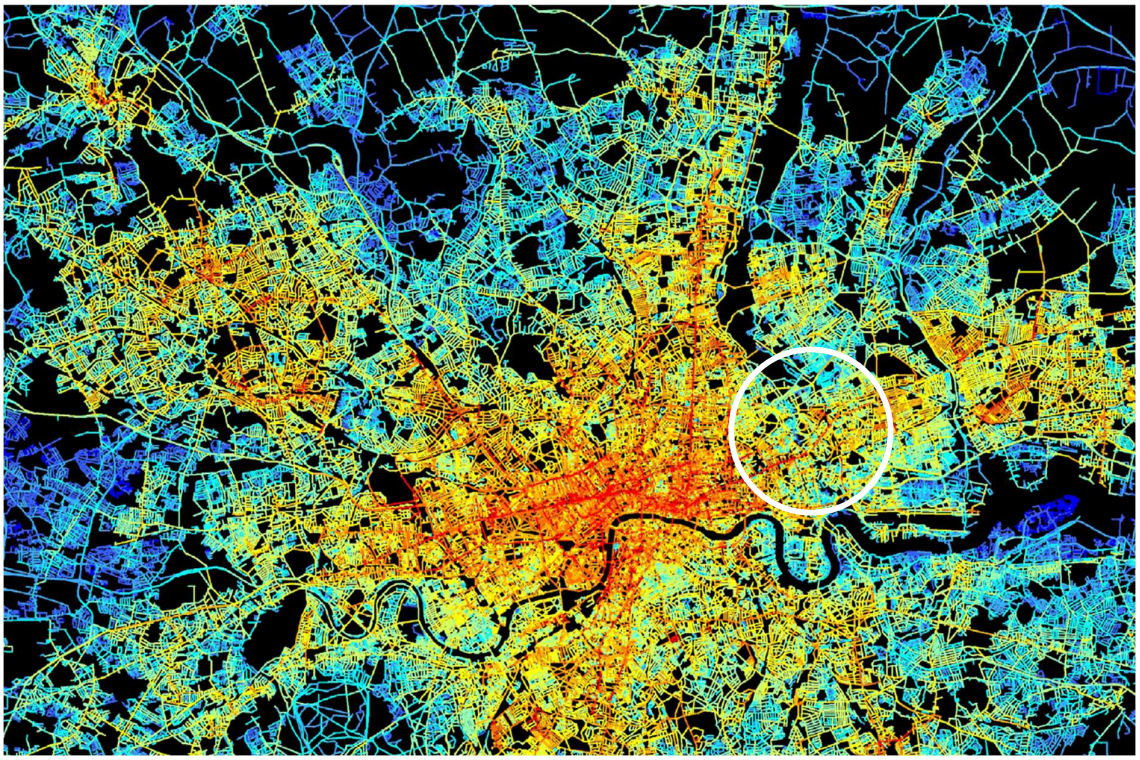

Figure 9 Multi-modal Integration Analysis at Rn of London in 2017

5. Socio-Economic Impact Assessment

Socio-economic parameters indicated in Figure 2 are studied for 'before' and 'after' the Olympics at the LSOA statistical level. The difference between the values is also calculated and can be seen in Figure 10 to Figure 20.

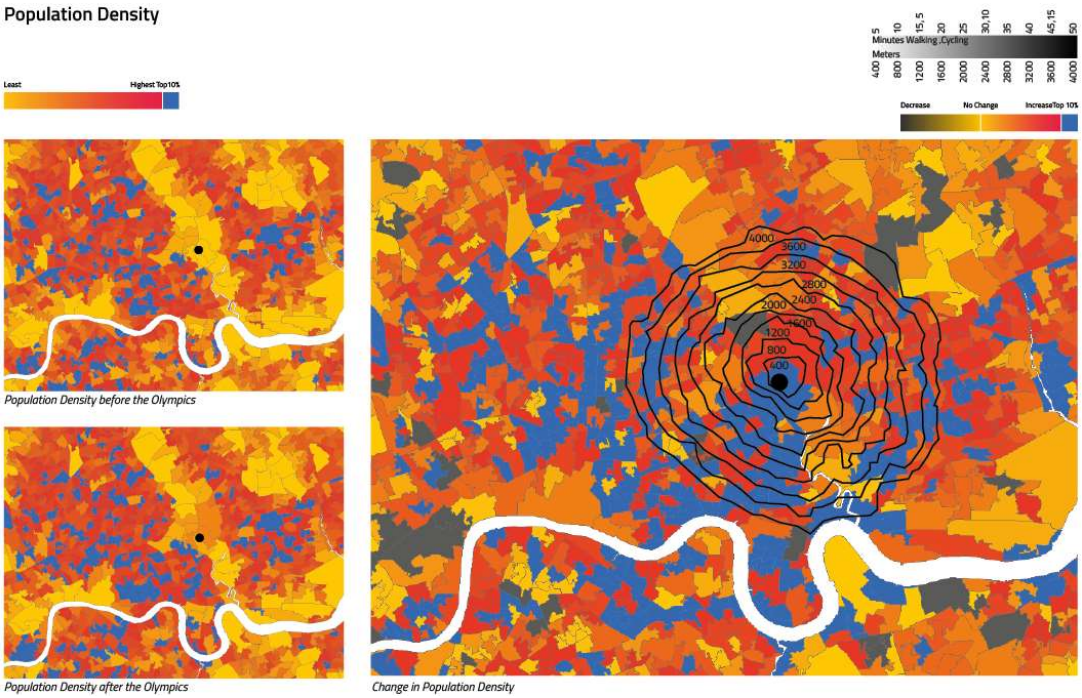

Figure 10 Comparison of population density before and after the games (Office of National Statistics, 2018)

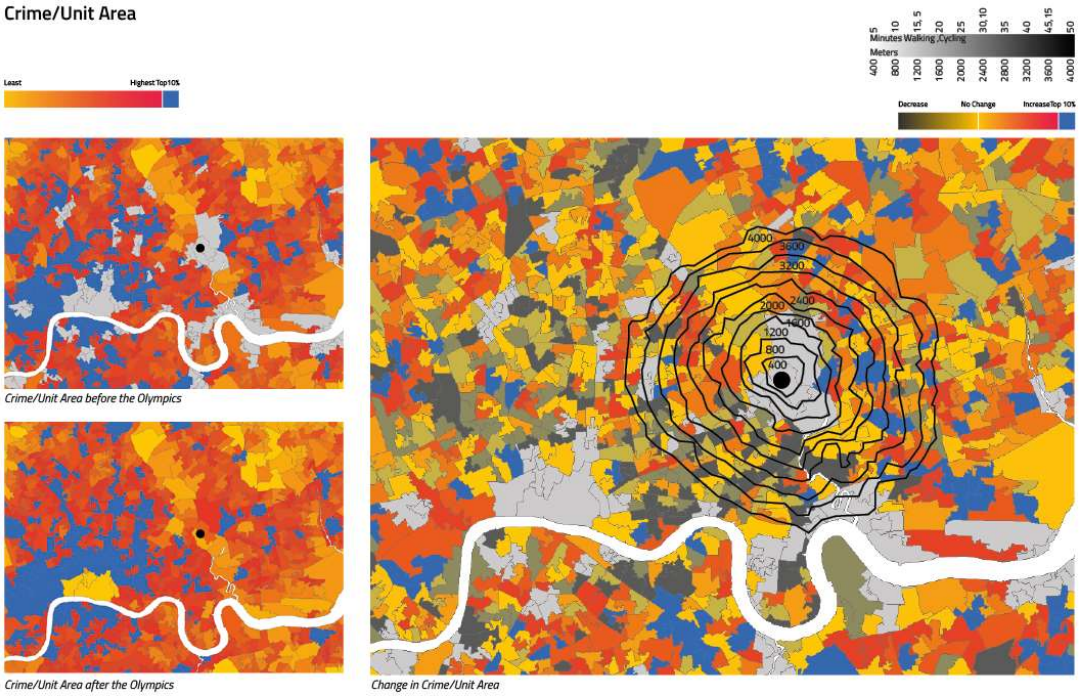

Figure 11 Comparison of crime per unit area, before and after the games (Metropolitan Police, 2018)

Figure 12 Comparison of Indices of Multiple Deprivation (IMD) before and after the games (Ministry of Housing, Communities & Local Government, 2018)

