

*Derelict Land, Deprivation, and Health Inequality in Glasgow, Scotland:
The Collapse of Place*

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Abstract

The population of Glasgow, Scotland has very poor health, compared to Scotland as a whole and the rest of the U.K., and even compared to other post-industrial cities with similar levels of deprivation and worklessness. This research maps and analyzes several health indicators to examine health inequities *within* Glasgow and explore the spatial correspondence between areas of poor health, high deprivation, and proximity to derelict land, much of which is contaminated from past industrial uses. People in high deprivation areas are significantly more likely to be hospitalized for respiratory disease and cancer; have low birth weight infants; and for men to have much lower life expectancy than those not living in the high deprivation areas, indicating substantial health inequities within Glasgow. They are also much more likely to live in close proximity to derelict land. A methodology is described for creating an index (PARDLI - Priority Areas for Re-use of Derelict Land Index), combining scores for these health, deprivation, and environmental variables. The Index is used to select and prioritize communities for resource allocation and planning efforts. Strategies for re-using the derelict land for the communities' public health benefit and neighbourhood regeneration are outlined, including urban agriculture/community gardens, urban forestation, active and passive recreation areas, and linkage to existing open space networks and natural areas.

Keywords:

Health inequities, deprivation, Glasgow, post-industrial, vacant and derelict land, brownfields, PARDLI index, open space, greenspace, urban agriculture, community gardens, community regeneration, urban planning

Background – The Collapse of Place

“The decline in [community] health is the inevitable outcome of the collapse of place.” [1]

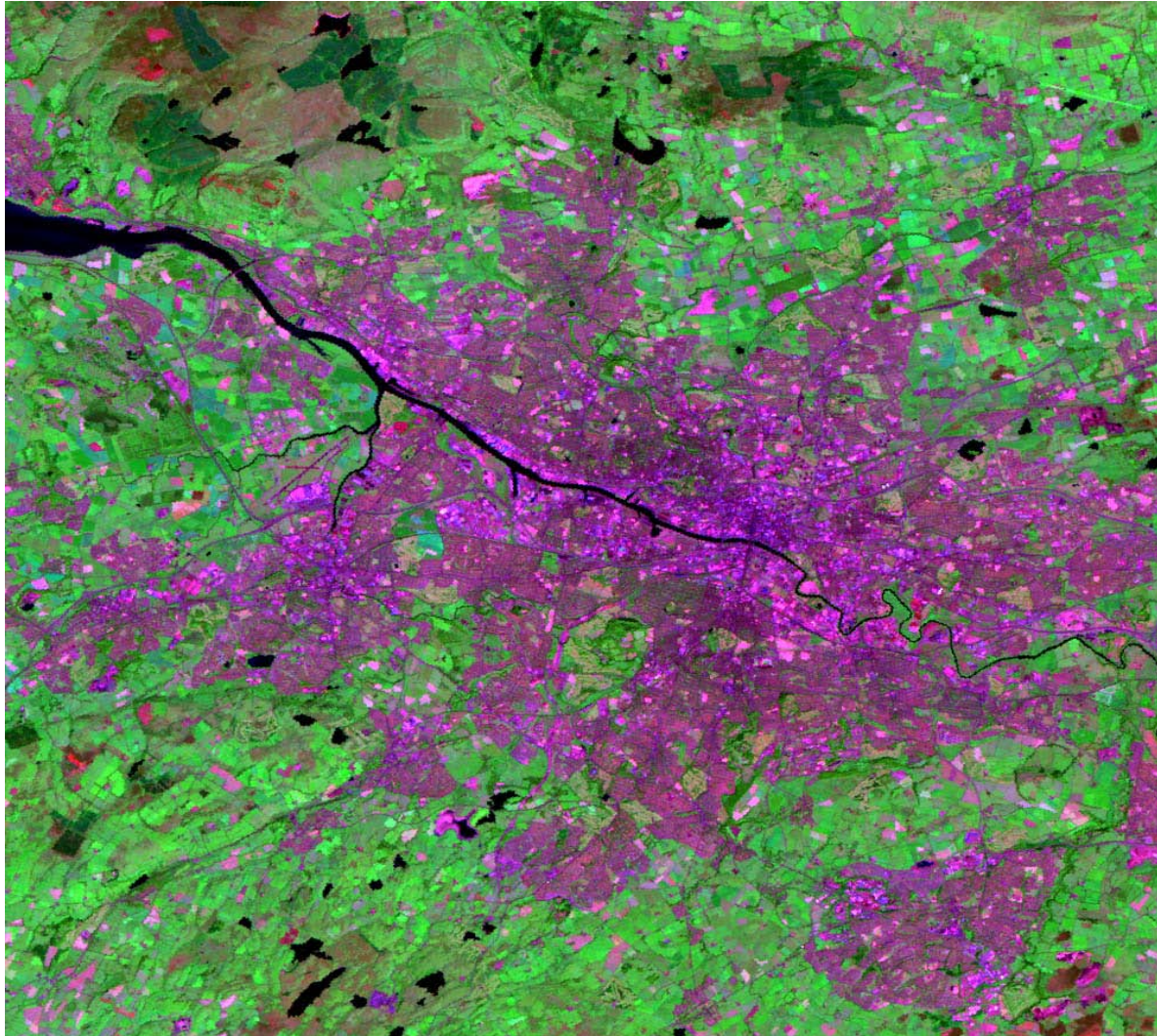


Figure 1 - False-color satellite image of Glasgow, the purple areas showing the extent of urbanization.

Glasgow is Scotland’s most populous city, with nearly 600,000 people. It covers an area of 68 square miles, and is located along the north and south banks of the River Clyde in West Central Scotland. [Figure 1] Since World War II it has become one of the quintessential examples of a post-industrial city whose fortunes suffered a sharp decline and many of whose peoples’ lives epitomize the tragedies of the dependency culture of the modern welfare state, rapid deindustrialization, urban blight, multi-generational worklessness, hopelessness, and random violence, some of which was instigated by faulty policies at the national level. Although the city began to turn itself around in the 1980’s, these negative perceptions and realities remain an influence on the health status of its residents.

The enduring poor health status of Glasgow’s population has been well-documented. According to the World Health Organization, [2] life expectancy for males in some Glasgow neighbourhoods is only 54 years, a shocking figure for an affluent nation, especially one with universal access to health care. This life expectancy is lower than that of many less-developed countries whose people have minimal access to health care and are exposed to communicable

diseases that by and large have been eradicated in Scotland. In comparison studies between Glasgow and other formerly highly industrialized cities, both in the United Kingdom and abroad, Glasgow's mortality rates are much higher, and health is not improving as quickly [3-6]. In "*The Grim Reaper's Road Map*," a recent atlas of mortality and other health indicators for all U.K. constituencies, Glasgow consistently shows up as a dark blotch, indicating the worst possible value for nearly every health variable being mapped [7]. Scotland as a whole suffers from inequalities in health, based on degree of deprivation, as compared to other parts of the U.K. and Europe, [8] but even within Scotland, Glasgow stands out as having worse health overall and higher inequalities. There seems to be no obvious explanation of why Glaswegians tend to have such poor health outcomes, even when compared to cities such as Liverpool and Manchester, whose populations are equally deprived economically, under stress from worklessness, and share a similar industrial history and culture [9].

The extreme health disparities between Glasgow's population and the rest of Scotland and the U.K. include metrics such as low life expectancy, high proportion of low birth weight babies, and high rates of hospitalization for diseases such as diabetes, cancer, respiratory illness, and heart disease [10, 11]. However, these figures represent city-wide averages. In Glasgow, the figures for individual neighbourhood health outcomes vary widely, and the health disparities/inequities that exist *within* Glasgow (differences in health outcomes amongst the wards, census districts, and neighbourhoods of Glasgow) need to be comprehensively mapped and analyzed spatially in order to compare these within-Glasgow differences and ascertain the magnitude of health inequities within the city. This paper reports on a mapping study of adverse health outcomes by census Data Zones within Glasgow, in relation to deprivation status and a specific category of environmental burdens – namely, vacant and derelict land (VDL).

The Deprivation-Health-Environment Connection

The connection between deprivation and poor health has been understood since at least the early 19th century [12]. After a fever epidemic struck Glasgow in 1843, Dr. Robert Perry, a surgeon at the Glasgow Royal Infirmary, mapped the homes of the fever victims in relation to socio-economic status in the various wards of the city, which also served as a proxy for housing and general environmental conditions. There was an extremely high degree of spatial correspondence between the two variables. On the map Dr. Perry produced, it is very striking how the affluent neighbourhoods of the city had few fever victims, but in the poorer areas - where clean water was not readily available, refuse and human waste piled up on the streets, overcrowding was rampant, housing did not have sanitary provisions, and industrial facilities with their attendant pollution were in close proximity to the homes - the epidemic was rampant [13]. Dr. Perry's maps and statistics successfully show the links between poverty, adverse health outcomes, and poor environmental conditions.

It may seem obvious to us today that there is a connection between deprivation and poor health, but there is also a link between deprivation and environmental burdens that has been less often acknowledged, especially prior to the environmental justice movement having brought it to the public's attention starting in the late 1980's-early 1990's [14 - 17]. In the United States, this connection between high deprivation populations and proximity to environmental burdens has an important racial and ethnic component. However, because minorities are disproportionately represented in the lowest economic subgroups, race/ethnicity and socio-economic status are inextricably linked in the U.S., and it is difficult to separate the effects of income/poverty level from race [18, 19]. In Scotland, race/ethnicity may also be a factor in environmental health justice, but because of the relatively much lower numbers/proportions of racial/ethnic minorities in Glasgow, and the high numbers of poor non-minority people, it is believed that the multiple deprivation index alone suffices to measure the possible connections between health inequities and proximity to environmental burdens.

