Impact of Waste Disposal Sites on Property Value in Moscow, Russia[1]

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This study analyses the impact of waste disposal sites on property value in Moscow, Russia and outlines contemporary hedonistic sustainability initiatives in some European and Asian countries. A case study is presented to show the modern scale of urban gentrification and neighbourhood revitalization within the Moscow metropolis. The research methodology comprises the analysis of property datasets and a cross sectional survey of Moscow residents. The model demonstrates the correlation between average property prices within the studied areas and their proximity to waste disposal sites. Data analysed points to the average price of private and commercial real estate considering factors such as accessibility, distance from the city centre and other physical and social factors. Findings reveal that properties located close to waste disposal sites were relatively undervalued by as much as 18% when compared to similar middle-income group housing and 36% when compared with higher-income group housing. Property prices also increased by every additional kilometre away from the source of pollutants despite being of further distance from the city centre. A case of social inequality is also largely felt between Moscow city and its suburb.
Keywords: Gentrification, hedonistic sustainability, property value, waste disposal sites, neighbourhood revitalization.

Introduction and Study Objectives

It is estimated that 55% of the world's population lives in cities, this number is expected to increase to 68% by 2050.[2] Urban planning systems are therefore faced with sustainability challenges posed by urban population growth rates (Prato and Pardo 2013). Housing, transportation and waste management are some of the key issues being evaluated by most governments in preparation for the growth of their urban centres. The Russian Federation is currently focused on the large-scale reform of its waste management system, this is key in driving sustainable development, especially for large urban settlements like the Moscow metropolis. Waste generation has increased drastically over the past decade as a result of urban population growth rate,[3] housing boom and the new consumerism culture. This sudden surge in waste generation has led to landfill overfilling, as the post-soviet waste management infrastructure is simply unable to cater to such volumes. This stagnation in the waste processing cycle has led to environmental degradation in communities in close proximity to industries, landfills and waste disposal sites, thereby triggering numerous community protests and public petitions. The problem of utilization, processing and disposal of waste requires a systematic approach and operational solutions tailored to the socio-cultural norms of the citizenry. It is believed that the efficiency of the new environmental policy reforms and the introduction of

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[2] United Nations: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
[3] Russia's Urban Population Growth Rate
https://data.worldbank.org/indicator/SP.URB.TOTL?locations=RU

green technology will provide assurance to investors that real estate value will not decline due to, or depend heavily on the proximity of properties to industries, landfills and waste disposal sites.

This situation is definitely worth analyzing, especially in light of the recent real estate infrastructure boom in Moscow following the adoption of the *2017 renovation program* which threatens the demolition of housing estates built in the early 1950s and 1960s (Gunko et al. 2018). According to the news outlet *vedomosti*,[4] over 5.5 million square meters of real estate was commissioned in the first half of 2019, including 2.2 million square meters of housing, which is three times that commissioned in the same period the previous year. According to the Russian federal bureau of statistics Rosstat,[5] in the first half of 2019 over 29,880 new apartments were commissioned in Moscow and 47,409 in the Moscow region. Mass housing projects are popping up everywhere in Moscow and its suburbs, thereby redefining the cityscape. Real estate pricing in Moscow is primarily determined by a number of factors, such as the property's proximity to mass transportation (subway, bus and tram), distance from the city centre, floor space per square meter and access to utilities and social services (clinics, schools, and so on). Lower asking prices in areas close to waste disposal sites may therefore seem a lucrative offer especially for young families who cannot afford more expensive options.

The present study looks into the current pricing of real estate (specifically, residential housing), based on property's proximity to waste disposal sites as compared to other areas located farther away with better ecological attributes. The discussion seeks to answer the following questions: Are ecological factors considered to be key attributes when selecting a property in Moscow? Does the proximity to landfills and waste disposal sites have a negative impact on property value in Moscow? What is the average property price variance for properties located close to landfills by distance (in Kms)?

The null hypothesis applied for the data analysis states that the location of landfills has no negative impact on property pricing in Moscow. Our alternate hypothesis states that the location of landfills has a negative impact on property pricing in Moscow.

The following sections present a comprehensive outlook on the 'Moscow' study area in light of recent housing demands and current waste management challenges. A review of relevant urban planning theories and literature is presented. The methodology and findings describe the methods used in the quantitative and qualitative research and the findings. Finally, we offer suggestions and recommendations for urban planning and municipal policy.

Study Scope: Moscow, Russia

Moscow covers an area of 2561 square kilometres, with a population of 12.5 million.[6] It is the most populated city in Russia and second most populated city in Europe. The city comprises 12 administrative districts, or *okrugs* (subdivision of state administration), which are further

[4] https://www.vedomosti.ru/realty/articles/2019/07/08/806121-vvod-zhilya-v-moskve-priblizhaetsya-k-rekordam

[5] https://www.gks.ru/bgd/free/b04_03/IssWWW.exe/Stg/d04/144.htm

[6] www.macrotrends.net

subdivided into 123 *raions* (local municipal districts). The city shares its boundaries with the Moscow region (Moscow Oblast) and has notably been expanding outwards; in July 2012, part of the Moscow region currently known as the Novomoskovsky (New Moscow) and Troitsky *okrugs* were transferred to Moscow (Figure 1). The Moscow city and Moscow Region are commonly identified jointly as the Moscow Megapolis (Porfiryev and Bobylev 2018). Nonetheless, social inequalities exist between the two regions, as officially registered residents of Moscow city are afforded numerous advantages, such as facilitated administrative processes, social welfare and access to numerous subsidies (Vershinina et al. 2018).

KEY	District	Housing Price (Jan-20)			Dec-19
		RUB	USD	EUR	
1	Central District	313,646	5,091	4,581	-0,3%
2	Northern District	176,546	2,865	2,579	+0,8%
3	Northeast District	157,454	2,556	2,300	+0,1%
4	Eastern District	163,442	2,653	2,387	+0,8%
5	Southeast District	150,407	2,441	2,197	+1,2%
6	Southern District	158,816	2,578	2,320	+1,1%
7	Southwestern District	207,606	3,370	3,032	-0,1%
8	Western district	194,561	3,158	2,842	+0,9%
9	Northwest District	183,938	2,985	2,687	-0,2%
10	Zelenogradsky District	134,409	2,182	1,963	+1,1%
11	Novomoskovsky District	134,409	2,182	1,963	+1,1%
12	Troitsky District	134,409	2,182	1,963	+1,1%

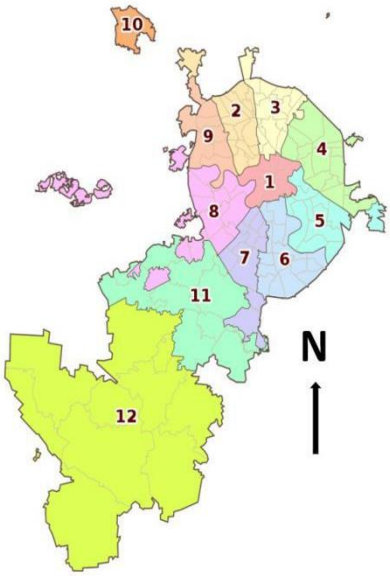

Figure 1. Administrative districts[7] and housing prices[8] in Moscow, Russia. Adapted from www.irn.ru by the authors.