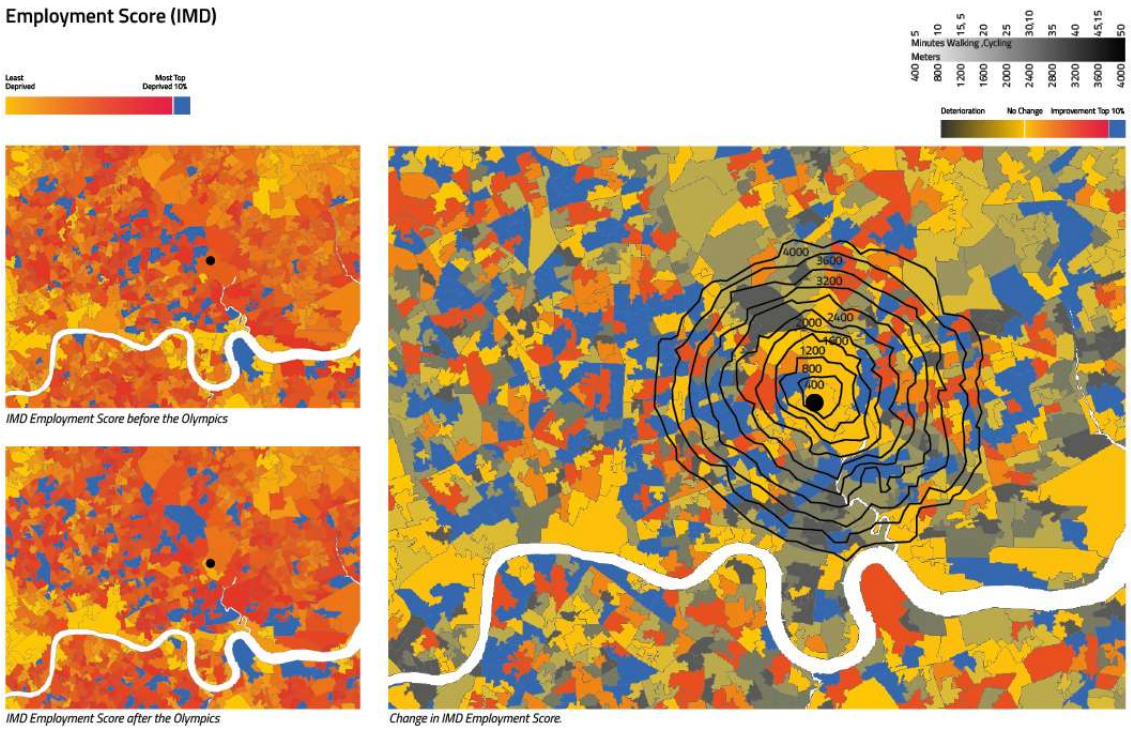

Figure 13 Comparison of Employment score (IMD) before and after the games (Ministry of Housing, Communities & Local Government, 2018)

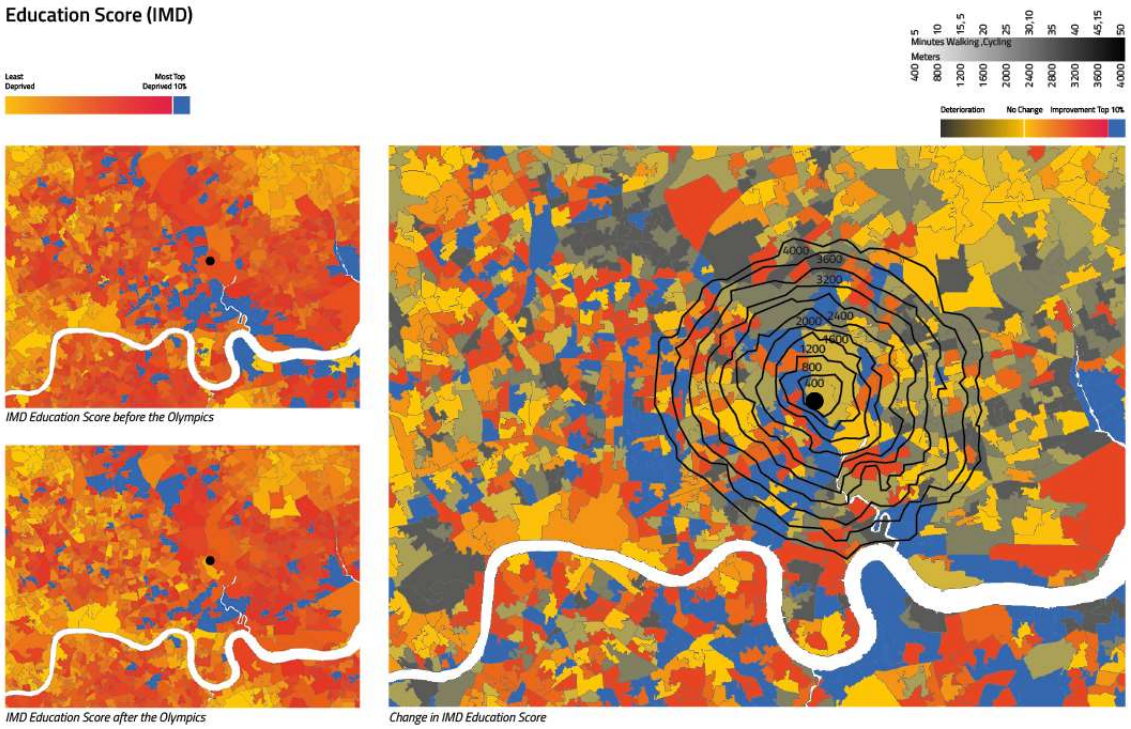

Figure 14 Comparison of Education score (IMD) before and after the games (Ministry of Housing, Communities & Local Government, 2018)

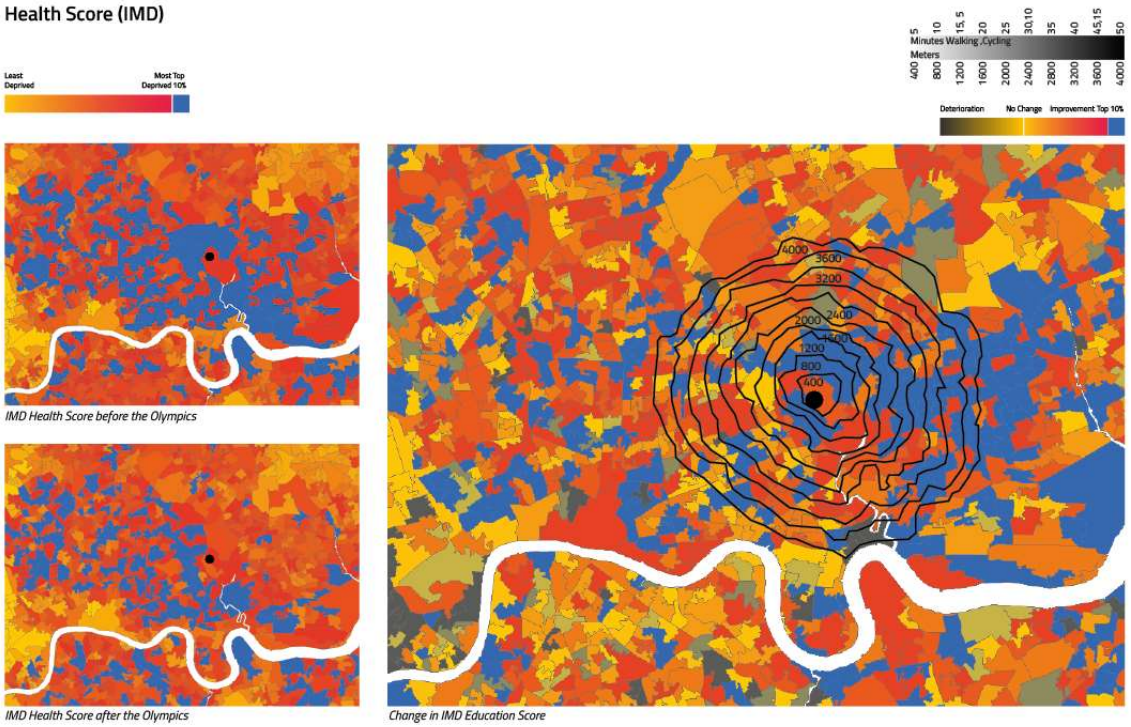

Figure 15Comparison of Health score (IMD) before and after the games (Ministry of Housing, Communities & Local Government, 2018)

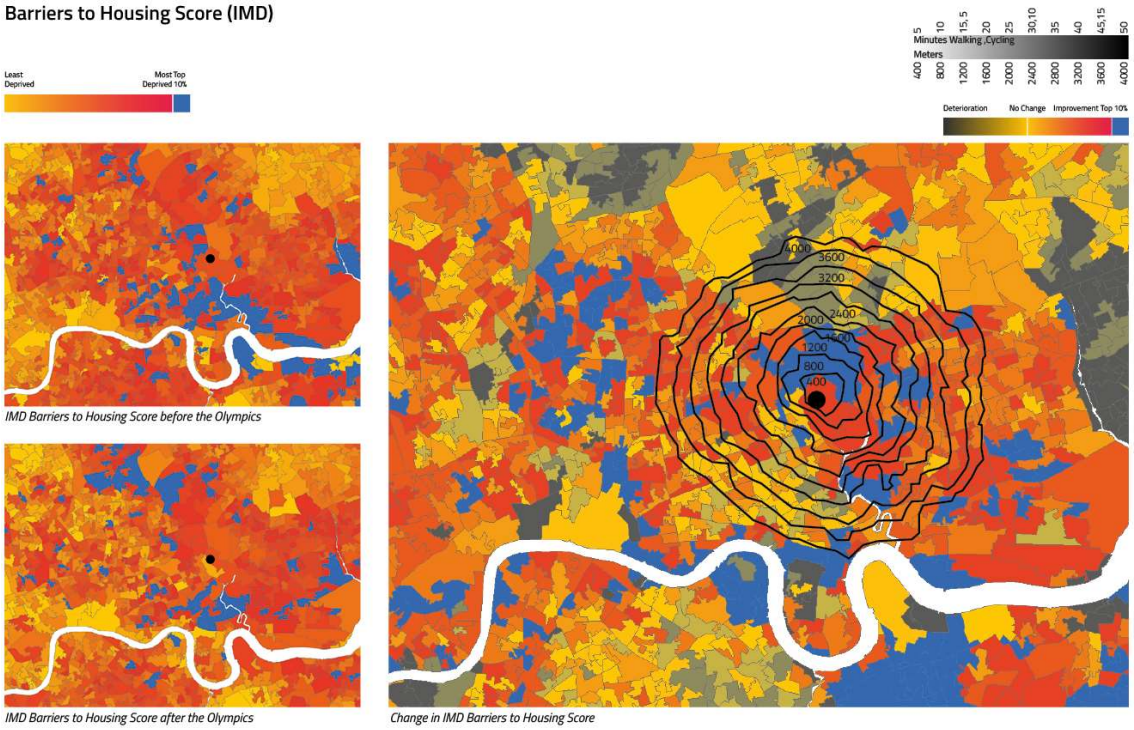

Figure 16 Comparison of Barriers to housing score (IMD) before and after the games (Ministry of Housing, Communities & Local Government, 2018)