Reporting on a study pertaining to all of Scotland, Fairburn, et al state that “For *industrial pollution, derelict land and river water quality* there is a strong relationship with deprivation. People in the most deprived areas are far more likely to be living near to these sources of potential negative environmental impact than people in less deprived areas,” [20]. Glasgow, having more of its share of industrial activities over the past few centuries than other parts of Scotland, would therefore also likely see these effects experienced more severely by the poorer populations than many other places.

The Landscape of Industrial to Post-Industrial Glasgow

In the 18th through the early 20th century, Glasgow was called “The Second City of the Empire,” due to its importance as an industrial center and economic engine for the United Kingdom and the entire British Empire. Many of the industries prevalent in Glasgow and the Clyde River Valley at that time were “dirty” ones, with high levels of air pollution, toxic and dangerous chemicals routinely used in industrial processes, and environmental degradation of the surrounding areas. These industries included shipbuilding, steelmaking, coal mining, textile fabrication, dye works, brick works, rope works, tanneries, distilleries, railway locomotive works, cast iron foundries, chemical manufacturing, and the transportation industry [21-24].

The population of Glasgow increased dramatically during the period of intensive industrialization, and by the end of the 19th and beginning of the 20th centuries, Glasgow had one of the highest population densities in the world: about 700,000 people concentrated in three square miles of central Glasgow. Most of the city’s population lived in overcrowded conditions in 3- and 4-storey sandstone tenement buildings, often entire large families in one or two rooms [10, 25 - 28]. There was little in the way of provisions for clean water and sanitation, and both communicable and chronic diseases were endemic. In the 1920’s and 30’s, these areas were acknowledged as being the worst slums in Great Britain. In the inter-war and post-WWII periods, large portions of Glasgow’s tenement neighbourhoods were demolished and people were relocated to new housing estates and high-rise blocks of flats, often in peripheral areas at a distance from city centre. These new housing schemes, while offering modern amenities not previously available in the tenements (such as bathrooms within each dwelling unit, modern kitchens, and increased space and privacy), had important drawbacks: they were typically not well-constructed, were difficult and expensive to heat well, had inadequate transportation connections to the rest of the city, negligible shopping provisions, and helped to destroy the existing community life and social infrastructure of the old tenement neighbourhoods [26].

By the 1960’s, Glasgow was no longer the industrial powerhouse that it had been, owing to shifts in the global economy, changes produced by increasingly technological processes, and policy decisions at the national level designed to de-industrialize Scotland and diminish the strength of its highly unionized workforce. Factories and shipyards closed by the dozens, and the aftermath of this process was the visual blight of de-industrialization and abandonment in large swathes of the city, and the multi-generational worklessness that afflicts many Glaswegian families to this day. This problem of worklessness, in turn, has led to physical and mental health problems amongst the residents [29].

There are many anecdotal explanations for Glaswegians’ poor health, primarily circulating around individual behavioural issues of excessive drinking, smoking, drug use, violence, and poor diet. Poor quality housing, with damp and mold, is also offered as a possible reason for poor health. The poverty and worklessness also translate into stress-related problems, mental breakdowns, feelings of hopelessness, loss of confidence in the future, alienation, and lack of control over their own lives, which can have direct and indirect physical health consequences [30]. Doubtless these are all valid reasons, and surely explain, at least partially, Glasgow’s overall poor health, which is likely due to a complex combination of factors, and not any one thing.

But what about the external environment? Might not some of the high levels of poor health and health disparities be due to environmental factors? And even if causal links between environmental burdens and the overall poor health in Glasgow cannot be definitively demonstrated, wouldn't it be worthwhile to apply the precautionary principle in the absence of evidence to the contrary, and improve environmental conditions in the most deprived and least healthy places, where people are the most vulnerable? "When an activity [or lack of activity, in the case of VDL] raises threats of harm to human health or the environment, precautionary measures should be taken, even if some cause and effect relationships are not fully established scientifically," [31]. The precautionary principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk.

Environmental Justice and Vacant and Derelict Land in Glasgow

Environmental justice (EJ) is the concept that environmental benefits and protections should be distributed equally amongst all populations, and environmental burdens should not disproportionately impact any subpopulation [32]. Most often, however, low-income communities, immigrant neighbourhoods, and communities of color bear a disproportionate burden of our pollution problems, whilst experiencing fewer environmental benefits and protection. There is a substantial body of evidence from previous research that has accumulated over the past 2 decades, as evaluated in a 2010 comprehensive review of the literature by Brender, Maantay, and Chakraborty, that has found that proximity to environmental pollution is linked to poor health outcomes, and that this tends to disproportionately affect poor and minority populations [33].

The issues surrounding environmental justice in Scotland have been less often-researched, and EJ appears to be a more recent concern here than, for instance, in the United States. However, EJ in Scotland has been discussed in several books and papers covering environmental conditions, although health inequities are not the major focus, and differences amongst communities within any particular city are not addressed [34 - 37].

Due to the preponderance of vacant and derelict land in Glasgow, and the fact that the sites appear to be located primarily in the most deprived areas, this research concentrates on vacant and derelict land as an environmental burden and a potential environmental justice concern. There are 1,300 hectares of vacant and derelict land (VDL) in Glasgow, with 927 individual sites, many of which are contaminated from past uses [38, 39]. This constitutes nearly 4% of Glasgow's total land area, and Glasgow's vacant/derelict land makes up over 12% of all Scotland's vacant/derelict land. Amongst Scottish Local Authorities, Glasgow has the highest amount of urban vacant land, in terms of both absolute number of hectares, as well as percentage-wise, by a very wide margin [10]. Approximately a third of the VDL sites have been vacant or derelict since 1990 or earlier, with about 10% of the VDL sites vacant or derelict since 1980 or earlier, or more than 30 years.

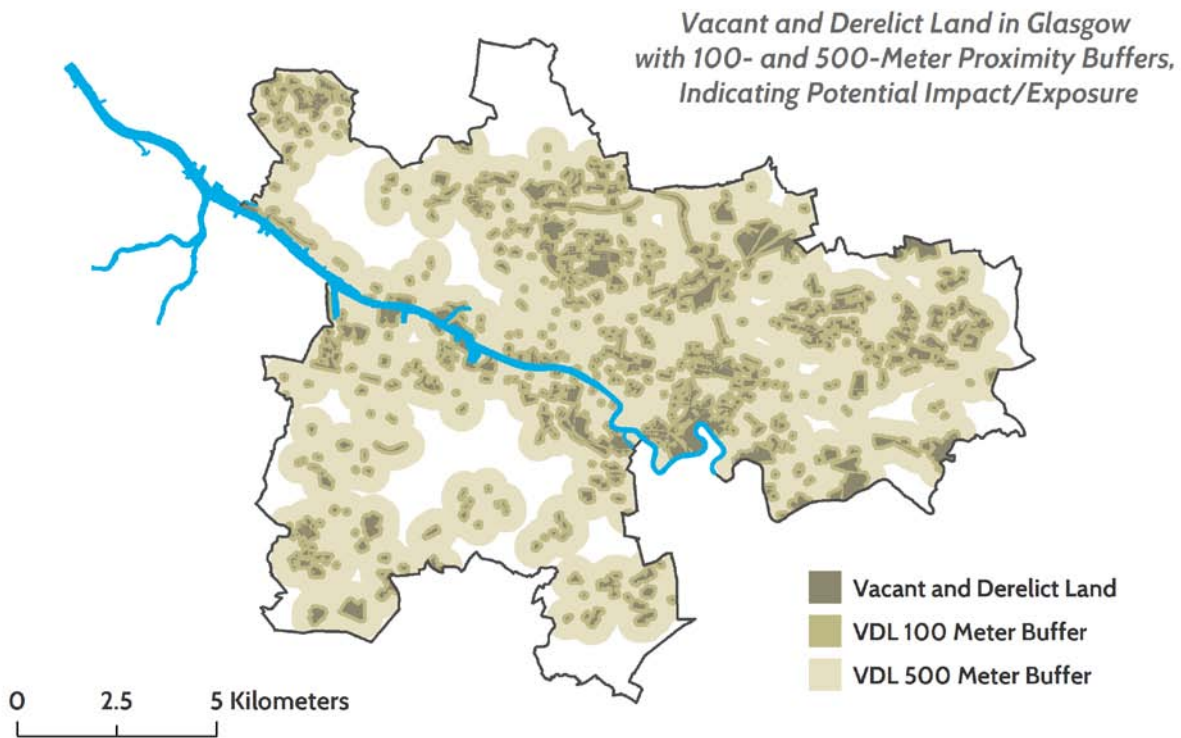


Figure 2 – Vacant and Derelict Land in Glasgow, with 100- and 500-meter proximity buffers, indicating areas of potential impact/exposures. *Data Sources:* UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL).

Over 60% of Glasgow City’s population lives within 500 meters of a derelict site, and over 92% live within 1,000 meters of a derelict site. [Figure 2] (Five hundred meters is a generally accepted distance threshold in environmental analysis for assessing potential impact or exposure to contaminants. I have added a 100-meter buffer to the map to show a more conservative alternative exposure zone. A 1000-meter buffer would blanket virtually the entire city.) Glasgow has the highest percentage of people living in close proximity to VDL of any local authority in Scotland [39]. Most of this vacant and derelict land lies within the most deprived data zones - thus, VDL is an important and significant aspect of environmental injustice in Glasgow. The distribution of VDL disproportionately affects the poorest populations who, for many reasons, may also be the most vulnerable, health-wise. Previous research has demonstrated that given the same exposure to pollution or other environmental hazards, the people of lower socio-economic status will be more susceptible to their effects than the more affluent, due to existing health and quality-of-life vulnerabilities, material deprivation, and psychosocial stressors [40]. The impact of neighbourhood blight and incivilities and the perceptual attitudes must also be taken into account in assessing risk to vulnerable populations [41].