The city is characterised by a mix of baroque and neo-Russian historical buildings, post-revolution structures and modern high-density apartment blocks. Over the past decade residential housing has been on the rise with about 37 million square meters built between 2011 and 2019.[9] Moscow ranked 6th globally in the CBRE Global Report[10] with a growth rate of 8.9% in 2018. This was attributed to low unemployment rates and attractive credit and mortgage facilities especially for young families with several children who receive government subsidies and welfare support. Property prices are highest in the city centre and western districts (Figure 1). Housing in the outer districts (Zelenogradsky, Novomoskovsky and Troitsky) is relatively lower but has been steadily increasing in value since 2015 and, more recently, following the announcement of new social infrastructure and rail lines. New social infrastructure, including schools, clinics and parks, as well as public transportation, has been a key priority for the government and is being developed to complement the city's expansion. One of such projects is the city's subway (Metro) expansion over 120 Kilometres (66 new subway stations)

[7] Stan Shebs [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)]

[8] https://www.irn.ru/

[9] https://stroi.mos.ru/news/doklad-zamiestitielia-mera-moskvy-v-pravitiel-stvie-moskvy-m-sh-khusnullina

[10] https://www.cbreresidential.com/uk/en-GB/content/moscow

developed between 2010 and 2018.[11] Currently, the *Third Interchange Circuit* (TIC) and *Moscow Central Diameters* (MCD 1-5) are under construction; TIC is an outer circular ring of the current subway network covering 69 Kilometres and 31 stations and is aimed at connecting 31 city districts; project completion is scheduled for 2020. The MCD are outward routes connecting Moscow city with the suburbs (regions); currently MCD-1 (54 Kilometres, 28 stops) and MCD-2 (80 Kilometres, 33 stops) are nearing completion. Transportation routes provide important metrics when comparing property prices, especially in relation to landfills.

Figure 2. Average property prices in Moscow by Housing type 2020. Adapted by the authors.

Air quality in Moscow has generally improved since 2006. However, municipal waste remains a high concern, due to indiscriminate dumping and overcapacity of existing landfills (Bobylev et al. 2015). Ecological assessment in Moscow usually considers the following factors:

- Pollution from waste incineration plants, thermal power plants and chemical industries;
- Wind direction promoting air pollution from the aforementioned industries;
- Air pollution from densely populated highways especially around the area of MKAD ring road;
- The presence of nuclear facilities (radiation).

Figure 3 below depicts the impact radius of three main waste incineration plants in Moscow and this study evaluates the effect of property pricing near these sites.

Government subsidies are currently given to citizens living in close proximity to landfills and waste disposal sites, for instance up to 70% discount on waste management fees is applied to those who live within a 2-Kms radius from landfills and other objects of MSW handling.[12]

[11] https://www.mos.ru/en/city/projects/metro2022/

[12] Moscow Region Government Website: https://mosreg.ru/sobytiya/novosti/news-submoscow/kak-zhiteli-podmoskovya-budut-platit-za-vyvoz-musora

Type of Housing Structure	Average Apartment Price Jan-20			Dec-19
	RUB	USD	EUR	
Old panel (5-storey and other apartments with a small kitchen)	153,580	2,493	2,243	+0,9%
Typical panel (9-14 floors, standard areas)	157,421	2,555	2,299	+0,3%
The modern panel (16 floors and above, non-satandard areas)	168,586	2,736	2,462	+0,9%
Old brick (5-storey and other apartments with a small kitchen)	168,668	2,738	2,464	+0,4%
Stalin blocks and typical brick (6-11 floors)	195,050	3,166	2,849	+0,9%
Modern monolith-brick (monoliths, brick)	198,852	3,227	2,904	+0,8%
All panel and block houses	159,862	2,595	2,335	+0,7%
All monolithic and brick houses	187,523	3,044	2,739	+0,7%
Living Space				
Studio apartments	175,768	2,853	2,567	+0,5%
One bedroom apartments	178,036	2,890	2,600	+1,3%
Two bedroom apartments	172,016	2,792	2,512	+0,6%
Large apartments	185,791	3,015	2,714	-0,1%
Source: https://www.irn.ru/index/				

Figure 3. Impact Radius of Incineration Plants in Moscow (2017/18). Source: https://mosnov.ru/

Literature Review

A number of research studies have established the correlation between property value and proximity to waste disposal sites or landfills. Empirical evidence often indicates that hedonic pricing on property is regressed by approximately 5-7% per 1.6 Kilometres relative distance of the property from such locations, and the effect on pricing is often felt on properties that are situated within a 3 to 6 Kilometres radius of landfills or waste disposal sites. The most affected (as much as 20% to 30% price reduction) are properties located within a 400-800 Kilometre radius (Nelson et al. 1992, Akinjare et al. 2011). Wind direction also seems to play a key role when reviewing the surrounding ecology of the property in question (Li and Li 2018), as does the volume of waste being disposed at nearby landfill sites (Ready 2010). These past studies are quite relevant to this research as we consider property distance, air quality and landfill capacity in our analysis.

There are also studies that show no negative impact on property value (Cartee 1989, Parker 2003, Ready 2010), although it could be argued that these instances involve either low capacity or technologically advanced landfills and that the residential communities located nearest to such sites are quite dispersed with a low density housing index. Our study, however, covers high density housing, which is characteristic of Moscow districts. There has not been much prior research into the effect of landfills on property pricing in Moscow. Our research fills this gap by providing the price correlation of both residential and commercial properties in districts close to landfills and in the concentric periphery of Moscow, which is considered a highly polluted zone due to smog from highways and nearby industrial and incineration plants.