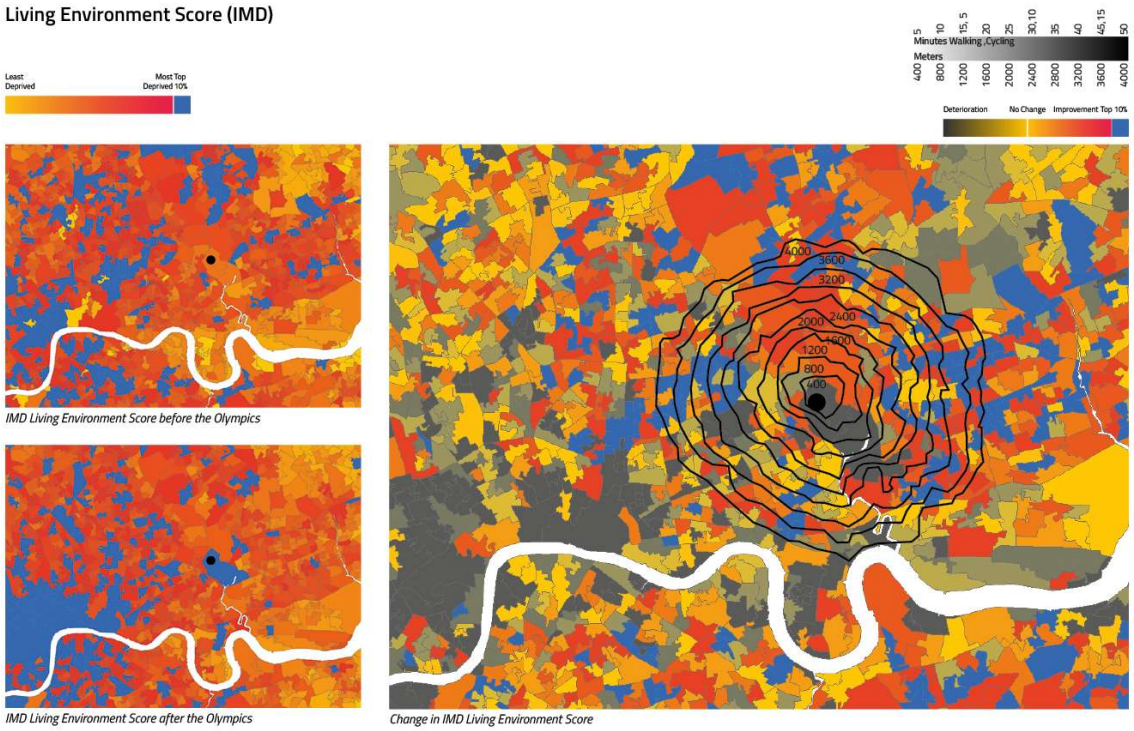

Figure 17 Comparison of Living environment score (IMD) before and after the games (Ministry of Housing, Communities & Local Government, 2018)

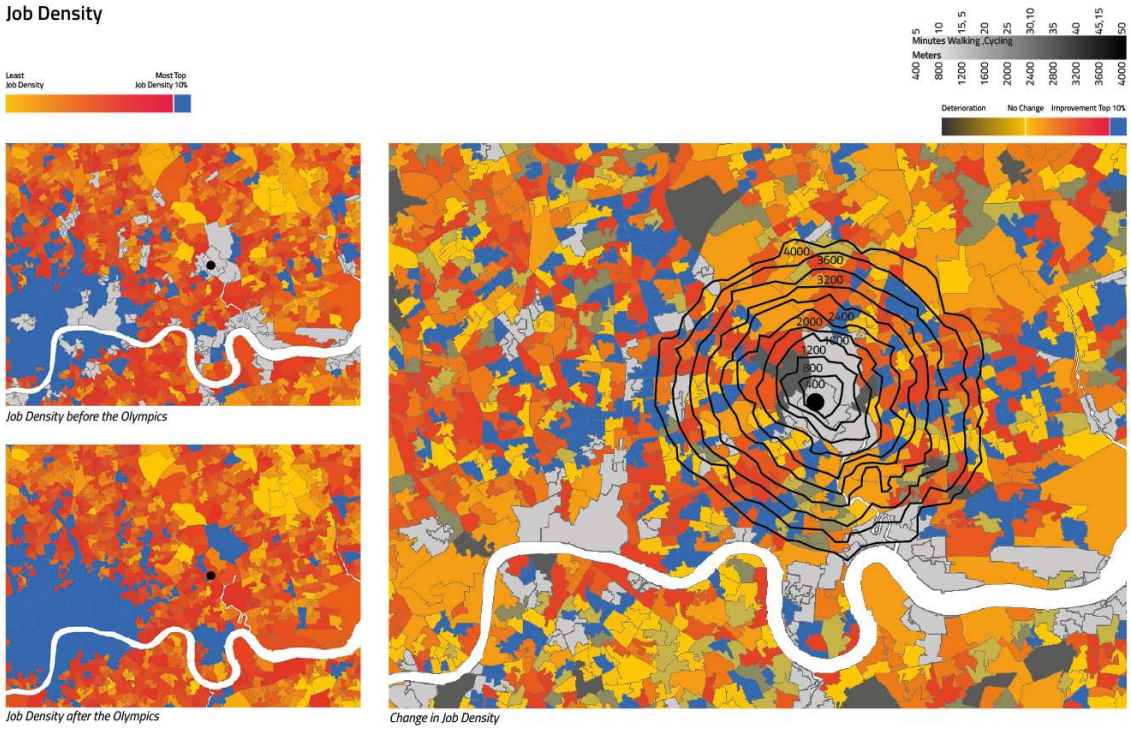

Figure 18 Comparison of Job density before and after the games (Nomis - Official Labour Market Statistics, 2018)

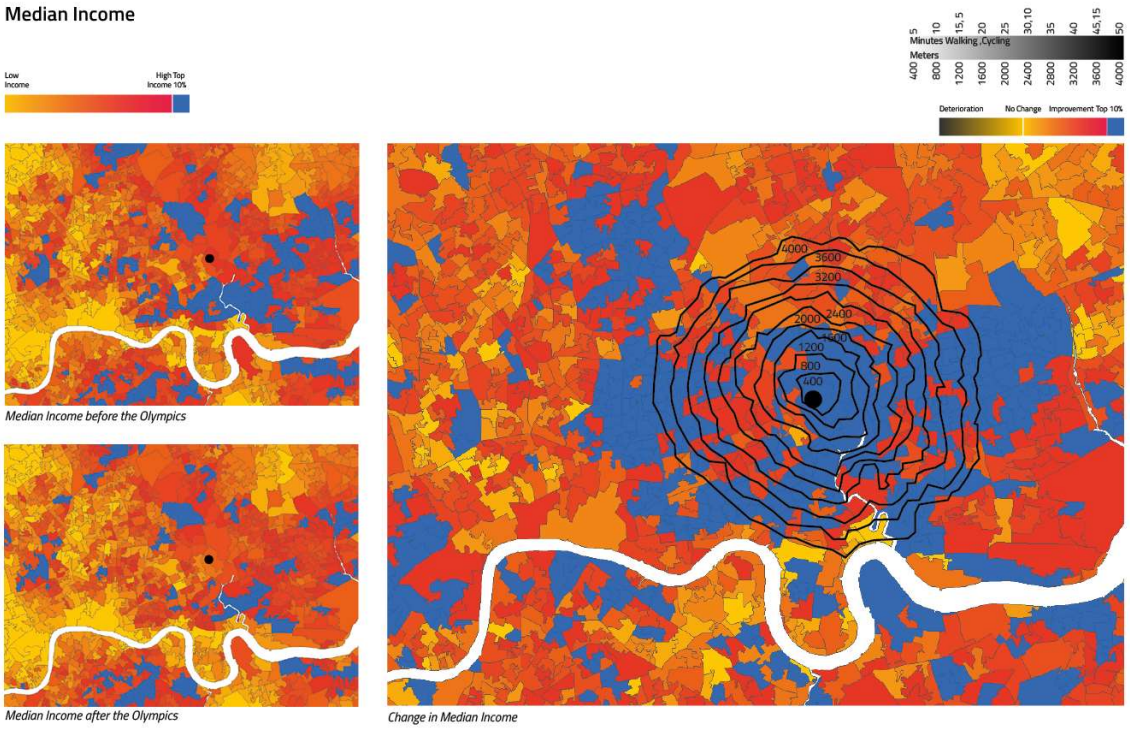

Figure 19 Comparison of Median Income before and after the games (Greater London Authority, 2018)