What types of industries in the past were occupants of the now-derelict land, and what might the specific contaminants be that remain? Based on the known industries located in Glasgow (as mentioned in the section above) the following carcinogenic or otherwise harmful substances were likely in use and emitted to the environment: bonding agents, e.g., formaldehydes, and plastic compounds (polyurethane, acrylics and polyvinyl); asbestos; coal tar/creosote; phenols; cyanide & sulphur; heavy metals, e.g., cadmium, lead, barium, chromium; phytotoxic metals (damaging to plants), e.g., copper, nickel, zinc; plating salts, e.g., various compounds, some containing cyanide; aromatic & chlorinated hydrocarbons, e.g., benzene, trichloroethane, trichloroethylene, toluene, ethylene, xylene; fuel additives, e.g. MTBE,

hydrochloric acids, chloride & sulphide compounds; solvents, e.g., kerosene, white spirit; fuels and fuel byproducts, such as diesel, petroleum, aromatic hydrocarbon fractions, mineral oils, hydraulic fluid, engine oils, anti-freeze, petrol additives, diesel additives and detergents; inorganic compounds, such as borates, bromide, fluoride phosphate & ammonium compounds (salts); chlorinated organic compounds, e.g. TCE, PCE; sizing agents, e.g., PVA, poly-acrylic acids [42].

These contaminants can live on in the environment long after the industry that produced or used them is gone. Exposure to the contaminants is an on-going concern, particularly because children and youth often make use of VDL for impromptu playgrounds and football fields. There are a number of potential health impacts and pathways of exposure. Research has linked proximity to contaminated sites with pre-term and low birth weight infants, fetal deaths, congenital malformations, heart disease, various cancers, and respiratory disease [43 - 51]. Contaminant exposure may occur through airborne means, especially when soil is disturbed, through dermal contact, or ingestion of soil or groundwater (although Glasgow's drinking water supply does not rely on the City's groundwater). Aside from direct exposure to contaminants, VDL is often unsafe and hazardous land to enter, and the effects of the resultant visual blight of vacant land reduces quality-of-life and may result in additional day-to-day stressors on residents [52].

Many areas of Glasgow have become little more than "sacrifice zones" - areas where the physical conditions are so poor that in an urban planning triage situation, given limited resources, some planners and economists consider that the sensible thing to do is to put the resources where there seems to be a hope of a turnaround, rather than throwing good money after bad, as it were. Thus, the very worst areas in terms of deprivation and health frequently do not get the additional resources to make a difference. Another related problem, which is common in virtually all cities and is not particular to Glasgow alone, is that governmental resource allocation is often not based on a rational objective assessment of need, but is decided on a more case-by-case basis, often driven by political expediency, or from opportunities that arise unpredictably for private investment. This analysis seeks to replace the subjective approach by providing decision-makers with a more quantitative, evidence-based foundation for determining priority areas.

Objectives

"Rebuilding brownfields neighborhoods through an integrative public health and planning approach will be essential for improving the odds for sustainable redevelopment and securing long-term gains in public health," [48].

Taking into account the spatial distribution of deprivation and health inequities, and examining the spatial correlation between these indicators and the locations of VDL and potentially contaminated sites, where might we prioritize community participatory interventions to utilize these derelict lands for the benefit of the affected communities? In other words, based on the spatial analysis, which areas in Glasgow have high deprivation, poor health outcomes, large amounts of vacant and derelict land, and would benefit from additional neighbourhood parks, natural areas, greenspaces, or other community uses?

What kinds of "ecological services" might these derelict lands provide the affected communities and the larger region? These ecological services might be flood control, stormwater management, urban agriculture, open space, natural areas, or recreational space for the surrounding communities or wider region. Temporary uses could also be considered, such as containerized gardening, or planting for phyto-remediation or phyto-stabilization, with eventual harvesting of the trees [53, 54].

The aim of this research is not to prove causality between vacant and derelict land and adverse health outcomes. This would be extremely difficult to do, considering the lack of data available on three key variables: specifics on the actual type and magnitude of site contamination in Glasgow; records of individual health outcomes; and residential mobility (since many diseases,

particularly cancers, have long latency periods). However, there is very likely to be a risk associated with living near many of these vacant and derelict sites, given the history of industrial land use in Glasgow, especially since even a site formerly used for housing might have originally been built on land contaminated by industry.

Regardless of whether or not the actual risk of exposure involved can be demonstrated, the populations in these areas are very vulnerable on a number of levels: they are already suffering from higher than expected rates of many diseases, do not enjoy long life expectancy, and have to bear the stress of poverty and other forms of deprivation. Therefore, there is a strong environmental health justice imperative in determining which neighbourhoods in Glasgow have the highest need for planning and implementation interventions and resource allocation.

Methodology and Analyses

Rationale for Decisions about the Spatial Analysis:

The boundaries of the City of Glasgow were selected as the extent of the study area, in order to provide a high level of consistency, availability, and comparability of data. Some of this consistency would have been sacrificed if the study area extent had been expanded to include surrounding suburbs, which make up the Greater Glasgow region, and lie within several different local authorities. The government's census Data Zone (DZ) was selected as the most appropriate unit of data aggregation, since each data zone comprises ~750 people on average, which is small enough to get a reasonably fine-grained perspective of the issues, and to conduct detailed spatial analysis, but not so small that the statistical problem of "small numbers" would be a problem in most cases. There are 694 Data Zones in Glasgow. For some variables (i.e., Life Expectancy), it was necessary to use the larger-extent Intermediate Data Zone (IDZ) as the spatial unit, since data at a smaller extent would be unreliable due to small numbers, and for some variables the IDZ was the smallest extent available. There are 134 Intermediate Data Zones in Glasgow.

Exploratory Spatial Data Analysis

Exploratory Spatial Data Analysis (ESDA) is intended to allow relationships, patterns, and correlations to be revealed, clarified, and better understood. It is primarily used to generate hypotheses, and as a screening technique to indicate potential areas of fruitful further inquiry and research. A number of variables were mapped in order to formulate research questions and hypotheses, to investigate the issues on a first-pass screening basis, and to ascertain by visual inspection whether or not there are likely health inequity issues within Glasgow City. These variables are the following: the Scottish Index of Multiple Deprivation (SIMD); Health Decile, per DZ (derived from the SIMD's Health Domain); Rates of cancer hospitalization per 100,000, per DZ (CANCER); Rates of respiratory disease hospitalization per 100,000, per DZ (RESP); Low Birth Weight Infants as a percentage of all live births, per DZ (LBW); and Male Life Expectancy, per IDZ (MLE). These data were all obtained through the Scottish Government's National Statistics – Scottish Neighbourhood Statistics website [55].

The SIMD is a weighted index, and is frequently used as a proxy metric for allover deprivation. It is compiled from 38 indicators in 7 domains, which are income, employment, education, housing, health, crime, and geographic access. The income and employment domains carry the most weight in the Index, at 56% combined. By contrast, the health domain, itself made up of 7 variables, is weighted at only 14%. The health indicators in the SIMD are: standardized mortality ratios; alcohol-related hospital episodes; drug-related hospital episodes; comparative illness factor; emergency admissions to the hospital; proportion of the population being prescribed drugs for depression, anxiety, etc.; proportion of low birth weight infants [56]. The Scottish government uses a threshold of the most deprived 15% of the DZs for analysis and comparison purposes, particularly in longitudinal studies, looking at change over time. The SIMD was used in

this analysis rather than a simple “income” or “poverty” variable, since the SIMD encapsulates a variety of deprivation measures, not just monetary ones. However, by mapping income deciles it was seen that there is almost total spatial correspondence between the worst income deciles and the 15% worst ranks (i.e., the highest deprivation levels) of the SIMD, by DZ. The SIMD rank data are for 2009, the most current year available.

Health data are from 2009, covering the years 2005-2009. The health variables used in this study were selected as being salient factors in the overall poor health in Glasgow, and are fairly representative of the major types of health concerns. Arguments could be made that using more or different categories of health outcomes would have yielded better or different results. However, through consultation with a number of public health and medical geography professionals working in Glasgow and very familiar with its health conditions, it is believed that these variables as selected accurately capture the overall health status of each DZ. Additionally, because the SIMD’s health domain for the most part includes different variables than the ones selected here, there was a lesser risk of magnifying or double-counting the effects of health, or having confounding factors, yet by using both indices, achieve good coverage of a variety of health outcomes.