The new environmental policy in Russia involves sorting of waste at source and greater responsibility by manufacturers and importers; it also seeks to induce a sense of 'hedonistic sustainability' for the remediation of waste disposal sites; this concept involves a mutual and sustainable coexistence between people and the spaces they occupy, a relationship which also creates positive interactions and a flourishing sense of well being (Aoyagi et al. eds 1995, Mohtadi 2016). A successful land-use juxtaposition, or 'hedonistic sustainability', seems to

thrive in various regions, including Northern European countries (Denmark, Finland, Sweden and Norway) and Asian countries (in particular Japan). For example the Bjarke Ingels Group (BIG) designed a modern waste-to-energy power plant 'CopenHill',[13] which is capable of converting 440,000 tons of waste to clean energy annually and is now the epicentre of mountain sports in Copenhagen, Denmark. The project utilizes a unique smoke purification system, so that the emission of harmful substances into the atmosphere is practically reduced to zero. This project is of great importance to the Danish authorities and their new climate plan CPH 2025,[14] which aims at making Copenhagen the first carbon-neutral city with zero greenhouse gas emissions. Another great example is Sweden, which has an outstanding 1% landfill rate. With 34 waste-to-energy (WTE) plants and a very efficient waste collection system, the country actually has a nation-wide shortage of garbage. While in Russia this sounds implausible, Sweden manages not only its waste but also imports up to 800,000 tons of waste annually from Norway. Its waste management infrastructure boasts 99% utilization and by-products production; so, less than 1% actually ends up in landfills.[15] Although most of the country's power is generated through nuclear/hydro 83% and wind 7%, WTE provides heating to nearly 10 million residents. According to Avfall Sverige, the Swedish Waste Management and Recycling association, 4,771,450 tonnes of household waste was treated in 2018 (466 Kg per capita in 2018, compared to 473 kg in 2017) and 0.7% was landfilled. Such results are achieved, firstly, by a high environmental sensitization culture and, secondly, by a well-functioning system of separate waste collection. Infrastructure also plays a key role, as most of the waste is incinerated in state-of-the-art processing facilities.

Hedonistic sustainability is often driven by the need to maximize urban space, as in the case of Japan (Brumann and Schulz 2012). There, due to the geographical features of the area, which does not allow for mass disposal of waste, measures to promote policies for sorting municipal solid waste and their correct disposal were developed much earlier than in other countries. Japan initiated its first modern regulation on waste management in 1900 and Tokyo's first incinerator was commissioned in 1924. In Japan, the manufacturer is responsible for the disposal procedure; the costs are borne by the consumer; and the municipalities, with the support of regional authorities and the state, implement separate collection and processing of waste. Separate waste collection and recycling are implemented not only in large cities but also in remote areas, and often the residents themselves act as initiators. Some cities have over 40 garbage categories, and the sorting system depends on the disposal methods. Large fines are issued for sorting violations, and explanatory work is carried out among the population from an early age. Currently, most of Tokyo's waste is being managed by the union of Tokyo's 23 central wards the 'Clean Authority of Tokyo 23' (CAT23).[16] The group manages 19 active incineration plants amongst other waste treatment plants in the region. Waste is often channeled

[13] Copenhill/Amager Bakke https://www.copenhill.dk/en
[14] Carbon Neutral Capital https://international.kk.dk/artikel/carbon-neutral-capital
[15] Swedish Waste Management 2018
https://www.avfallsverige.se/fileadmin/user_upload/Publikationer/SAH_2019_EN.pdf
[16] http://www.union.tokyo23-seisou.lg.jp.e.de.hp.transer.com/

towards land reclamation; for example, 'The Central Breakwater' is an artificial island located in Tokyo Bay made up of incinerated ash and debris from waste treatment sites.[17] The project was initiated in 1973 to address the high volume of waste in the city and has since become an epitome of modern engineering and urban sustainability. The principles of sustainable development are widely promoted, strong associations linked to separate waste collection are created among the population. Waste management is also strongly ingrained in the Japanese culture (Sato 2017). The word *mottainai*, which translates to 'what a waste' or 'do not be wasteful', is commonly used in everyday life and promotes sustainable consumer behaviour (Sirola et al. 2019).

As a separate example, we cite Kamikatsu, a small village in Tokushima Prefecture, located in the southwest of Japan (in the northeast part of Shikoku Island). Forested mountains make up 85% of the total area of the village, with 1580 people in 800 households gathered in 55 communities.[18] Kamikatsu became the first municipality in Japan to declare a zero waste policy. It initiated a strict zero-waste campaign in 2003, whereby waste is sorted into 45 types under 13 categories, according to detailed instructions supplied by the municipal authorities to residents. There is also a waste collection point in the city where people can leave used clothes or furniture or exchange their old things for those of their neighbors. As a result of these measures, 80% of Kamikatsu's garbage is recycled, reused or composted, and the rest is sent to landfills.[19]

Countries generally develop environmental systems which are most convenient for their citizenry. For instance, in Germany special colour coded containers are used for sorting household waste at designated collection points. Switzerland has a littering police force whose responsibility is to control sorting and waste disposal. In France and Italy, chips are installed on containers that control the transport of waste; the chip allows you to determine the fullness of the container and set the date of removal, thereby rationalising transportation routes and improving overall efficiency (saving time and fuel costs). This GPS technology is now being introduced in Russia, specifically to cater to municipal waste transportation from Moscow city to designated landfills in the region to curb unauthorized dumping by waste collectors.

Based on data provided by Rosprirodnadzor, in 2017 industrial and household waste in Russia amounted to 6.2 billion tons, while 2.3 billion tons were buried at landfills and waste disposal sites, which makes up more than 38% of waste.[20] According to the Department of Natural Resources and Environmental Protection in Moscow, waste disposal at specialized

[17] https://storymaps.arcgis.com/stories/fdc02295fe7c4dce87a4b0926ecd6d95

[18] The Kamikatsu Zero Waste Campaign: How a Little Town Achieved a Top Recycling Rate // Nippon, July 13, 2018. URL: https://www.nippon.com/en/guide-to-japan/gu900038/the-kamikatsu-zero-waste-campaign-how-a-little-town-achieved-a-top-recycling-rate.html?pnum=2

[19] The simple way this Japanese town has become nearly zero-waste // Business Insider, Jule 10, 2017. URL: https://www.businessinsider.com/zero-waste-town-kamikatsu-japan-2017-7.

[20] State Report (in Russian) 'On the Status and on the environmental protection of the Russian Federation in 2017', Ministry of Natural Resources and Ecology of the Russian Federation. URL: https://gosdoklad-ecology.ru/2017/obrashchenie-s-otkhodami-proizvodstva-i-potrebleniya/otkhody-proizvodstva-i-potrebleniya/

landfills is currently the main recourse for waste management in the region. At present, in Russia, waste treatment methods include both technological processes (incineration, biogasification and composting) and redistribution as feed for livestock, accounting for a small proportion of waste treatment. Most of the waste is simply buried in landfills without pre-sorting or treatment, leading to mountains of waste with a very slow rate of decomposition. This situation negatively affects the surrounding ecology, causing to a large extent a chemical imbalance in air and soil quality which negatively impacts public health and may lead to increased mortality rates (Yablokov 2010, Pukhova 2018).