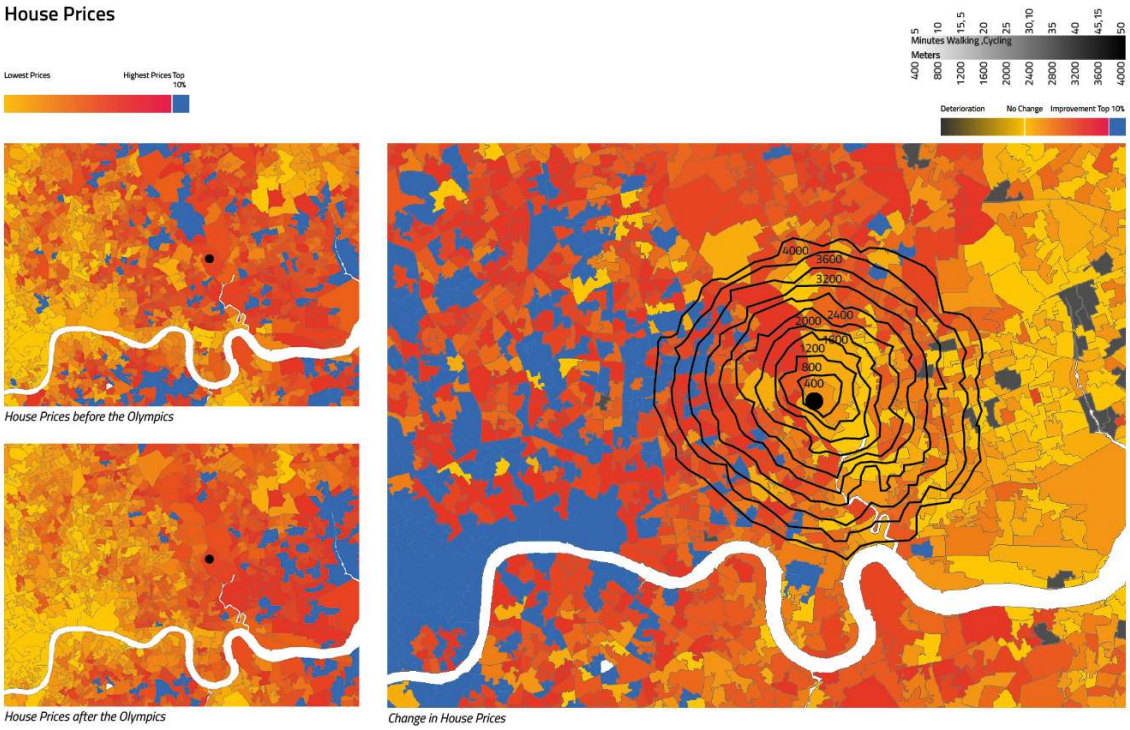

Figure 20 Comparison of House prices before and after the games (Land Registry, 2018)

It is clearly identifiable that Stratford and the Olympic park is among some of the most deprived parts of London before and after the Olympics (Figure 12), however, it has also seen some of the most drastic changes over the 10 year period in question. The average change between the 'before' and 'after' conditions can be seen for incremental distances from the venue on the left in Figure 25 and Figure 26.

In order to identify if these changes in socio-economic parameters follow a spatial logic, they are statistically tested for correlations against the changes in Normalised Angular Integration and Normalised Angular Choice (Only the radii with the highest correlations are included in this paper, which is 2400m for Integration and 1600m for Choice). They are also tested in relation to their metric and angular step depths from the park to identify the impact of the distance from the park on the socio-economic conditions of the neighbouring areas. Significant correlations with changes in integration and choice would imply that the changes correspond to changes in the accessibility of the network. Significant correlations with angular step depth would imply that changes in socio-economic conditions correspond to topo-geometric distance (Hillier, et al., 2007) from the venue whereas significant correlation with the metric step depth implies that the changes socio-economic conditions are dependent on the distance to the Park. Additionally, testing within incremental distances from the park is used to determine the extent of impact. This is seen in the tables in Figure 21 to Figure 24 and on the graphs on the right in Figure 25 and Figure 26.

Mean Metric Step Depth	IMD	IMD Employment	IMD Health	IMD Education	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 400	0	0	0	0	0	0	0	0	0	0	0
< 800	0	0	0	0	0	0	0	0	0	0	0
< 1200	-0.312	-0.200	0.025	-0.376	0.179	0.449	-0.100	-0.301	-0.110	-0.495	0.174
< 1600	0.053	-0.435	0.049	-0.144	-0.345	0.292	-0.442	-0.340	0.101	-0.354	0.162
< 2000	-0.166	-0.297	-0.221	0.026	-0.158	0.306	0.034	0.038	0.065	0.080	0.066
< 2400	-0.174	-0.236	-0.062	-0.114	-0.184	0.250	-0.154	0.162	-0.054	-0.047	0.023
< 2800	-.209*	-0.179	-0.134	-0.080	-.266*	0.142	-0.025	.267*	-0.014	-0.018	0.004
< 3200	-.227**	-0.098	-0.154	-0.037	-.174*	0.087	-0.012	.269**	-0.026	0.013	0.090
< 3600	-.215**	-0.078	-.167*	-0.035	-.177*	0.077	-0.013	.228**	-0.039	-0.016	0.090
< 4000	-0.092	0.008	-0.006	0.017	-.165*	0.080	-0.027	.259**	0.079	-0.045	0.079
< 4400	-0.103	-0.041	0.056	-0.070	-.192**	.178**	-.189**	.169**	0.045	-.156**	0.098
< 4800	-.137*	-0.072	0.026	-.118*	-.189**	.165**	-.165**	.143**	0.004	-.149**	0.092
< 5200	-0.097	-0.051	0.057	-.105*	-.152**	.164**	-.114*	0.082	0.024	-.150**	0.092
< 5600	-0.084	-0.046	0.039	-0.071	-.122*	.112*	-.100*	0.049	0.040	-0.062	.095*
< 6000	-0.070	-0.048	0.041	-0.075	-0.083	.091*	-.104*	0.063	0.041	-0.068	0.083
n	-.095**	-.060**	-.068**	-0.005	-.078**	-0.014	-0.022	0.023	-0.020	0.019	0.014

Figure 21 Linear Correlation between Socio-economic parameters and normalized angular integration at 2400m, within incremental distances from the Olympic Park. Yellow indicates statistically significant correlation, with '*' implying p<0.05 and '' implying p<0.01.**

Mean Metric Step Depth	IMD	IMD Employment	IMD Health	IMD Education	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 400	0	0	0	0	0	0	0	0	0	0	0
< 800	0	0	0	0	0	0	0	0	0	0	0
< 1200	-0.327	0.077	0.188	-0.086	-0.063	-0.564	.815*	-0.298	0.521	0.025	0.753
< 1600	-0.103	0.537	0.061	-0.336	0.299	-0.452	.664*	0.002	-0.098	0.419	-.584*
< 2000	-0.061	0.279	0.013	-0.164	0.294	-.375*	0.256	-0.105	-0.002	0.284	-.516**
< 2400	0.135	0.171	0.199	0.005	0.167	-0.221	0.168	-0.098	0.157	0.229	-.382**
< 2800	0.061	-0.003	0.130	-0.003	-0.016	-0.094	0.197	-0.201	0.151	.217*	-.311**
< 3200	0.031	-0.031	0.058	0.026	0.020	-0.098	0.152	-0.102	0.083	0.057	-.312**
< 3600	-0.062	-0.101	-0.026	0.047	-0.041	-0.078	0.092	-0.052	0.098	0.057	-.234**
< 4000	-0.092	-.152*	-0.048	0.035	-0.089	-0.051	.146*	-0.019	0.058	0.052	-.214**
< 4400	-0.109	-.150*	-.128*	0.052	-0.099	-0.071	.181**	-0.055	0.020	0.078	-.181**
< 4800	-0.100	-.140*	-.119*	0.024	-0.092	-0.105	.143**	-0.091	-0.007	0.083	-.147**
< 5200	-0.092	-.141**	-.135**	0.019	-0.045	-0.056	.149**	-0.099	-0.060	0.059	-.151**
< 5600	-0.086	-.151**	-.132**	0.012	-0.069	-0.030	.124**	-.115*	-0.081	0.015	-.148**
< 6000	-0.079	-.141**	-.111*	0.023	-0.051	-0.028	.106*	-0.087	-0.086	0.004	-.168**
n	-.123**	-.128**	-.123**	-.032*	-.094**	0.010	.043**	-.135**	-.122**	0.024	-.045**

Figure 22 Linear Correlation between Socio-economic parameters and normalized angular choice at1600m, within incremental distances from the Olympic Park. Yellow indicates statistically significant correlation, with '*' implying p<0.05 and '' implying p<0.01. Red indicates significant correlations>0.7**