These SIMD and health indicators were then examined in relationship to the location of the vacant and derelict sites, which were then also buffered with 500-meter and 100-meter exposure buffers. The vacant and derelict land data (non-spatial attribute data) were obtained from the Scottish Government’s Survey on Vacant and Derelict Land, 2011, published in January, 2012. The spatial data for the vacant and derelict land was obtained through the Glasgow City Council’s Development and Regeneration Services. The variables were all mapped and visually examined in relationship to the location of vacant and derelict land. [Figures 3 – 8]

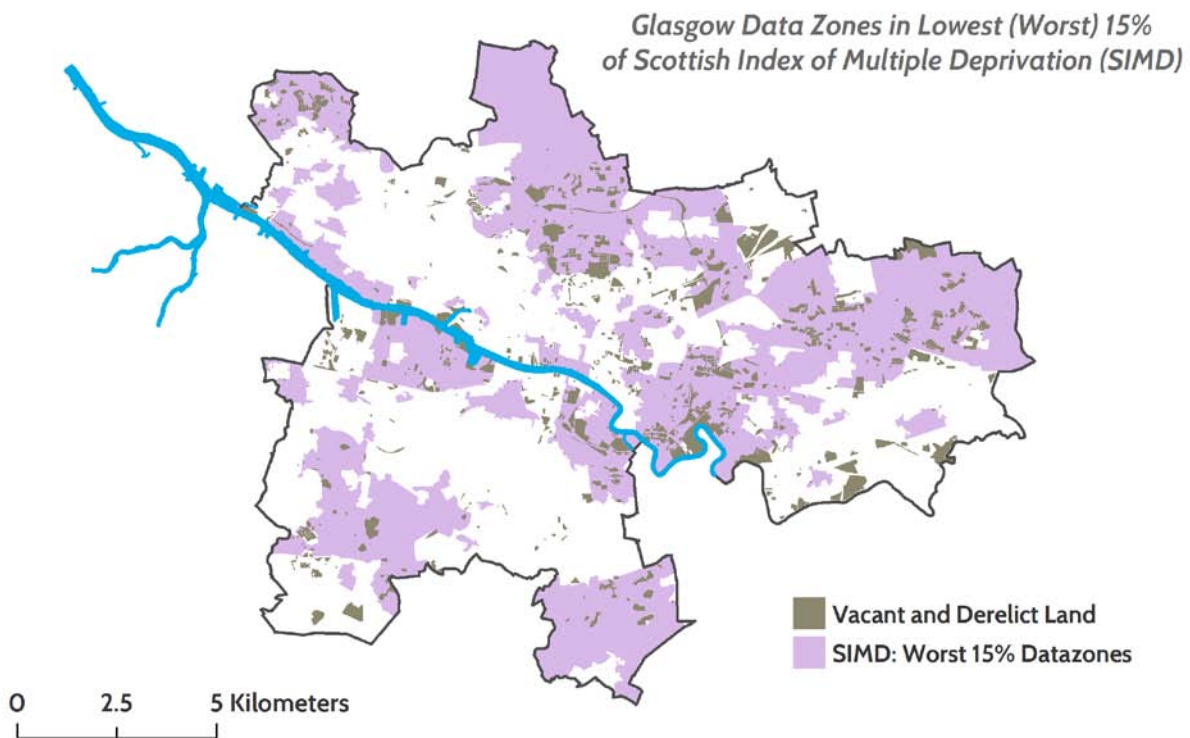


Figure 3 – Glasgow Data Zones in Lowest (Worst 15% of SIMD. Data Sources: UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL data); Scottish Index of Multiple Deprivation, General Report and Technical Report, Scottish Government Census, 2009 (SIMD data).

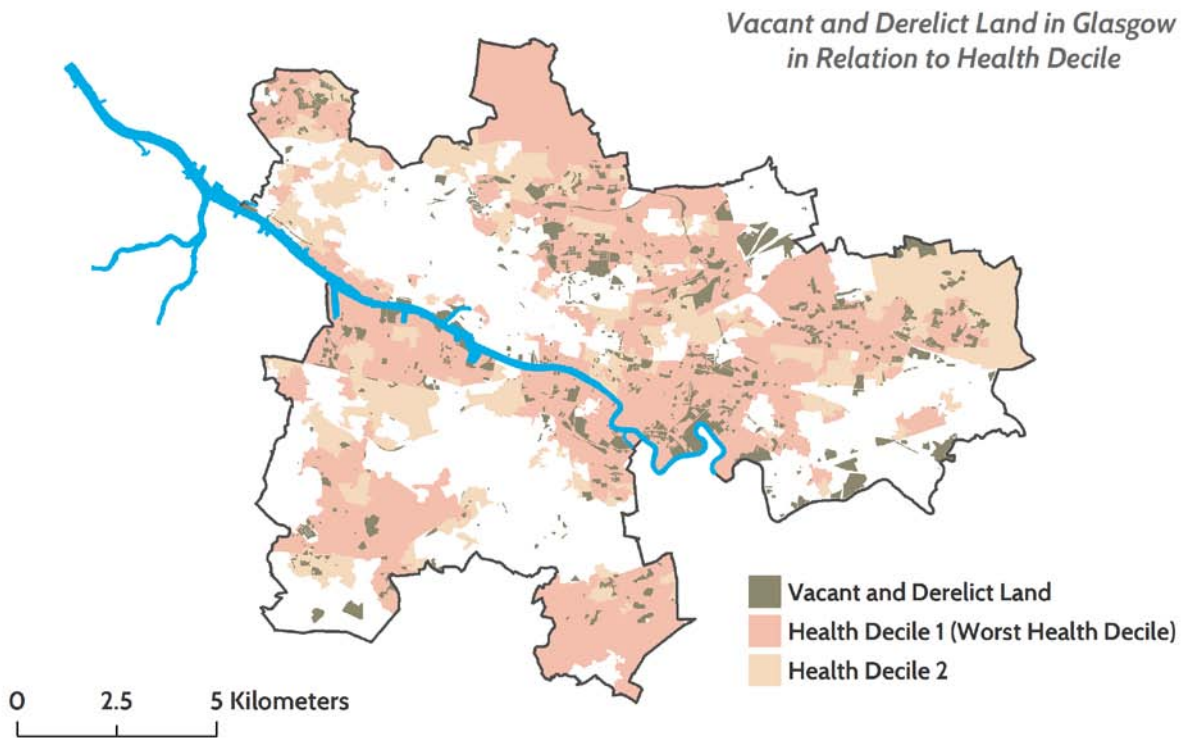


Figure 4 – Vacant and Derelict Land in Relation to Health Decile. *Data Sources:* UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL data); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data).



Figure 5 – Male Life Expectancy (MLE) by Glasgow Intermediate Zone. *Data Sources:* UK Ordnance Survey (basemap layers); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data).

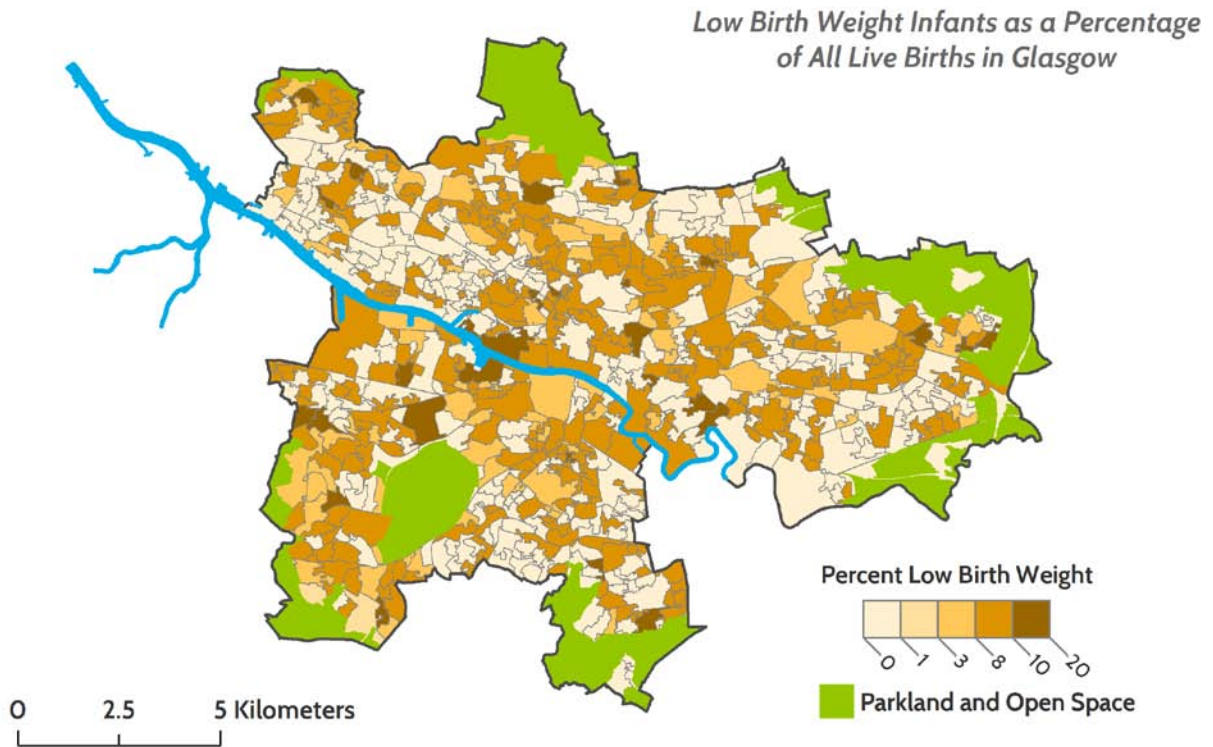


Figure 6 – Low Birth-Weight Infants as a Percentage of All Live Births in Glasgow. *Data Sources:* UK Ordnance Survey (basemap layers); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data);