Most of the landfills were located in old waste dump sites even before the *perestroika*, and they do not possess secondary aeration systems or conduits to handle gas or leachate evacuation; and, now that a significant part of the waste dumped is plastic, these landfills simply grow in size causing greater degradation of the surrounding environment. The effects of landfills and incineration sites is dependent on the technology utilized. Wind direction and the position of underground water reservoirs also determine the impact on the surrounding community (Phillips et al. 2014, Pukhova 2018).

Many experts admit that even for large developers, construction in areas close to industry and waste disposal sites is associated with certain economic risks, such as lower demand for real estate (Grigoriev et al. 2012, Vershinina and Martynenko 2019). When developing a site located close to a landfill, the developer, as a rule, estimates that housing will be sold at a discount and an extra effort will have to be made on external aesthetics and marketing. The price per square meter in a residential complex located in close proximity to landfills is much lower than the market average for similar apartments located elsewhere. Nevertheless, since the base cost of such plots tend to go at a bargain, most developers can afford to reduce their asking price to a minimum. Economy-class projects are mainly implemented on such sites, often these are blocks of the popular monolith panel housing structures, and the difference in price compared to new buildings in a more attractive area can reach upwards of 15-20%.

Real estate prices are affected by multiple variables; some weigh more than others, depending largely on public preferences. For instance, access to water (Cho et al. 2011), noise pollution (Del Giudice et al. 2017), distance from industrial plants (Grislain-Letrémy and Katossky 2014), proximity to incineration plants (Farber 1998, Phillips et al. 2014) and many more. Most researchers often use the hedonic pricing model to determine the variability in such instances; it is depicted as P = f1, f2, f3, …, fn), 'P' being the property price and 'f' the function that affects the property price (Li and Li 2018). The model by Lavee and Bahar (2017) depicted below identifies property price factors according to internal characteristics and external factors affecting the property:

$$Pi = f\ (d, s1, s2, \ldots sn; n1, n2, \ldots, nm)$$

Where:

Pi: is the apartment price;

f: is the function that studies the relationship between housing prices and the

d: distance of the property from the environmental hazard;

s: are the characteristics of the housing structure (internal);

n: represents the characteristics of the housing neighbourhood (external).

According to www.rn.ru, the key criteria in selecting property depend on whether the property acts as a short or long term investment or is considered for immediate living purposes (usually through mortgage or outright purchase). In the latter case, the criteria for selection will depend also on the preferred type of property (newly constructed or existing) and the buyer's age group; for instance, when a property is purchased for elderly parents the focus may be more on ecological quality, distance from clinics and public transport and availability of disability access in the nearest subway station. On the other hand, property purchased by young families may prioritise price (ability to purchase bigger apartments for less), apartment quality, easy access to clinics, kindergartens and schools, quality of playgrounds, access to subway stations and the surrounding ecology. However, the most popular parameters often used in selecting apartments in newly constructed blocks within Moscow city and the Moscow region are identified as:

1. Location: Distance from the city centre and whether the property is located within the Moscow city border since being registered within Moscow provides administrative and social welfare incentives especially for pensioners, veterans and young families;
2. Price: Property value per square metre;
3. Developer ranking and apartment finishing: This is key, as some developers have been embroiled in class action suits for not completing projects: new apartment blocks were sold as shells and the buyer was required to complete the finishing based on their taste. Modern developers add this to the cost of the apartment popularly — known as 'white-box' — and the buyer is expected to furnish the apartment based on taste;
4. Access to social infrastructure: Distance to schools, clinics, parks (especially for residents with pets) and public transport, as well as the type of public transport — tram, rail, subway, and so on.

Our study offers a novel insight into other ethnographic factors of equivalent importance to Moscow residents; specifically, 'ecological considerations'.

Methodology

The methodology applied in this study utilizes both quantitative and qualitative research techniques. The primary data were obtained from a cross-sectional survey of Moscow residents, while secondary data were collated from the real estate analytical sites and examined alongside environmental factors (air and soil quality) in order to test the following hypothesis:

a) H0: The location of landfills has no negative impact on property pricing in Moscow.
b) H1: The location of landfills has a negative impact on property pricing in Moscow.

In order to determine data viability, certain considerations were applied prior to selecting the data source and analysing the data obtained. Care was taken to obtain secondary data only from sites that provided:

- Active and publicly available real estate market data;
- Active real estate repository data for up to 5 years (High ranking repositories);
- Valid methodology for property pricing (microeconomic and macroeconomic factors);
- Active ecological data (air and soil quality data).

With these considerations in mind, the open access real estate analytics sites www.cian.ru and www.irn.ru were selected as our data source for real estate market data, while Mosecomonitoring (www.mosecom.ru) and the website of the Department for Environmental Management and Protection (www.dpioos.ru) were consulted to verify data on ecological factors including air and soil quality. The real estate analytics sites www.cian.ru and www.rn.ru publicly provide their methodology for calculating the average price per square meter for apartments in various districts. It should be noted that their model takes into account various factors, such as living area, type of house, number of rooms, proximity to the city centre, distance from the metro, kitchen area, presence or absence of a balcony, and so on. Data on office and retail rental rates were also taken from the www.cian.ru website. Our empirical study collected the property prices in eight districts in Moscow located concentrically and adjacent to the MKAD ring road (Figure 4). The most expensive properties are generally located in the city centre and the western districts. Our study focused, however, on average property pricing for middle-income and upper middle-income groups in keeping with the methodology used by the 'cian/irn' analytics; so, certain aspect, such as high-income, elitist and atypical properties, were excluded from the analysis. The indices also reflect the real market sale value, which appears to be slightly lower than the overestimated offer prices.

Our survey of Moscow residents was conducted online due to the recent COVID-19 pandemic, a total of 921 responses was collected between 24 June and 24 July 2020. The general public was informed of our ongoing survey through social media platforms, forums and blogs. 'Google Forms' was used to conduct the survey and gather all responses. The majority of responses came from the 'Yandex Rayon' platform (https://local.yandex.ru/). Focus group discussions were also held on the platform and this provided further insight into the study areas. Unfortunately, interviews with select government officials could not be conducted, due to the pandemic and the official workload of the 2020 Russian constitutional referendum.