Mean Angular Step Depth	IMD	IMD Employment	IMD Health	IMD Education	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 3	-0.205	-0.847	-0.243	1.000*	-0.872	0.680	-0.532	0.887	-0.968	-0.684	-0.972
< 3.5	-0.044	-0.263	-0.272	0.030	-0.518	0.222	-0.590	0.128	-0.494	-0.487	0.429
< 4	0.074	-0.223	0.140	-0.052	-0.238	0.305	-0.354	0.050	-0.321	-0.332	0.299
< 4.5	-0.252	-.354*	-0.315	-0.050	-.349*	0.246	-0.149	0.080	-.393*	-.335*	0.055
< 5	-0.174	-.257*	-0.134	-0.156	-0.120	0.237*	0.002	-0.066	-.261*	-0.073	-0.089
< 5.5	0.037	-0.113	-0.002	0.003	-0.017	0.084	0.153	0.015	0.069	0.007	-0.088
< 6	-0.055	-0.115	-0.025	-0.023	-0.055	-0.008	.150*	0.088	0.077	0.028	-0.020
< 6.5	-.123*	-0.059	-0.079	-0.028	-0.005	-0.071	.144**	.118*	-0.063	0.044	-0.018
< 7	-.222**	-.108*	-.183**	-0.064	0.015	-.104*	.162**	.154**	-.149**	0.039	-0.044
< 7.5	-.203**	-.115**	-.183**	-0.038	0.010	-.093*	.120**	.190**	-.186**	-0.006	0.004
< 8	-.162**	-.097**	-.184**	-0.045	0.030	-0.060	0.033	.193**	-.176**	-0.024	-0.019
< 8.5	-.167**	-.082**	-.199**	-0.028	0.038	-0.056	0.004	.208**	-.212**	-0.046	-0.016
< 9	-.162**	-.084**	-.197**	0.010	0.006	-0.011	0.000	.133**	-.266**	-0.031	-0.032
< 9.5	-.164**	-.068**	-.181**	.059*	-0.048	-0.009	-0.020	.102**	-.265**	-0.012	-0.049
< 10	-.155**	-.070**	-.152**	0.046	-.059*	0.015	-0.029	.075**	-.281**	-0.036	-.064**
n	-.253**	-.135**	-.287**	-0.013	-.126**	.040**	-.050**	-.282**	-.306**	-.096**	-.108**

Figure 23 Linear Correlation between Socio-economic parameters and angular step depth, within incremental distances from the Olympic Park. Yellow indicates statistically significant correlation, with '*' implying p<0.05 and '' implying p<0.01.**

Mean Metric Step Depth	IMD	IMD Employment	IMD Health	IMD Education	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 400	0	0	0	0	0	0	0	0	0	0	0
< 800	0	0	0	0	0	0	0	0	0	0	0
< 1200	0.252	-0.506	0.028	0.062	0.274	.803*	-0.635	0.078	-.919**	-.910**	-0.585
< 1600	0.209	-.618*	0.011	0.356	-0.407	.716**	-.590*	0.025	-0.222	-.718**	0.234
< 2000	-0.189	-.508**	-0.166	-0.191	-0.259	.591**	0.137	0.190	-0.326	0.039	0.042
< 2400	-.362**	-.452**	-0.260	-.323*	-.407**	.537**	-0.195	0.248	-.392**	-0.174	-0.019
< 2800	-.307**	-.258*	-.315**	-.273**	-.378**	.238*	-.226*	.218*	-.270*	-.234*	-0.111
< 3200	-.196*	-0.162	-.187*	-.222*	-.319**	.241**	-.199*	.206*	-0.169	-0.037	0.019
< 3600	-0.109	-0.073	-0.145	-.246**	-.241**	.212**	-0.100	0.142	-.162*	-0.075	-0.024
< 4000	-0.026	-0.031	-0.083	-.157*	-.187**	.180**	-0.014	0.107	-0.089	-0.068	0.004
< 4400	-0.004	0.015	-0.083	-0.092	-0.112	0.064	0.077	0.107	-0.096	0.044	0.010
< 4800	0.032	0.078	-0.002	-0.051	-0.104	0.061	0.085	0.083	-0.063	0.041	0.012
< 5200	-0.001	0.074	0.024	-0.036	-0.051	0.036	.117*	0.090	-0.067	0.044	0.011
< 5600	-0.042	0.055	0.006	-0.043	-0.057	-0.034	.125**	0.061	-0.027	0.077	-0.025
< 6000	-0.068	0.019	-0.031	-0.076	-0.065	-0.035	.094*	0.067	-0.065	0.055	0.019
n	-.285**	-.081**	-.319**	-.134**	-.129**	-0.019	-.045**	-.194**	-.430**	-.124**	-.105**

Figure 24 Linear Correlation between Socio-economic parameters and metric step depth, within incremental distances from the Olympic Park. Yellow indicates statistically significant correlation, with '*' implying p<0.05 and '' implying p<0.01. Red indicates significant correlations >0.7**

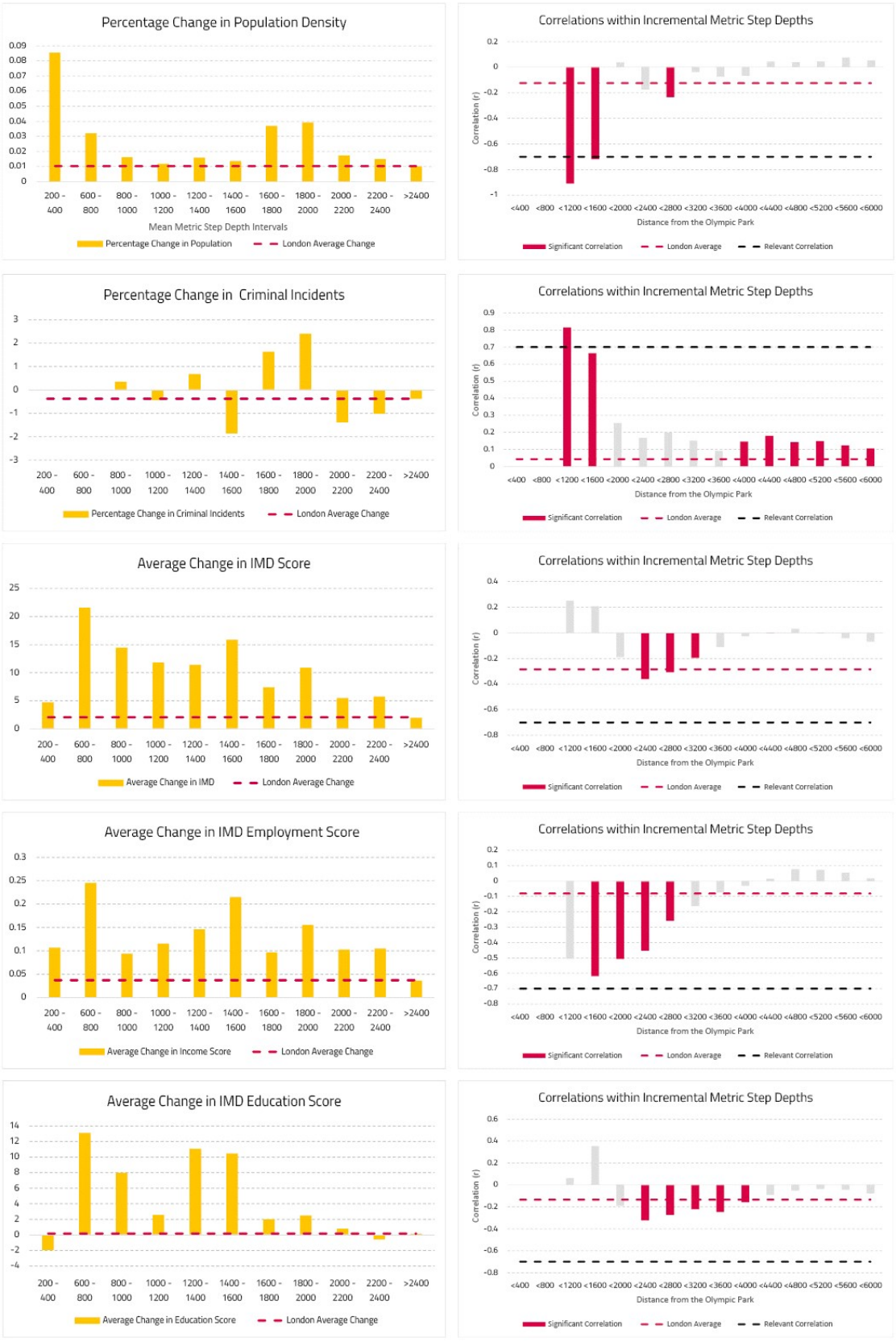

Figure 25 Changes in socio-economic parameters and their correlations with spatial parameters