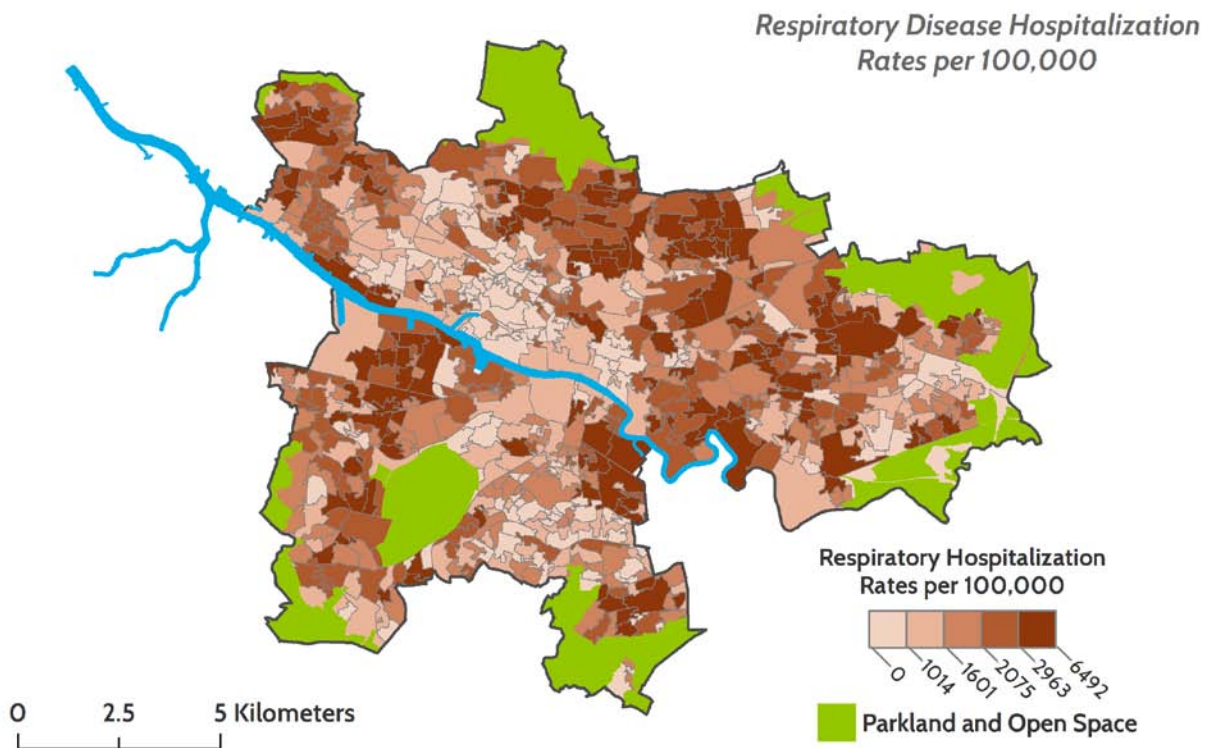


Figure 7 – Respiratory Disease Hospitalisation Rates per 100,000 by Glasgow Datazones. *Data Sources:* UK Ordnance Survey (basemap layers); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data).

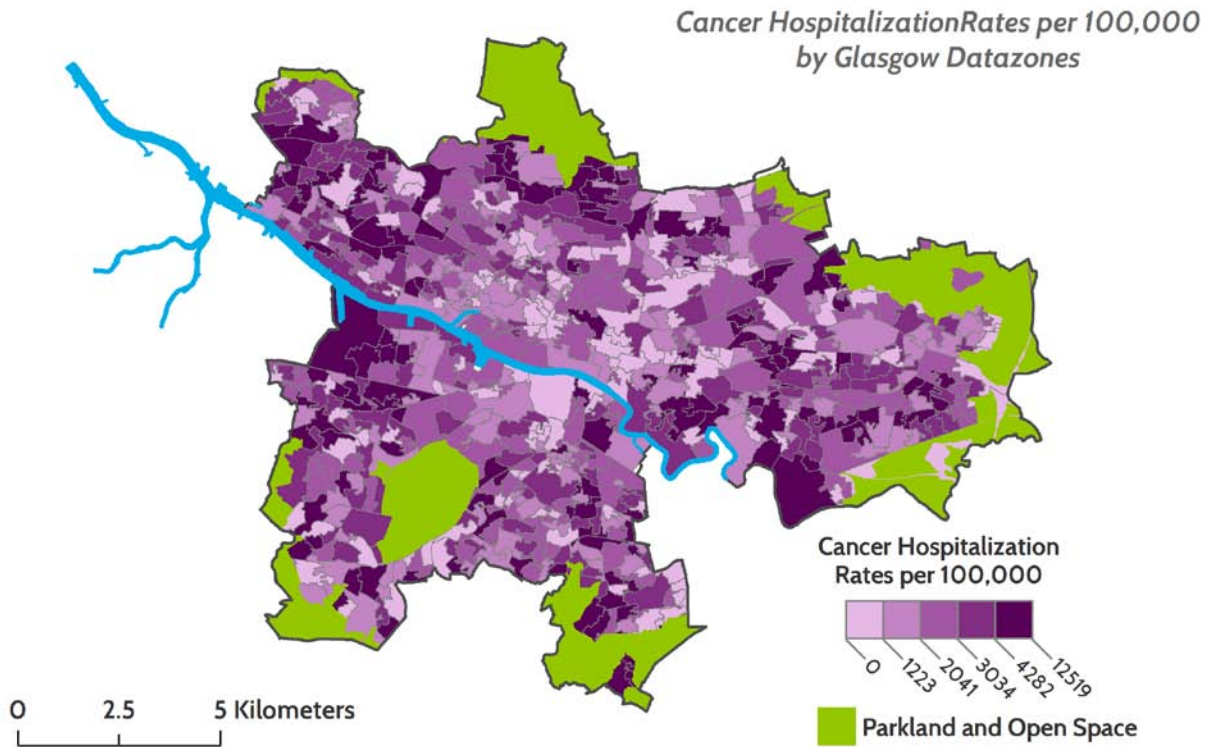


Figure 8 – Cancer Hospitalization Rates per 100,000 by Glasgow Datazones. *Data Sources:* UK Ordnance Survey (basemap layers); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data).

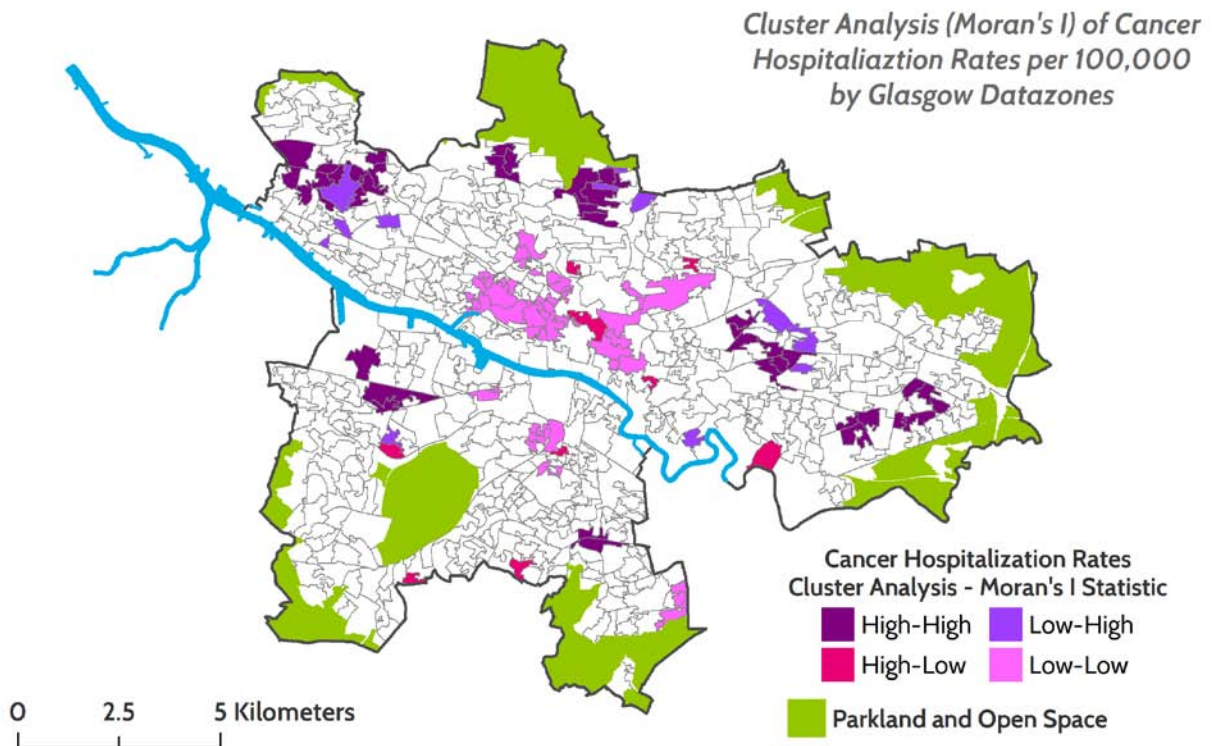


Figure 9 – Cluster Analysis (Moran's I) of Cancer Rates per 100,000 by Glasgow Datazone. *Data Sources:* UK Ordnance Survey (basemap layers); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data).