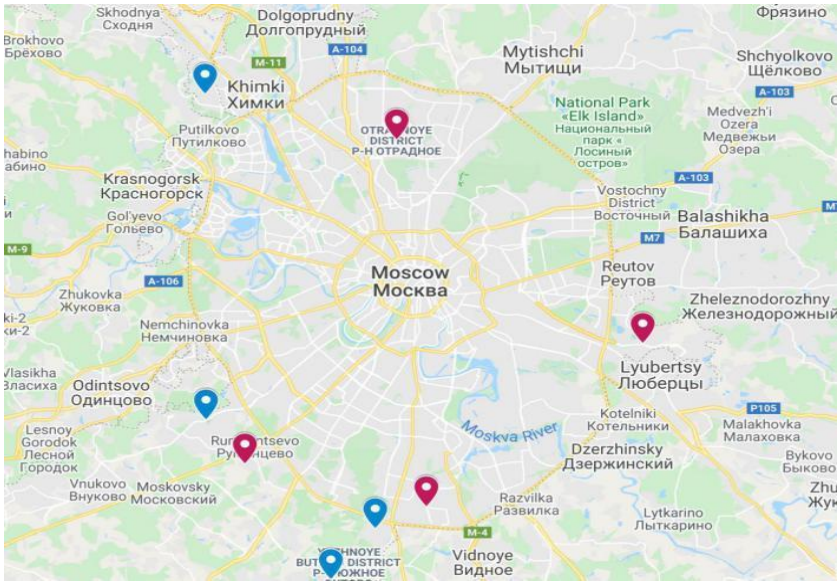

Figure 4. Map of Moscow and the districts under study.[21] Designed by the authors using Google Maps.

[21] The *red pins* are districts close to waste disposal sites and the *blue pins* are districts least affected by poor ecological considerations.

The eight districts under study are located along the Moscow ring road (MKAD). The stretch of real estate along the MKAD is known to be of low ecological quality (especially the eastern route); yet, it is quite popular for most middle-income families who need to commute daily to the city for work. Four of these sites are close to landfills and incineration sites (0.5 Kms), while the remaining four (1-10 Kms to the MKAD) are within as easy access to the MKAD and the city centre and fall within the same property price range, but are not located near any waste disposal sites. For the purpose of objectivity, these districts were selected for their overall ranking in terms of affordability and the increased rate of new residential developments. The following information was sourced from the www.cian.ru property database:

- average prices of apartments in select Moscow districts (January/February 2020);
- average rental rates for office space (January/February 2020);
- average rental rates for retail premises (January/February 2020);
- comparative real estate prices by select districts (3-5 year review);
- environmental data (air and soil quality);
- price analysis of properties located close to landfills and waste disposal sites (between 500 meters to 3 Kilometres);
- ecological factors that significantly affect the value of real estate were considered to be air pollutants — particularly, carbon monoxide (CO) and nitrogen oxides (NO and NO_2) — as well as the index for soil pollution.

Microsoft Excel was used for statistical analysis and plotting charts. Correlations coefficients for the property types were further analysed and the critical value determined as explained in the next section.

Findings

We conducted an empirical analysis of the dependence of the average cost of real estate in several Moscow districts on their proximity to waste disposal sites. All prices are in Russian Rubles. We found that there is a dependence of the real estate price on the distance to the municipal landfill and or incineration plant.

Our analysis revealed that there is a negative dependence between the location of waste disposal sites and property value; hence we reject the null hypothesis. On average, each kilometre away from the waste disposal sites (landfills and incineration plants) increases the price of real estate by 2-2.3% for apartments, 1.2-1.3% for rented offices and 1% for rented shopping areas (retail space). The significance of the findings was verified using Fisher's F-test, as well as Student's t-test. Both tests showed that our findings (models and coefficients) are significant at a significance level of 1%.

Based on the World AQI Ranking,[22] Moscow is generally considered to have moderate air quality. In 2017, Moscow ranked 8.4 and in 2018 fell to 10.1, indicating that the volume of soil and air pollution identified were still within acceptable global parameters. However, the

[22] World AQI Ranking: https://www.airvisual.com/world-air-quality

presence of smog, soot deposits and occasional foul odours is still largely felt in areas within 1-3 Kms from waste disposal sites. Even in small amounts, the presence of CO, NO and NO_2 may still lead to health issues if inhaled over a prolonged duration, and poor soil quality affects the surrounding environment. It should be noted, however, that most major landfill sites are located in the outskirts of the Moscow metropolis in the Moscow Oblast (Moscow Region) and that cases of air pollution poisoning have been recorded with children being the most affected.[23] So, while official statistics and indicators may show acceptable levels of pollution, the situation on the ground may be significantly worse with unmonitored carcinogens polluting the atmosphere, especially considering that most of these plants have been operating for over forty years (example the garbage incineration plant No. 2 was built in 1975) and only recently have begun to implement modern environmental safety measures which are seen as ineffective by the majority of residents living in close proximity to the plants, who continue to complain of their deteriorating health.[24]

The indices on environmental quality provide supporting metrics for evaluating the districts most affected by industrial and anthropogenic emissions from the waste processing plants and the MKAD and could support future research on the environmental impact assessment of the MKAD highway. The study provides evidence to show that the impact of environmental factors on real estate prices in Moscow is quite significant and this determines the overall attractiveness of districts in the city. The tables and figures below show an obvious negative correlation between average property prices and the location of landfills and waste disposal sites. Real estate prices are much lower in areas within 1-3 Kilometres from landfills or waste incineration plants. Moreover, in the neighbouring ecologically clean areas, the cost of apartments seems to grow significantly (Kurkino, Butovo, and so on). Our study further suggests that, despite other major variables in real estate selection such as distance from the city centre, metro location and social infrastructure, ecological factors play an important role in property selection and this trend has increased over recent years.