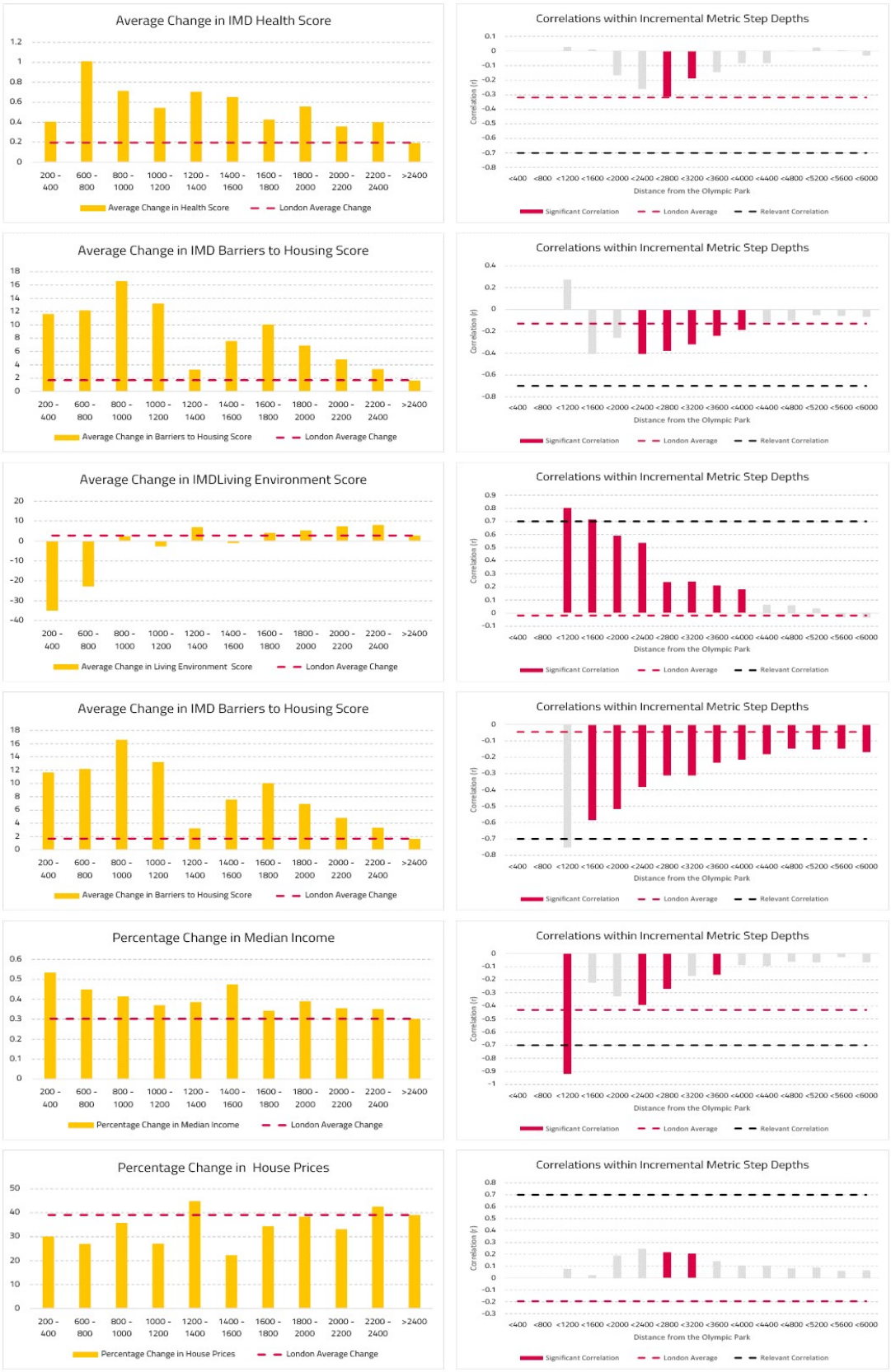

Figure 26 Changes in socio-economic parameters and their correlations with spatial parameters

Once the significant correlations are identified as seen in Figure 21 to Figure 24, these are tested for linear regression to identify the coefficients of determination (Figure 27 and Figure 28). Additionally, the impact of all spatial parameters is tested in a Multi-regression analysis (Figure 29) in order to understand their combined effect. Normalised Integration is omitted from the multi-regression analysis since it is colinear with normalised choice.

Mean Metric Step Depth	IMD	IMD Employment	IMD Health	IMD Educa-tion	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 400											
< 800											
< 1200							.597				
< 1600							.389				.281
< 2000						.111					.240
< 2400											.174
< 2800										.105	.152
< 3200											.142
< 3600											.121
< 4000		.065					.045				.102
< 4400		.062	.032				.091				.092
< 4800		.035	.041				.056				.084
< 5200		.043	.039				.060				.051
< 5600		.052	.038				.024	.019			.048
< 6000		.043	.032				.023				.055
n	.025	.035	.024	.003	.004		.002	.018	.022		.002

Figure 27 Linear regression analysis between normalized choice at 1600m and socio-economic parameters, showing values for r^2 within incremental distances from the Olympic Park. Red indicates that the change in the socio-economic parameter is dependent on normalized choice, with $r^2>0.5$

Mean Metric Step Depth	IMD	IMD Employment	IMD Health	IMD Education	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 400											
< 800											
< 1200						.574			.814	.794	
< 1600		.326				.468	.288			.472	
< 2000		.233				.327					
< 2400	.116	.190		.088	.150	.276			.138		
< 2800	.084	.056	.089	.064	.133	.046	.040	.037	.062	.044	
< 3200	.031		.027	.042	.094	.051	.032	.035			
< 3600				.055	.053	.039			.021		
< 4000				.020	.030	.028					
< 4400											
< 4800											
< 5200							.011				
< 5600							.013				
< 6000							.007				
n	.081	.006	.102	.018	.016		.002	.037	.185	.015	.011

Figure 28 Linear regression analysis between metric step depth and socio-economic parameters, showing values for r^2 within incremental distances from the Olympic Park. Red indicates that the change in the socio-economic parameter is dependent on metric step depth, with $r^2>0.5$

Mean Metric Step Depth	IMD	IMD Employment	IMD Health	IMD Education	IMD Housing	IMD Living Environment	Crime	House Prices	Income	Population Density	Employment Density
< 400											
< 800											
< 1200						.915 (M,A)			.798 (M)	.842 (M)	
< 1600						.552 (M)				.388 (M)	
< 2000		.232(M)				.394 (M)					.189 (C)
< 2400	.106 (M)	.180 (M)		.073 (M)	.149 (M)	.281 (M)			.134 (M)		.118 (C)
< 2800	.169 (M)		.078(M)	.046 (M)	.140 (M)	.031 (M)	.092(M)		.080 (M)	.092 (M)	.097 (C)
< 3200	.025 (M)		.015(M)	.032 (M)	.130 MA	.040 (M)	.063 MA	.070MA			.077 (C)
< 3600				.056 (M)	.113MAC	.029 (M)			.071MA		.046 (C)
< 4000				-.020*	-.030**	.028**					.036 (C)
< 4400											
< 4800											
< 5200							.011*				
< 5600							.013**				
< 6000							.007*				
n	-.081**	-.006**	-.102**	-.018**	-.016**		-.002**	-.037**	-.185**	-.015**	-.011**

Table 33. Coefficients of determination (r^2) values resulting from Multiple Regression Analysis between all socio-economic parameters and Metric Step depth, Angular Step Depth & Normalised Angular Choice (1600m)

Figure 29 Multiple regression analysis between normalized choice at 1600m, metric step depth and angular step depth, and socio-economic parameters, within incremental distances from the Olympic Park. Red indicates that the changes in the socio-economic parameter is dependent on these spatial parameters, with $r^2>0.5$

7. Findings

7.1 Spatial Changes

While there have been limited changes to the spatial network as a result of the Olympic Park development, the changes to the public transport network have been significant. On taking a closer look of the areas around the park, (Figure 35 and Figure 36), it is seen that at a local level, there is a shift in the significance of different global centres. In 2007, the 'Stratford Centre' had a relatively high accessibility from all of London. This has shifted to the newly developed Westfield Mall with it being highly accessible now, while the Stratford Centre has moved into the background. This can be understood as being the effect of improved public transport connectivity to Stratford Station as well as direct connectivity from the Station to Westfield mall making it a prominent centre for all of London (Figure 30 & Figure 31).

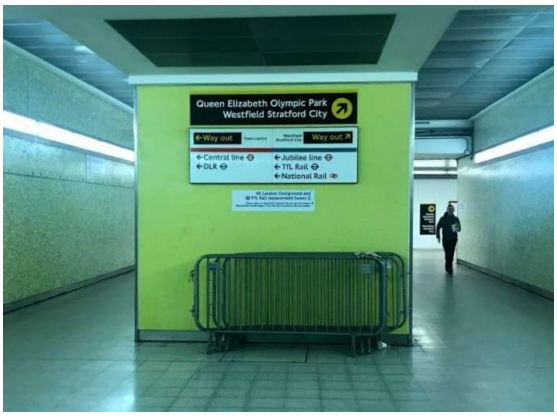

Figure 30 Signage in Stratford Tube station directing towards Westfield Mall

Figure 31 Bridge connecting Stratford Tube Station and Westfield mall

Figure 32 Inside Westfield Mall (Image credit: Berit Watkin)

Figure 33 Inside Stratford Center (Image Credit: Geek Street Travels)