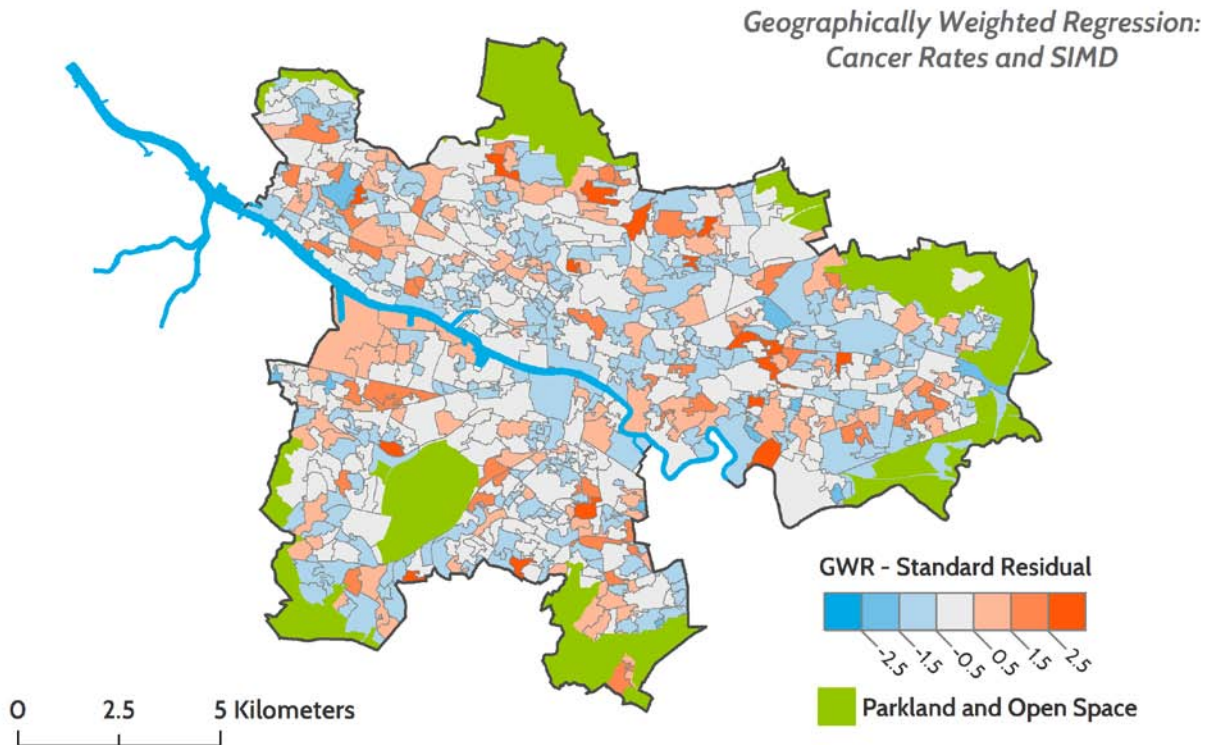


Figure 10 – Geographically Weighted Regression (GWR) of Cancer Rates and SIMD. Data Sources: UK Ordnance Survey (basemap layers); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data); Scottish Index of Multiple Deprivation, General Report and Technical Report, Scottish Government Census, 2009 (SIMD data).

Cluster Analysis, Geographically Weighted Regression, Descriptive Statistics, and Odds Ratios

After mapping the health variables and analyzing them visually, the cancer hospitalization rate dataset was selected as an example for further ESDA. Cluster analysis using Moran's I [57], and Geographically Weighted Regression [58] were performed on the data in order to determine more specifically where inequities existed, where potentially anomalous high- and low-rate areas were located, and if any spatial patterns could be observed. [Figures 9 and 10]

Subsequently, the 694 Data Zones of Glasgow were segmented into three classes, based on SIMD rank: High Deprivation DZs; Medium Deprivation DZs; and Low Deprivation DZs. [Figure 11] The descriptive statistics for each deprivation class were then calculated for each of the variables. Odds Ratios (OR) and Relative Risks (RR) were also calculated for the three health indicators for which data was consistent with the process of developing ORs and RRs.

Development of PARDLI scores – Priority Areas for Re-use of Derelict Land Index.

In order to select Priority Areas for further analysis, and ultimately to recommend priority for these areas in resource allocation and planning initiatives, an index was created to rank each DZ on the variables as analyzed and then combine the ranks. Health variables (LBW, RESP, and CANCER) were re-classified into three categories: High, Medium, and Low, by classifying the rates and percentages by standard deviation. Numerical scores of 1, 2, and 3 were used to represent Low, Medium, and High, respectively. Any value above the first standard deviation over the mean received a "3" signifying the worst (or Highest) class. Any value below the first standard deviation below the mean received a "1" signifying the best (or Lowest) class. The middle group, between one standard deviation above and one standard deviation below the mean received a "2" signifying the middle (or Medium) class. For the LBW indicator, it was possible for a DZ to be assigned a score of "0," if the number of LBW infants for the years surveyed was zero. Nearly

half of the DZs had no LBW infants, while in some DZs, as many as 1 in five infants were low-birth weight babies.

Male Life Expectancy data was given by IDZ, so in order to be able to incorporate MLE into the Index, MLE values had to be assigned from the IDZ to the DZs within each larger zone. This is accomplished by spatially joining the DZs and the IDZs. The DZs nest hierarchically within the IDZs, so theoretically there should have been no overlap or gap issues. However, in the spatial database there were often slight boundary mismatches and therefore incorrect assignment of DZs to IDZs when spatially joining the polygons. In order to circumvent this problem, the centroids (points representing the geometric center of the polygon) of the DZs were spatially joined to the IDZ polygons instead. DZ centroids within a given IDZ were then assigned the MLE value of its parent IDZ, and the table containing the centroid values was joined to the original DZ polygon spatial database.

Vacant and derelict land was buffered with 100-meter buffer distance, and any DZ that intersected one or more of these buffers was considered to be in proximity to a vacant and derelict land site. The 100-meter distance, rather than the 500-meter distance, was used, since so much of Glasgow was covered by the 500-meter buffers that the result would have been rendered almost meaningless. Additionally, 100 meters is a more conservative estimation of impact, from the standpoint of both visual blight and quality-of-life factors, as well as any potential impact from contamination. This metric appears in the Index as a binary feature: the DZ is either proximate, in which case it received a score of “3,” or not proximate, in which case it received a “0,” to a vacant or derelict site. [Figure 12]

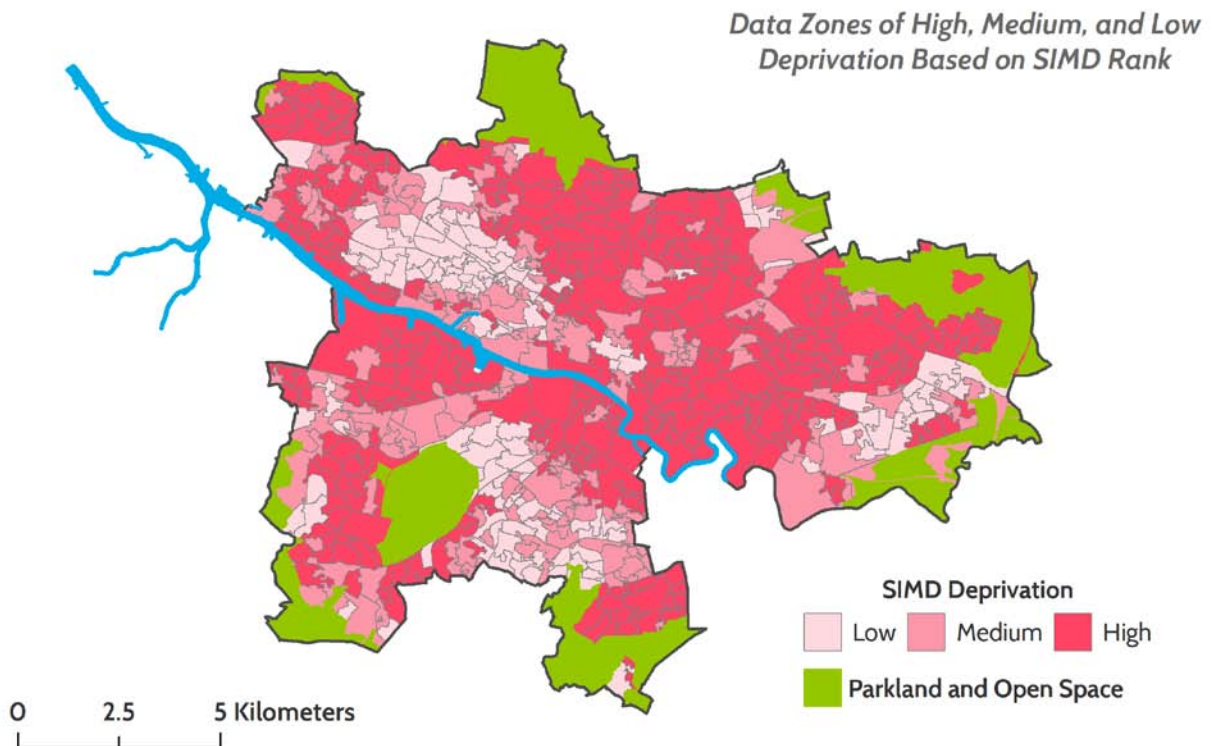


Figure 11 – Datazones of High, Medium, and Low Deprivation, Based on SIMD Rank. Data Sources: UK Ordnance Survey (basemap layers); Scottish Index of Multiple Deprivation, General Report and Technical Report, Scottish Government Census, 2009 (SIMD data).

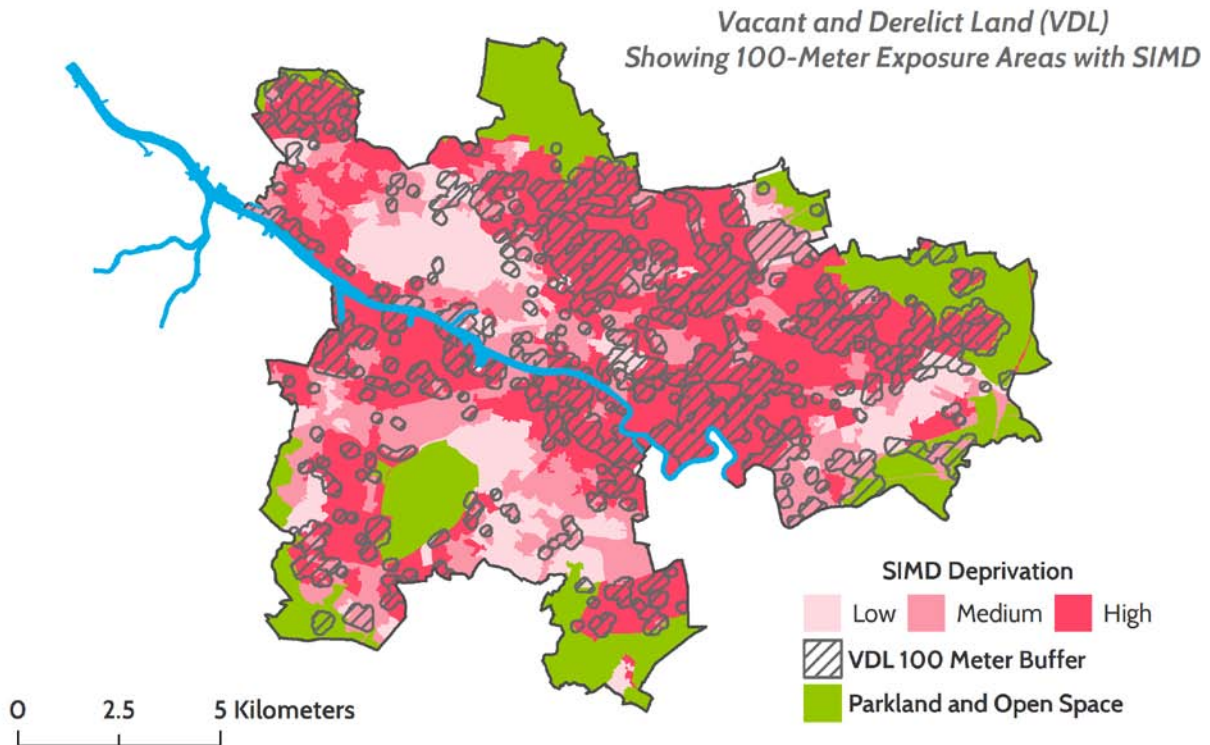


Figure 12 – Vacant and Derelict Land, showing 100-meter Exposure Areas with SIMD. Data Sources: UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL data); Scottish Index of Multiple Deprivation, General Report and Technical Report, Scottish Government Census, 2009 (SIMD data).