[23] About 77 children were hospitalized in the Volokolamsk District of the Moscow Oblast in March 2018: https://www.nytimes.com/2018/04/05/world/europe/russia-landfills-gases.html

[24] Residents of the Eastern District continue to complain about worsening health conditions because of the waste disposal plant: https://www.themoscowtimes.com/2019/08/15/moscow-trash-incinerator-spews-bright-purple-smoke-a66890

Table 1: Average property price and location of waste disposal sites - Correlation coefficient

Municipal Administrative District (Distance in Kms)	**Average Price ",000" Rub/m²**			**Concentration of harmful substances in the air µg/m³**				**Soil pollution index**
	Apartment	**Office**	**Retail Space**	**CO**	**NO**	**NO_2**		
Salaryevo ('Salaryevo' Landfill)								
3	153.30	9.74	13.80	153.00	3.20	2.40		128.90
2.7	151.80	9.66	13.76	154.10	3.21	2.43		129.00
2.5	148.17	9.62	13.73	155.00	3.23	2.44		129.05
1.7	146.87	9.58	13.70	155.40	3.24	2.46		129.09
1.5	146.00	9.54	13.68	156.00	3.25	2.48		129.15
1.2	145.27	9.51	13.65	156.70	3.25	2.50		129.20
1	144.00	9.45	13.57	156.77	3.26	2.52		129.38
0.8	143.50	9.40	13.50	156.85	3.26	2.55		129.50
0.5	143.00	9.38	13.40	156.98	3.27	2.56		129.60
Otradnoye (Garbage incineration plant No. 2)								
3	158.23	11.88	15.25	125.00	2.00	1.60		104.55
2.8	157.40	11.82	15.19	126.10	2.01	1.62		104.62
2.5	156.94	11.79	15.13	127.00	2.01	1.63		104.70
1.7	156.30	11.72	15.04	127.70	2.02	1.64		104.78
1.5	155.90	11.66	15.00	128.30	2.02	1.65		104.92
1.2	155.55	11.62	14.94	128.90	2.02	1.65		105.00
1	153.20	11.53	14.90	130.10	2.03	1.66		105.30
0.7	152.56	11.45	14.86	131.00	2.04	1.67		105.50
0.5	152.00	11.40	14.83	131.30	2.05	1.67		105.60
Biryulovo West (Garbage incineration plant No. 3)								
3	146.31	11.26	14.14	159.00	3.50	2.50		118.76
2.8	144.76	11.13	14.02	160.00	3.53	2.52		119.00
2.5	144.20	11.08	13.97	160.40	3.54	2.53		119.08
1.75	143.70	11.05	13.89	160.60	3.55	2.55		119.15
1.5	143.38	11.03	13.85	160.80	3.55	2.55		119.20

1.2	142.80	11.00	13.81	161.30	3.56	2.55		119.28
1	141.00	10.99	13.79	161.70	3.57	2.56		119.30
0.7	140.48	10.97	13.77	162.00	3.58	2.56		119.34
0.5	140.10	10.95	13.76	162.20	3.59	2.57		119.37
	Kosino-Ukhtomsky ('Nekrasovka' Landfill)							
3	149.34	9.44	12.45	193.00	4.00	3.10		148.30
2.75	148.00	9.40	12.40	193.30	4.03	3.12		148.37
2.5	147.10	9.39	12.39	193.45	4.04	3.13		148.44
1.8	146.00	9.37	12.37	193.60	4.06	3.14		148.48
1.5	145.00	9.36	12.34	194.00	4.07	3.15		148.55
1.3	143.10	9.34	12.30	195.10	4.12	3.16		148.63
1	141.34	9.31	12.26	196.21	4.15	3.17		148.70
0.7	140.00	9.25	12.24	197.00	4.20	3.20		148.90
0.5	139.35	9.20	12.15	197.40	4.22	3.22		149.00
Solntsevo	163.62	16.55	18.45	80.00	1.90	0.90		40.10
Kurkino	170.18	19.22	20.01	69.00	1.40	1.10		25.88
Chechora	165.85	20.13	17.83	43.00	1.50	1.20		37.66
Butovo North	167.57	19.76	18.44	55.00	1.30	0.70		24.97
Correlation coefficient for apartments				-0.87	-0.88	-0.87		-0.84
Correlation coefficient for office space				-0.91	-0.75	-0.81		-0.97
Correlation coefficient for retail property				-0.96	-0.88	-0.93		-0.99

Table 2: Significance of Correlation Coefficients

Significance of correlation coefficients				
Correlation coefficient for apartments	22.15742006	24.40670669	22.56024596	17.74185627
Correlation coefficient for office space	31.87886741	10.59482103	14.55400377	92.80881779
Correlation coefficient for retail space	83.29351581	24.11082339	42.47272096	248.0616836
			Critical Value	**2.707913184**

Table 3: Price variation by distance (in Kms) from landfill and incineration sites (Moscow)

District	Apartments		Offices		Retail Space	
	%	RUB ,‘000’	%	RUB ,‘000’	%	RUB ,‘000’
Salaryevo (‘Salaryevo’ Landfill)	2.81 %	3.941	1.41%	0.132	0.99%	0.133
Otradnoye (Garbage incineration plant No. 2)	1.50 %	2.280	1.55%	0.177	1.10%	0.162
Biryulovo West (Garbage incineration plant No. 3)	1.55 %	2.167	0.89%	0.097	1.00%	0.137
Kosino-Ukhtomsky (‘Nekrasovka’ Landfill)	2.82 %	3.886	0.85%	0.078	0.81%	0.099

Table 4: Model Significance Test

District	Apartments	Offices	Retail Space	Concentration of harmful substances in the air µg/m³			Soil pollution index
				CO	NO	NO2	
Salaryevo	1.98518E-05	4.13083E-06	0.000506847	3.27012E-05	5.05455E-06	6.64321E-06	0.000250864
Otradnoye	0.000191146	1.26183E-05	9.6692E-09	4.88893E-06	0.000241155	8.74768E-06	0.000185166
Biryulovo West	7.48938E-05	0.000313339	1.52666E-05	3.15251E-05	4.71773E-05	2.15023E-05	0.000104968
Kosino-Ukhtomsky	4.42901E-06	0.000266314	8.0513E-05	0.000350546	8.63652E-05	4.87568E-05	9.37042E-05

The property price is further presented in the form of the regression model (Table 5):

$$y = a0 + a1x$$

Where:

- y is the dependent variable: real estate price (thousand rubles);
- x is the independent variable: distance from the landfill (in Kms);
- a0 is the average property base price;
- a1 is the relative amount increase per Kilometre from the waste disposal site.

Table 5: Regression Model

District	Average Price (y = a0 + a1x)		
	Apartments	Offices	Retail Space
Salaryevo (‘Salaryevo’ Landfill)	y=140,355+3,941*x	y=9,32335+0,132*x	y=13,4234+0,133*x
Otradnoye (Garbage incineration plant No. 2)	y=151,567+2,280*x	y=11,3598+0,177*x	y=14,7481+0,1642*x
Biryulovo West (Garbage incineration plant No. 3)	y=139,382+2,167*x	y=10,8901+0,097*x	y=13,6616+0,137*x
Kosino-Ukhtomsky (‘Nekrasovka’ Landfill)	y=137,861+3,886*x	y=9,20893+0,078*x	y=12,1562+0,099*x

A survey of Moscow residents was conducted to assess the environmental situation in the city districts. The survey was held online for a month (from June 24 to 24 July 2020) using primarily the Yandex.Rayon service, which is an internet platform of Russia's tech giant Yandex. The service allows neighbours and local organizations to share information, request and offer services, jointly solve problems and improve life in their neighbourhoods.