Figure 34 Stratford Centre, with Bus Terminal in front of it

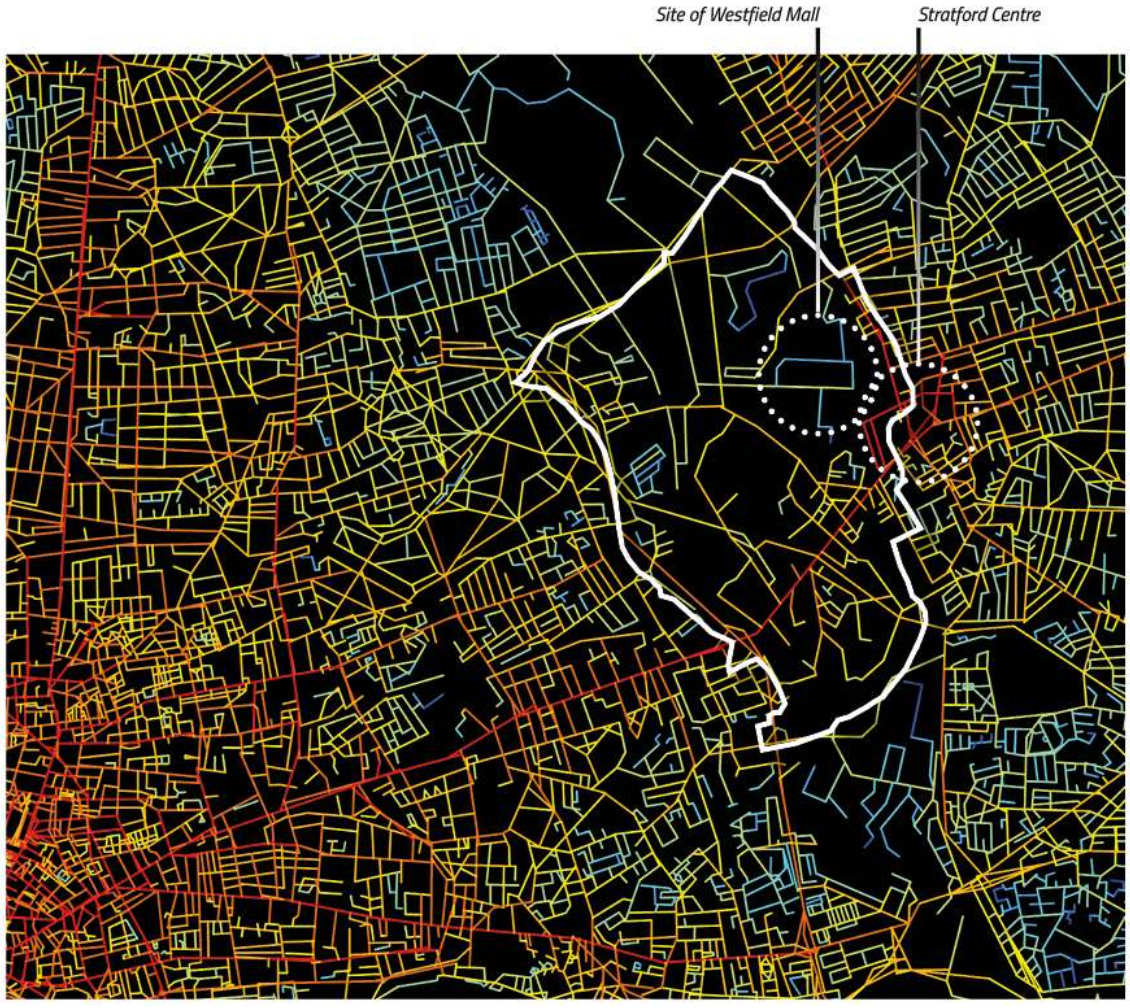

Figure 35 Zoom-in of Multi-modal integration map of 2007 showing Stratford, with the LLDC boundary shown as well.

Figure 36 Zoom-in of Multi-modal integration map of 2017 showing Stratford, with the LLDC boundary shown as well.

This also correlates with one's experience visiting the two retail destinations. Westfield mall comprises of large-scale retail and flagship stores (Figure 31, Figure 32), connected to London easily by the Tube, whereas the Stratford Centre is home to local retailers selling everyday goods and services (Figure 33), most easily accessed from the surroundings by bus (Figure 34).

7.2 Socio-economic changes

From Figure 10 to Figure 20, and Figure 25 and Figure 26, one can see that there have been significant changes with respect to socio-economic conditions of the region with certain trends clearly identifiable.

With regards to population density, from Figure 10, we can clearly identify that the area around the park has seen some of the highest increase in population density, which can be seen declining up to 1200m from the park (Figure 25). Linear correlations between the Change in Population density and angular & metric step depth, Choice & integration (Figure 21 to Figure 24) shows that population density has significant correlations with Metric Step depth. Linear regression analysis against Metric Step Depth shows that the Population density depends on the metric step depth from the park, up-to 1200m since r2> 0.5 (Figure 28). Subsequently, a multiple regression analysis (Figure 29) confirms that the distance from the park is the most significant factor in determining the change in population density. With a significant inverse

relationship between distance from the park and population density. It is identified that the change in population density decreases as the distance from the park increases up to 1200m from the park, implying that more people have moved in closest to the park.

In the case of Crime per unit area, one is unable to see a trend or logic in the relationship with the distance from the park. (Figure 11). However, linear correlations (Figure 22) show that change in criminal incidents has the highest correlations with Normalised Choice. Linear regression against normalised choice (Figure 27), indicates that while there is a correlation between Crime and metric step depth, crime is not dependent on distance from the park. The significant results of the regression analysis between the change in crime/ unit area and the change in Normalised Choice (at 1600m), with r^2=0.597, implies that in areas where spatial accessibility has improved, crime has increased, up to 1200m from the park.

One is able to see a trend of decrease in change in IMD as the distance from the park increases, up-to 1200m (Figure 12). Linear correlations (Figure 21 to Figure 24) show that change in IMD does not correlate significantly with any of the spatial parameters. In order to confirm that change in IMD Scores are independent of spatial logic, linear and multiple regression analysis are performed which show that there are no coefficients of determination that are greater than 0.5. Since there are no significant correlations, there is no spatial logic to the change in the overall IMD Score. Therefore, each Factor is therefore looked at individually.

In the case of the IMD Living Environment score, even though one is unable to see a clear trend in the Figure 25, linear correlations between the Change in Living Environment score and spatial parameters, show that Living Environment has strong correlations with Metric Step depth (Figure 24). Linear regression establishes that the Living Environment depends on the metric step depth from the park, up-to 1600m since r^2> 0.5. Subsequently, a multiple regression analysis establishes the combined effect of the factors. It is seen that both Angular and Metric step depth significantly affect the living environment conditions, with r^2 = 0.915. With a significant correlation up to 1600m, it can be said with statistical surety that the Living Environment has deteriorated closest to the park, in terms of both Metric and Angular distance. The impact of the distance from the park is reduces as one moves away from it. The living environment score is a combined measure, with air quality being a significant indicator of living environment. With increased accessibility by trains as well as on-going construction, sites closer to the park have seen increased deterioration of living environment.

With regards to Income, one is able see a trend in Figure 19 that there has been a significant change in income, close to the park. Linear correlations between Income and all spatial parameters confirm that Income has significant correlations with Metric Step Depth (Figure 24). A linear regression analysis against Step depth and subsequently, a multiple regression analysis against all factors confirm that Income depends on metric step depth from the park. It can be understood that high income residents have moved in closest to the park and this reduces as the distance from the park increases, up to 1200m from the park.

The measures of Employment, Education, Health and Barriers to housing (which are components of the Indices of Multiple Deprivation) as well as Job Density & House Prices show limited correlation with all the four spatial factors. Both Linear & Multiple regression analysis with the spatial parameters do not yield high coefficients of determination indicating that there is no spatial logic to the change in the Job density, House prices and IMD Employment, Education, Health and Barriers to housing score.

Social (Difference)	Spatial (Difference)
Population Density	Mean Metric Step Depth
Crime / Unit Area	Normalised Angular Choice (1600 m)
Indices of Multiple Deprivation (IMD)	Mean Metric Step Depth
IMD Employment	Mean Metric Step Depth
IMD Education	Mean Metric Step Depth
IMD Health	Mean Metric Step Depth
IMD Barriers to housing	Mean Metric Step Depth
IMD Living Environment	Mean Metric Step Depth
Job Density	Normalised Angular Choice (1600 m)
Income	Mean Metric Step Depth
House Prices	Mean Metric Step Depth

Figure 37 Table showing spatial parameter with the highest correlation on each social parameter. Red indicates significant impact with $r^2>0.5$. Yellow indicates those with $r^2>0.25$

It is clear that changes to the spatial network configuration are responsible for changes in socio-economic conditions of surrounding neighbourhoods. Additionally, while it can be understood from above that the population density, income, crime per unit area and living environment have all seen significant changes as a result of the Olympic park development, it is also clear that they are all limited to a distance of 1600m from the park. A visual comparison between the London Legacy Development Corporation (LLDC) Boundary and the area of impact as identified by this study, i.e., within 1600 m of the Olympic Park, shows that they have a very high degree of overlap. Changes in spatial network configuration is also limited to the LLDC boundary.

The LLDC is the government body responsible for executing the legacy of the Olympic Games and 5 years after the games, the impact of it is seen as being limited to within its boundaries. Impacts on the neighbourhoods in the four London boroughs situated in and around the LLDC Boundary is limited. Their involvement in the planning of the development would need to be investigated further. Such is often the case with mega-event driven development, where impacts of the developments are limited to the boundaries of the development authority. London, as of 2017, is also understood to have limited impacts outside of this boundary.