In the absence of any compelling rationale for weighting one variable higher than the others, the Index was created by simple addition of the six variables' scores. Combined PARDLI scores ranged from a low of 4 (best, lowest priority area) to a high of 18 (worst, highest priority area). A score of "4" indicates that the DZ has the lowest (best) scores possible for all variables: four "1"s and two "0"s. A score of 18 indicates that the DZ has the highest (worst) possible scores for all six variables: six "3"s. The scores were then divided into the three classes of Low, Medium, and High, as before for the individual variables.

Selection of Case Study Priority Areas

The intention of developing the PARDLI scores is to select the areas with the highest need on an objective, quantitative basis. [Figure 13] These areas would presumably have the highest deprivation scores, worst health outcomes scores, and be proximate to vacant and derelict land. The following neighbourhoods (using the Intermediate Data Zone boundaries as representing more accurately actual neighbourhoods than do the individual DZs) meet those criteria: from west to east in Glasgow: Drumchapel South; Govan-Linthouse; Possil Park; Calton-Gallowgate-Bridgeton; and Old Shettleston-North Parkhead. [Figure 14]

The selected Priority Areas will be the focus of a more detailed analysis, to consider the role of historic land use and settlement patterns; possibly more detailed health data from surveys rather than just aggregated statistics; a quality assessment of parks and open space; existing and proposed development initiatives; and existing community organizations and activities taking place in each neighbourhood. Although there is a flurry of diverse planning initiatives on-going or in the development stages for Glasgow, these appear to be somewhat disjointed, with perhaps some gaps and overlaps amongst them. They might benefit from a more unified focus and implementation strategy. [Figure 15]

A detailed perspective of the specific Priority Areas, drilling down in the data to the largest possible scale, or “looking through the spatial microscope,” is an important step in developing effective policy recommendations and implementation schemes. Basic science enables the generation of general principles, which are likely place-less. But the application of scientific knowledge to policy, especially to local policy, requires a thorough understanding of spatial variation at the local level, at a high level of resolution, and is rooted in “place-ness;” thus, the necessity of delving deeper into the micro-environment to ferret out the impact of neighbourhood effects, [59]. [Figure 16]

Although individual behavioural factors undoubtedly account for some of the poor health of Glasgow’s most deprived populations, neighbourhood effects are also an important consideration, and include such influences as differential exposure to stressors and differences in social infrastructure [60 – 63]. Scotland’s Chief Medical Officer, Sir Harry Burns, believes that these stressors and their concomitant health impacts go a long way in explaining the poor health here [30].

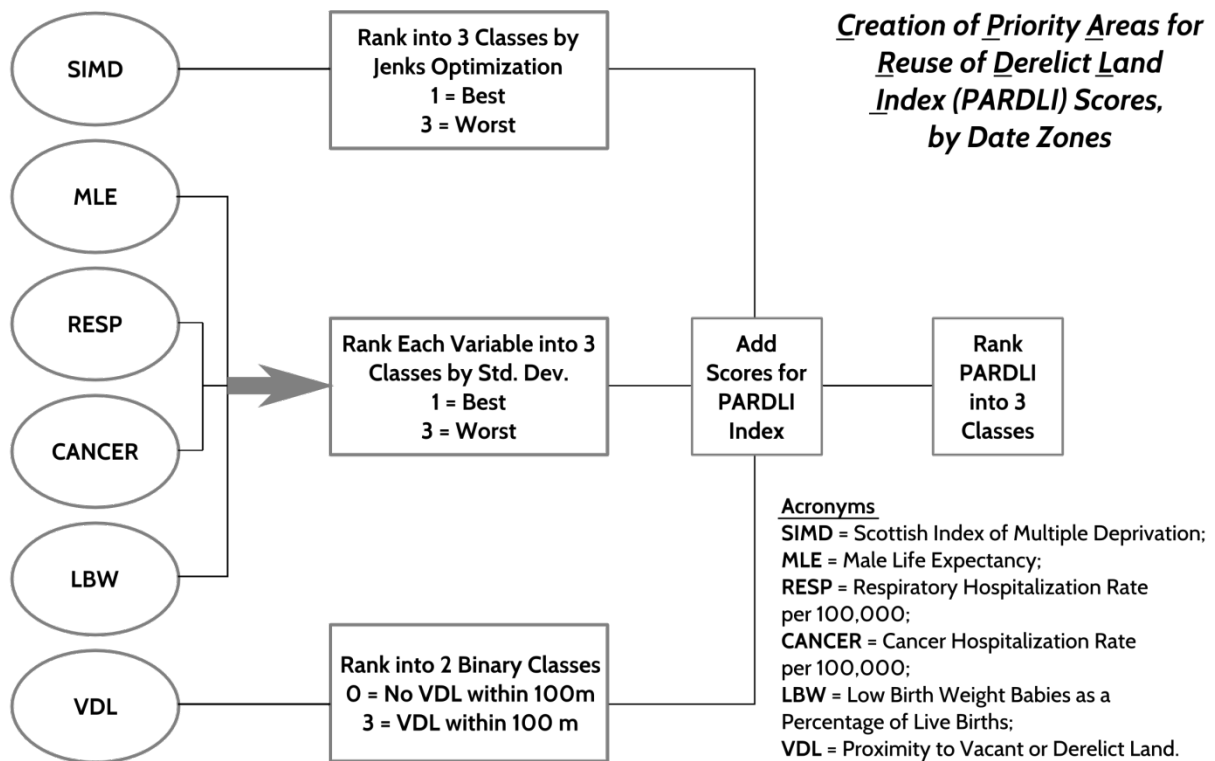


Figure 13 – Flow Diagram Depicting the Development of the PARDLI Index

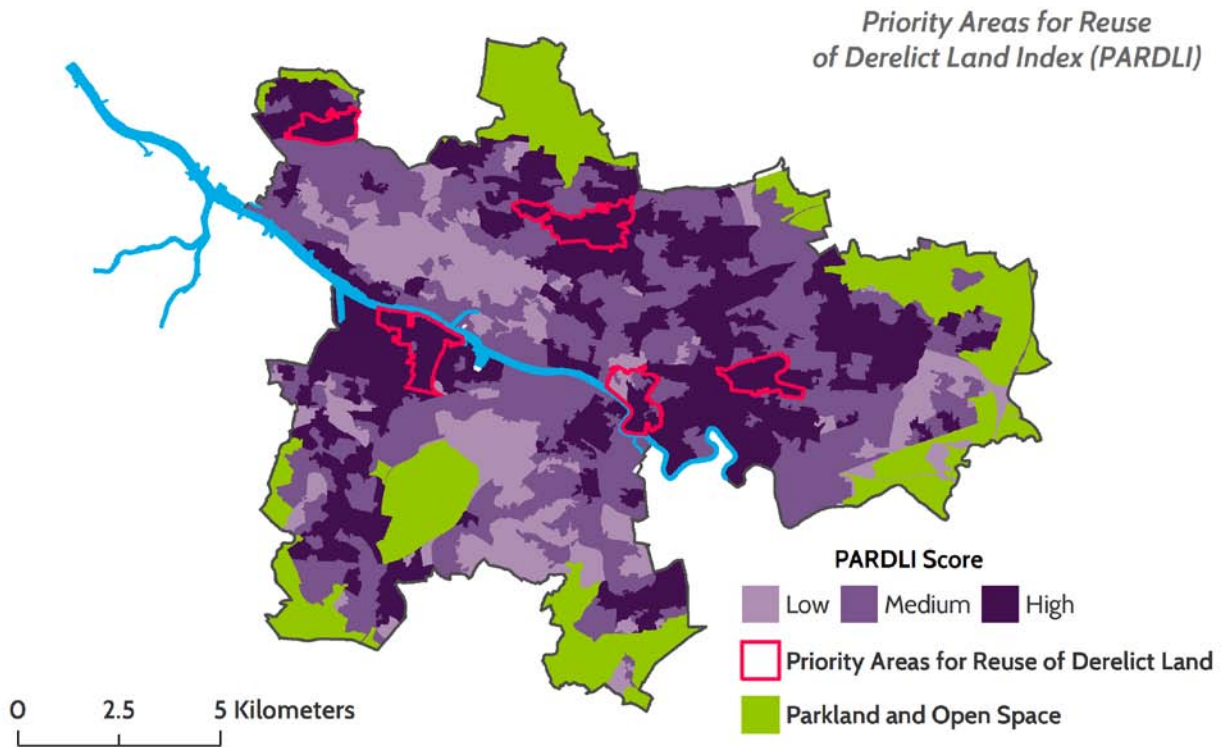


Figure 14 – Priority Areas for Reuse of Derelict Land Index (PARDLI). Data Sources: UK Ordnance Survey (basemap layers); Maantay (PARDLI scores, see Figure 13 for datasets included).