During the survey period, 921 residents took part in the questionnaire, which is a representative sample of the city's population. The respondents were asked to indicate their age-group and area of residence in Moscow. The majority were residents aged 25 to 64 years in approximately the same proportion (an average of 20% in each age-group variated by a span of 10 years); approximately 10% of the respondents were over 65 years old and 5% were aged between 18 to 24.

Our survey revealed that the majority of Moscow residents (52.4%) do not sort their household waste, even though they said that their districts were equipped with some form of at-source waste sorting system (for plastic, glass and paper waste). At the same time, 42.4% of respondents were positively engaged in sorting their household waste, while 5.2% had not even known about such a possibility before the survey. For those currently sorting their household waste, we evaluated the impact of the COVID-19 pandemic on their decision to continue sorting waste: 75% said that they continued to sort their waste as usual, and some stated that they started sorting their household waste during the self-isolation period; 12.5% said that they faced new challenges with sorting waste, while only 10.5% had to completely abandon sorting their household waste due to the current COVID-19 pandemic.

Regarding neighbourhood pollution, 58.6% felt that their neighbourhood was polluted and primarily attributed this to air (92.1%), noise (67.4%), water (29.6%) and solid waste (28.1%) pollution. 25% of respondents stated that some form of waste disposal plant was located close to their residences and 37.4% had no idea if such facilities existed in their neighbourhoods. Interestingly, 71.7% of all respondents felt that the waste collection and sorting system in their neighbourhood was inadequate.

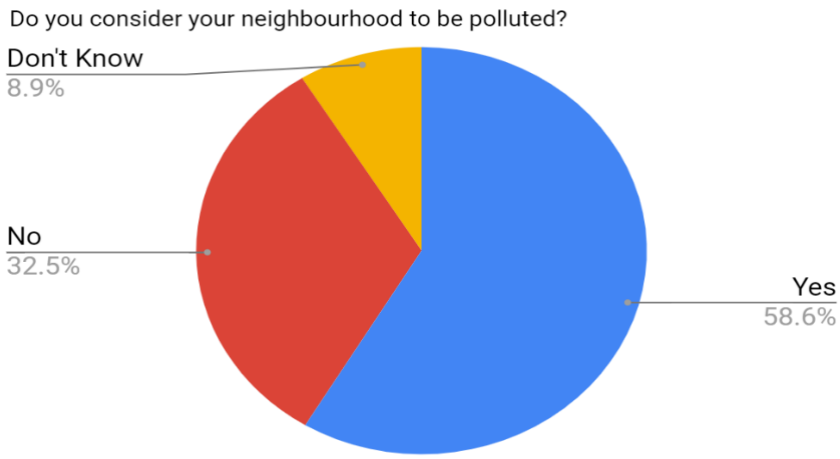

Figure 5. Survey of Moscow Residents (Question 4).

Respondents were also asked to rate key factors in their selection of residential property. Six factors were listed: property price, distance from the city centre, accessibility of public transport, ecological situation in the area, type of building and developer. 661 people (71.7% of all respondents) assessed the environmental component ('ecological situation in the area') as 'very important', which surprisingly ranked higher than two other leading factors — 'real estate prices' and the 'availability of public transport'. This shows that Moscow residents are highly sensitized about their environment and prefer residing in areas with good ecological conditions.

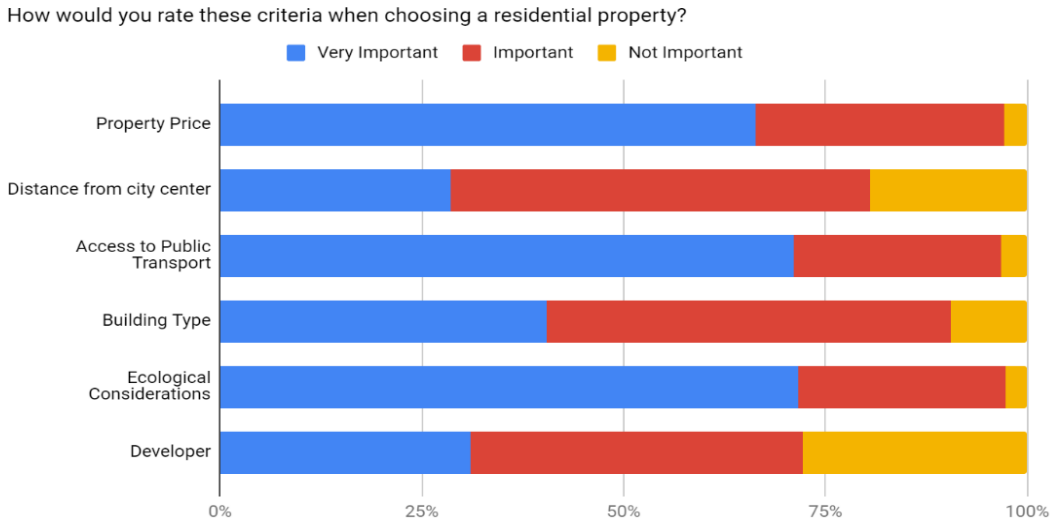

Figure 6. Survey of Moscow Residents (Question 5).

Our focus group discussions provided further insights on the ecological situation in the Salaryevo and Nekrasovka districts. The 'Salaryevo' landfill remediation covers 590,000 square metres. The reclamation project approved by the Moscow Urban Planning and Land Use Commission was initially planned to facilitate transport infrastructure in the region. Currently, it is being managed by 'Pik Group', a well-known mass housing property development company,[25] which has reported its successful efforts in reducing leachate and bio-gas levels. As a result, the land use for the area was amended in 2016, providing allocations for new residential development in the area, which are currently situated 500 meters from the decommissioned landfill (Figure 7). During our site visit, there was no foul smell in the area and residents were generally pleased with the landfill reclamation project. The same cannot be said for Nekrasovka, where the ecological situation is notably worse. During our multiple site visits to the district, we noticed a recurring foul stench emanating from the Lyubertsy Aeration Station (LOS) and the waste incineration plant No.4. Some residents confirmed that the stench of hydrogen sulphide was permanent in the area and depended largely on the wind direction. Local residents are in the process of gathering signatures for a petition to combat air pollution in the area.