However, the spatial changes are also limited to within this boundary. Since we have understood that socio-economic changes depend on spatial changes, in order to have wider reaching impacts, the spatial changes also need to be wider reaching, enabling the development to be more spatially embedded (John & Karimi, 2019) within its surroundings so that the impacts would penetrate further into the neighbourhood. However, in order to do so, it is imperative to work with local governments and authorities in the surrounding regions to identify potential synergies between the event-organiser/developers and the communities in the vicinity

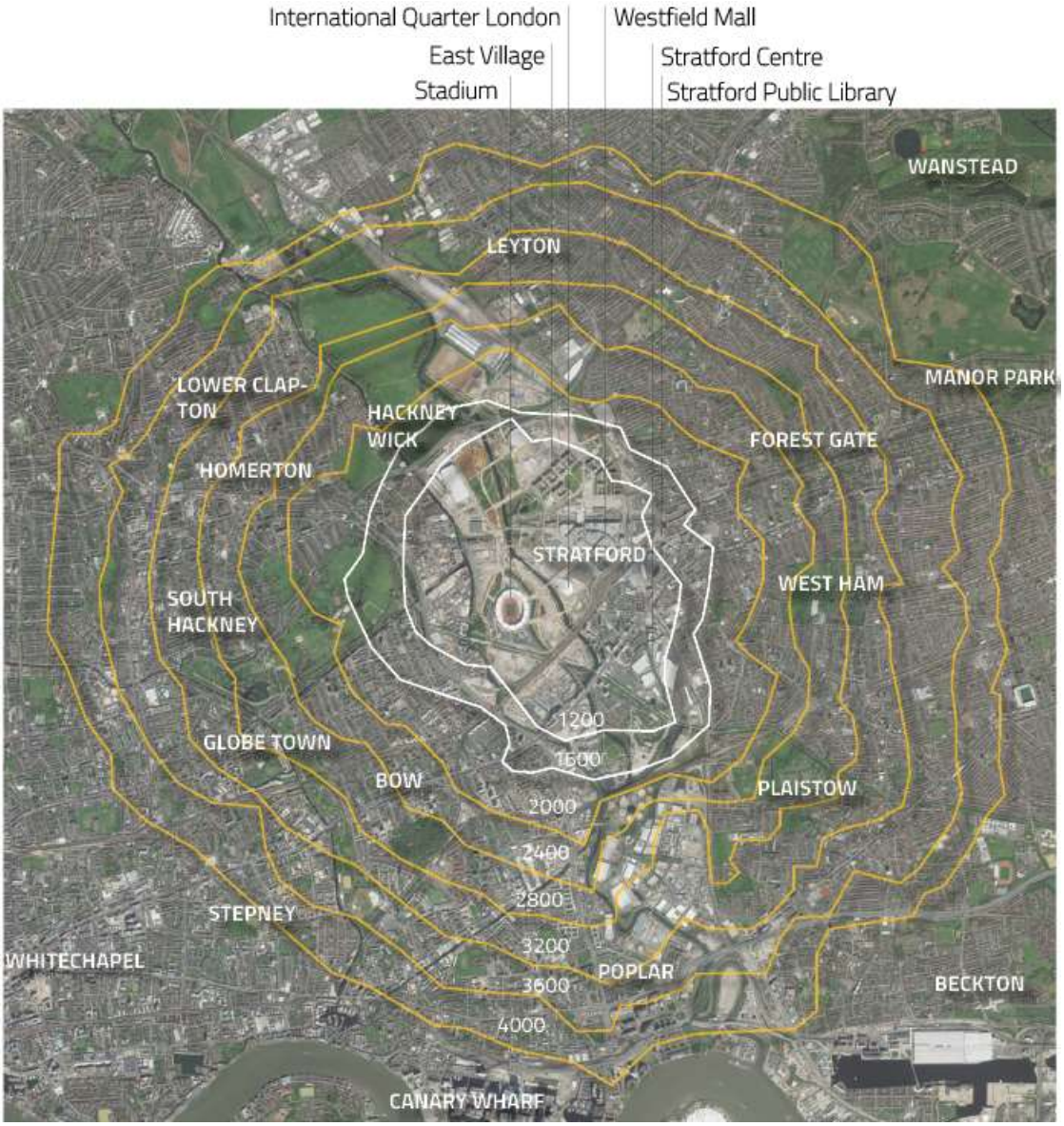

Figure 38 Impact area of the Olympics. Upto 1600m indicated in white

Figure 39 LLDC boundary overlaid on the area of impact of the park

7.3 Demographic Change

With upscale new developments taking place within the LLDC Boundary, the question of division, both physical and social, also arises. With higher income residents moving in close to the park, their relationship to those already living in the surrounding areas is to be understood.

Stratford, presently, is "acting as an overspill for Bow and Canary Wharf, hosting 'value for money' accommodation, with excellent transport connectivity" (Bernstock, 2014). The new higher income residents are mainly comprised of young professional workers, with very few new families moving into the area, due to a lack of good schools (Ibid). Bernstock, through primary research, undertaken with estate agents, developers, and residents, has also identified that the new residents located themselves spatially in new Stratford, visiting Westfield Mall and the Olympic Park (2014, p. 179). They also tended not to use the local services in the area, like the GP or the schools (Ibid,p.180).

7.4 Gentrification

While the Olympic park has improved the standard of living of East London, it is due to the influx of new, higher income residents into the new, modern developments in the area and not into the existing neighbourhoods. However, among the long-term residents of the area, there is a general consensus that Stratford is developing in a manner that would is not beneficial for them. Primary research by Paul Watt, interviewing residents of the area at Carpenter's estate, a social housing tower, which has since been partly privatised, indicates that residents feel that the 'Council wants to get rid of poor people', and generally, that the development 'is not for us' (Watt, 2013).

Despite commitments towards mixed neighbourhoods, on the ground, the subtle reality is that even in cases where social renters are integrated into new Stratford, they are separated from its new residents. Bernstock reports of cases where there are separate entrances in the same building for social renters, effectively reinforcing social divisions (Bernstock, 2014, p. 183)

7.5 Shaping the City

Apart from social implications, there are spatial implications to the limited impact area witnessed in the case of Stratford. While LLDC is only developing a limited area around the park, the remaining area is consequently affected. Stratford Centre, which was at the heart of Stratford, was once a global attractor. But with the new development, it lost its prominence, pushing it further into the background network (Figure 35 and Figure 36).

In the post-Olympic condition, the new Stratford town centre occupies a highly prominent location within the spatial network, with its surrounding areas losing their significance. The new town centre is seen as having developed into a sole attractor in the area, pushing all else into the background.

> *" ... three years after the borough(s) hosted the Olympic Games, if one chooses to venture beyond the magic garden of Westfield and the QEOP, little has changed."*
> *(Armstrong, et al., 2016)*

The results of the study corroborate this view that the benefits of the Olympic park development have been limited to the Queen Elizabeth Olympic Park and the LLDC boundary. There has been little benefit for the communities in the surrounding areas. While IMD Levels indicate that the deprivation of the area has seen improvement, this is due to the introduction of new agents into the area and not due to improvement of conditions of the people already living there.

8. Conclusion

This extensive study of the impact of the Olympic park development, investigated various social parameters and identified their change over a period of ten years, from 2007 to 2017. Their relationship to the Olympic Park and the Spatial changes as a result of the Olympic Park development were studied to identify direct impacts of the Olympics. In addition, the extent of impact has been investigated.

This research has established that the changes in the configuration of the city, brought about by a large scale new development, have impacted the socio-economic conditions of the surrounding neighbourhoods, albeit only to a limited extent due to the limited extent of the spatial changes. Hosting the Olympics is seen to have improved public transport accessibility, population density & income levels in the vicinity of the Olympic Park, while crime has seen an increase and the living environment quality has decreased in the area as a result of the games. It is also understood that the extent of impact of the development is limited to walking distance from the park and the local communities have derived little or

no benefit yet. The influx of high-income residents into the area, has also caused a disruption in the social balance of the area, with a large number of people displaced as a result of increased rents, and rehousing of social renters. Despite previous mega-event planning having shown similar signs of gentrification, this could not be prevented in London as well. The development has also introduced increased social division into the area. With large sums of money being invested into the LLDC boundary, the expected trickling of benefits to the surrounding areas is yet to be seen. Since the study is limited to 5 years after the Olympics, it is too soon to state that it has been unsuccessful in being beneficial to the residents of East London. However, as of 2017, as investigated, the benefits of the Olympics are seen to be for large developers, strategically located on the site, as well as the new residents of the area.

9. Further Research

By setting up a framework for studying the relationship between the spatial and socio-economic impacts of mega-developments, this study opens up possibilities to apply the same methodology to study other host cities and compare between them to identify what has been done differently in different cases, to create a best case method for planning for mega-events and their ensuing urban development. This framework, in conjunction with the legacy planning framework (John & Karimi, 2019), can also be adopted to assess proposed legacy plans for mega-events to assess possible outcomes of planning decisions and propose improved plans as appropriate.

10. Limitations

Since the lowest level of detail for socio-economic data is only at the level of the Lower Layer Super Output Area and not at the street level, disaggregating it to the street level would pose the Modifiable area unit problem (MAUP). In order to work around it, all analysis has been restricted to the boundary of the LSOAs. Since these are arbitrary outlines based on census statistics, they are not ideal for network-based analysis. Also, aggregating data implies loss of fine grain & detailed information, which is available in the network model. However, since the Census and statistical data for the social parameters are only available at this level of detail, this is the highest resolution possible currently.

Other socio-economic parameters such as ethnic diversity, well-being, and community infrastructure have not been omitted due to unavailability of data at the detailed LSOA level. Additionally, in case of LSOA's whose boundaries have changed between 2001 and 2011 census, the data from 'before' has been mapped to the 2001 boundaries and these values are transferred to the respective 2011 boundaries. In case of crime and job density data, data before 2011 is not available from the respective sources for the 2001 boundaries.

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