[25] https://www.pik.ru/recultivation

Figure 7. Salaryevo Landfill Moscow. Photo taken by Authors.

Case Study: Gentrification in Nekrasovka, Lyubertsy District

Gentrification often drives changes in the local housing market and boosts new businesses (Pardo et al. 2020), it could also be seen as the precursor of neighbourhood revitalization, as in the case of 'Nekrasovska' in the South-Eastern Administrative okrug, in the Lyubertsy District.[26] Nekrasovka is considered one of the fastest growing micro-regions in the Moscow metropolis and provides mass housing for middle-income, especially young, families. Nekrasovka is quite unique, as it is located within the Lyubertsy District of the Moscow Region (Moscow suburb). Until September 2011, most of its current territory (the Lyubertsy fields) was part of the Moscow Region. Lyubertsy is for the most part an industrial district and accommodates a much disputed landfill. This landfill was operational between 1997 and 2000 and was handed over to the Moscow authorities for remediation in 2009 but still bears ecological concerns for residents in the area.[27]

Figure 8. Map showing Nekrasovka landfill in close proximity to residential buildings. Source: Yandex Maps[28]

[26] Lyubertsy District Map: https://yandex.ru/maps/-/CCQpNWAcpC

[27] Lyubertsy Ecological Petition: https://democrator.ru/petition/ekologicheskaya-katastrofa-v-lyubercahnekrasovkeko/

[28] https://yandex.ru/maps/-/CCQpR0r21C

Multiple industrial sites are also located in the vicinity, resulting in overall poor ecological indices and low property pricing in the area. Nonetheless, in recent years developers have been allocated land close to the old landfill site; specifically, less than 500 meters, which is the standard norm for decommissioned sites. It is unclear if this development was spurred by modern urban planning considerations, developer lobbying or corruption (Torsello 2012), but the effects are vividly observable in the rapid revitalization of the district, which includes state-of-the-art infrastructure and transportation routes. The announcement of the new 'Nekrasovka' subway line in 2012 increased the local property value by 7-10% and after the launch of four of eight stations along this line in June 2019 the property value of newly constructed residences increased by a further 6%, regardless of the ecological considerations in the area[29] and continues to rise steadily as more young families. Figure 9 below shows the landfill next to a residential block with ongoing excavation works.

Figure 9. Nekrasovka Landfill located beside residential buildings. Photo taken by Authors.

Gentrification is not only felt through the new real estate developments in the region but also via outward urban mobility (Krase and DeSena 2015 and Krase and DeSena eds 2020), as most young families seek affordable housing solutions in the city's periphery, particularly in areas with relatively good access to public transport, especially the subway. A measure of social inequality as discussed by Pardo and Prato (2020) can also be seen in the social infrastructure differentiation between areas considered 'Moscow city' and 'Moscow region', despite these areas being less than ten minutes drive from each other. A photographic comparison is shown in Figure 10 and 11 below.

[29] https://www.irn.ru/geo/rayon_nekrasovka/

Figure 10: Lyubertsy Moscow Region - Bus Transport Services. Photo taken by Authors.

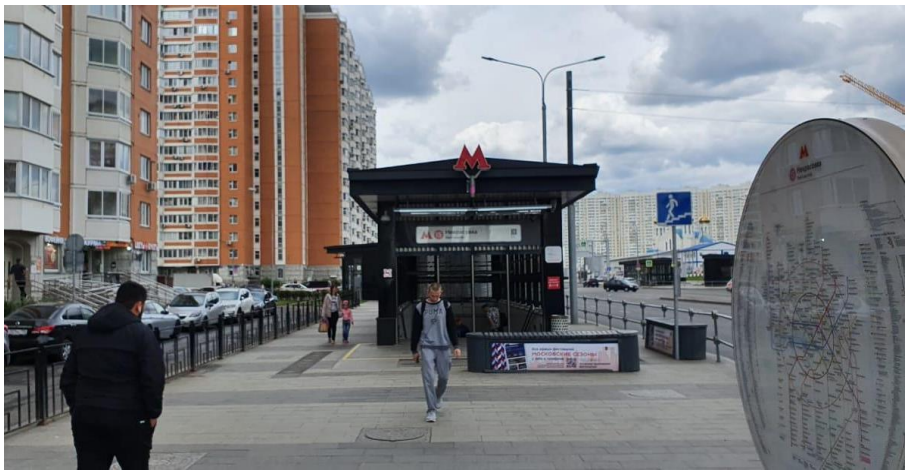

Figure 11. Lyubertsy Moscow City - Subway Transport Services 'Nekrasovka Station'. Photo taken by Authors.

Conclusion

This study shows that ecology plays an important role in economic decisions and impacts our everyday lives. The analysis of current real estate data and our qualitative study further reveals that:

1. The ecological factor is important for Moscow residents when selecting properties for residential, business and retail purposes;
2. Waste disposal sites have a negative impact on the surrounding local economy, which is evident through property devaluation.
3. The variance devaluation of properties located close to waste disposal sites in Moscow as compared to properties in other districts with similar economic indices is upwards of 17-20%; and it is 30-36% when compared to districts with above higher economic and ecological indices such as the western and south-western districts.
4. Property prices are further devalued by about 1-3% for every 1 Km from the landfill, depending on the economic purpose of property (residential, business or retail).

Most people are generally reluctant to live in areas with a high pollution index, and most young families and elderly folk will seek locations in the suburban outskirts of town in the hope that there city fumes and industrial pollutants will be much less. Unfortunately, the situation is not as straightforward in Moscow, where industries, landfills and waste incineration sites are located at the periphery to avoid epidemiological outbreaks in a congested metropolis with 12 million residents. This has resulted in increased pollution in the suburbs and lower property prices along the concentric MKAD ring road.

We have seen that waste management influences multiple factors in various sectors; specifically, public administration and spatial economics. The efficiency of structured processes and the implementation of new technologies in landfills and waste incineration plants can provide improved ecological welfare for citizens and boost the local economy, including realty value. As seen through multiple cases, *hedonistic sustainability* is achievable and may be the only solution for a densely populated metropolis like Moscow. This option will undoubtedly involve tremendous political will, large budgetary investment, community buy-in and much creativity, but in the long-run the outcome could ensure a better district ecology. Interestingly, our study reveals that this system is already gaining some foothold with local property development companies that are working towards the remediation of decommissioned landfills. Further research into various case of neighbourhood revitalization through hedonistic sustainability initiatives even at a local level could provide much-needed socioeconomic and ethnographic perspectives for efficient urban planning.

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