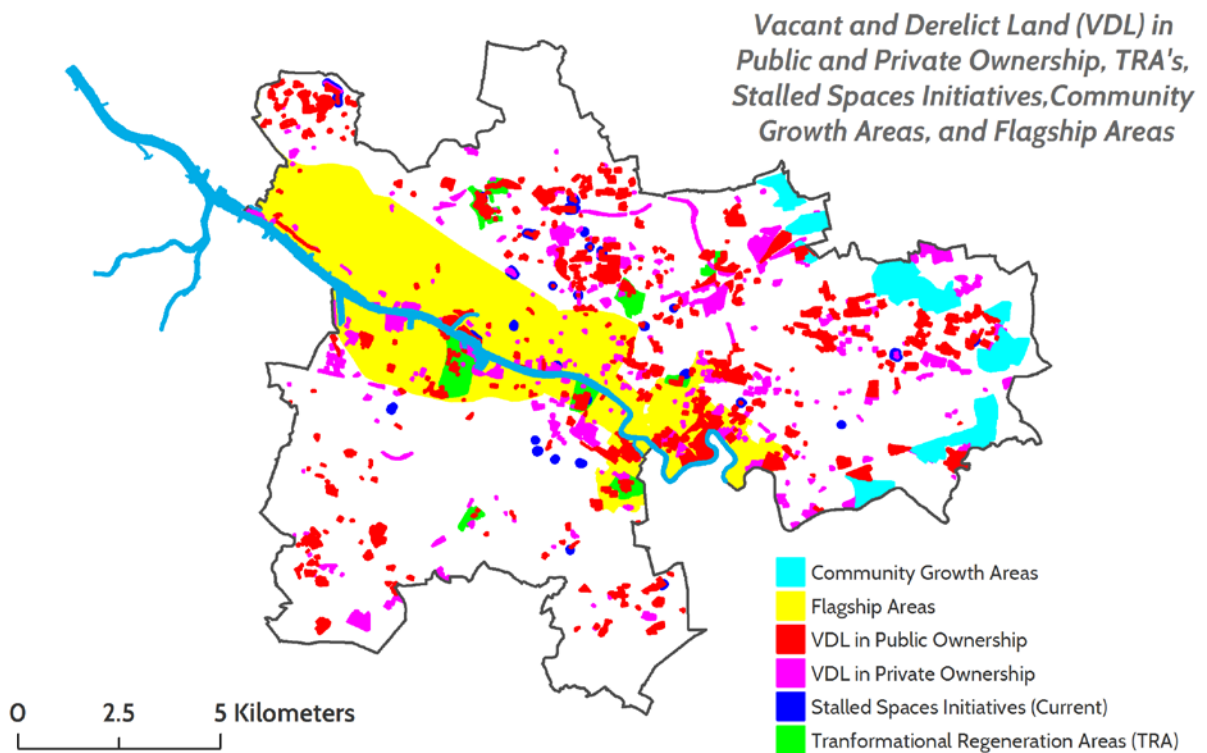


Figure 15 – Vacant and Derelict Land in public and private ownership, Transformational Regeneration Areas (TRAs), Stalled Spaces Initiatives, Community Growth Areas, and Flagship Areas. Data Sources: UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL data); Glasgow City Council Development and Regeneration Services; Glasgow and Clyde Valley Green Network Partnership.



Figure 16 – The proposed Govan Priority Area – An example of looking at the health data at the local level. Brown areas are the VDL. The darker the blue, the lower the male life expectancy (MLE). Most of Govan is in the worst or second worst MLE class, out of the original five classes mapped. *Data Sources:* UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL data); Scottish Neighbourhood Statistics, Scottish Government, 2010 (health data).

Greenspace Analyses

Many research studies have examined the relationship between access to open space and health benefits, and although the link has not been definitively and consistently demonstrated, a number of studies have found correlations between health benefit and access to open space and areas promoting physical activity [64 - 74]. Ideally, some measure of access to or amount of greenspace for each DZ could have been included in the PARDLI Index. After all, if we are thinking about creating priority areas for re-use of vacant and derelict land for the possible augmentation of existing greenspace, or in some way to compensate for the lack of accessible greenspace, this would have been a logical indicator to have incorporated. However, there are some rather unique factors involved with the quantity and distribution of Glasgow's existing greenspace, as well as some more typical problems of arriving at a true estimate of greenspace access, which are the same in any analysis of a city's greenspace.

Glasgow is extremely well-endowed with parks and other publicly-available open space. There is a sizable greenbelt area which nearly encompasses the perimeter of the city, and several large parks are centrally located throughout the city. Additionally, there are myriad other categories of designated open space and active recreational facilities, as well as a significant quantity of land protected as natural habitat areas. Indeed, when we look at a map with all these classes of open space plotted out, Glasgow is practically covered with greenspace of one kind or another. [Figure 17]

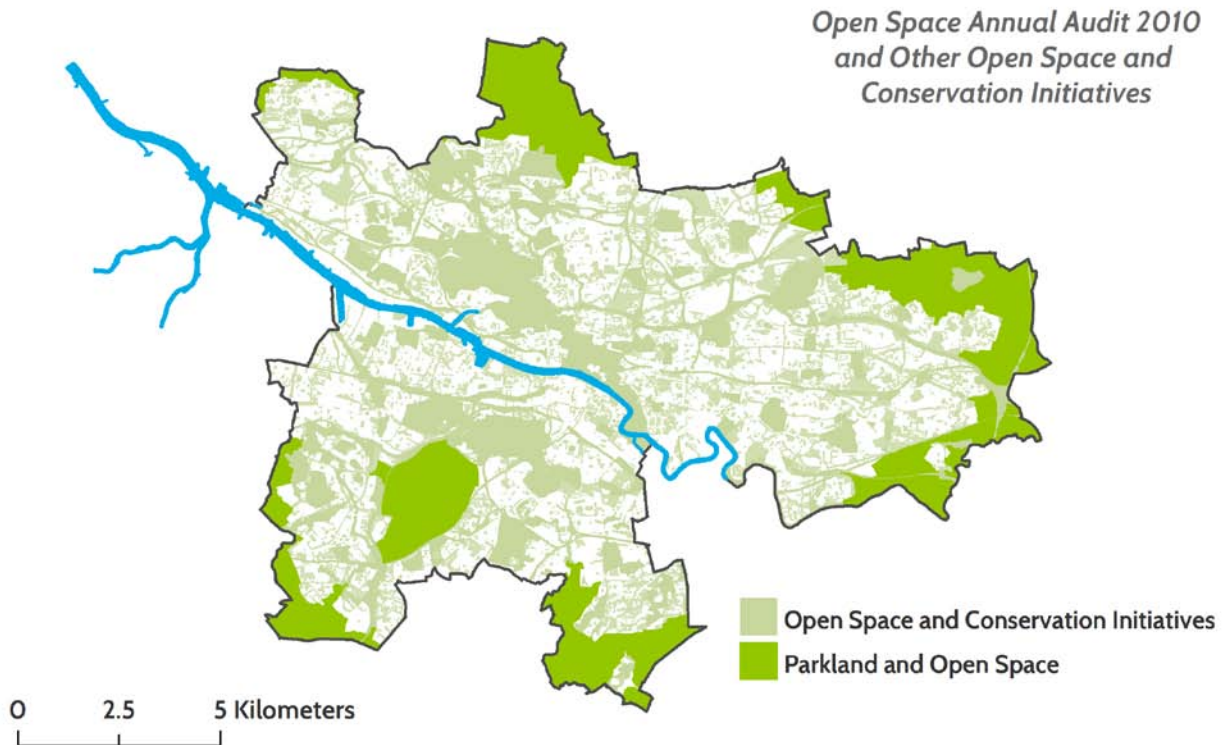


Figure 17 – Glasgow’s Open Space. There are 33 separate categories of public open space designated, including parks, gardens, sports areas, amenity spaces within developments, green corridors, protected natural areas, nature reserves, historic landscapes, and ancient woodlands. Data Sources: UK Ordnance Survey (basemap layers); Planning Advice Notice (PAN) 65 Planning and Open Space, Scottish Government, 2008, (open space data).

Several comprehensive analyses by other researchers have explored access to greenspace and greenspace quantities in Glasgow. The Center for Research on Environment, Society, and Health (CRESH) at the Universities of Edinburgh and Glasgow developed a model to predict percentage of open space in each ward of the entire United Kingdom [75 – 77]. When extracting and mapping just the Glasgow wards from their data, one can see that the only wards to have less than 20% of their area in open space are the more highly urbanized parts of the city centre, and in fact the wards have on average 38% of their area in open space. A few wards have nearly 90% of their areas in open space, which is an extraordinarily high figure, and these wards tend to be near the peripheral areas and in some of the more deprived areas of the city. [Figure 18]

A separate analysis, “Networks for People,” conducted by the Glasgow and Clyde Valley Green Network Partnership, was intended to show “connectedness” to greenspace by using actual network walking distance from each property lot to the greenspace entrance, taking into account physical barriers such as motorways and rivers. The city was divided up into a tessellation of 100-meter hexagonal cells, and a value assigned to each cell, indicating the degree of connectivity, based on the network analysis. [Figure 19] The white cells on the map indicate excellent connectivity, and the darker the purple, the worse the connectivity. The vast majority of the cells show very good connectivity, with some patches of disconnectedness, again, as with the CRESH analysis, most prevalent in the more densely built-up centre city areas, which in many cases correspond to the more affluent parts of the city [78].

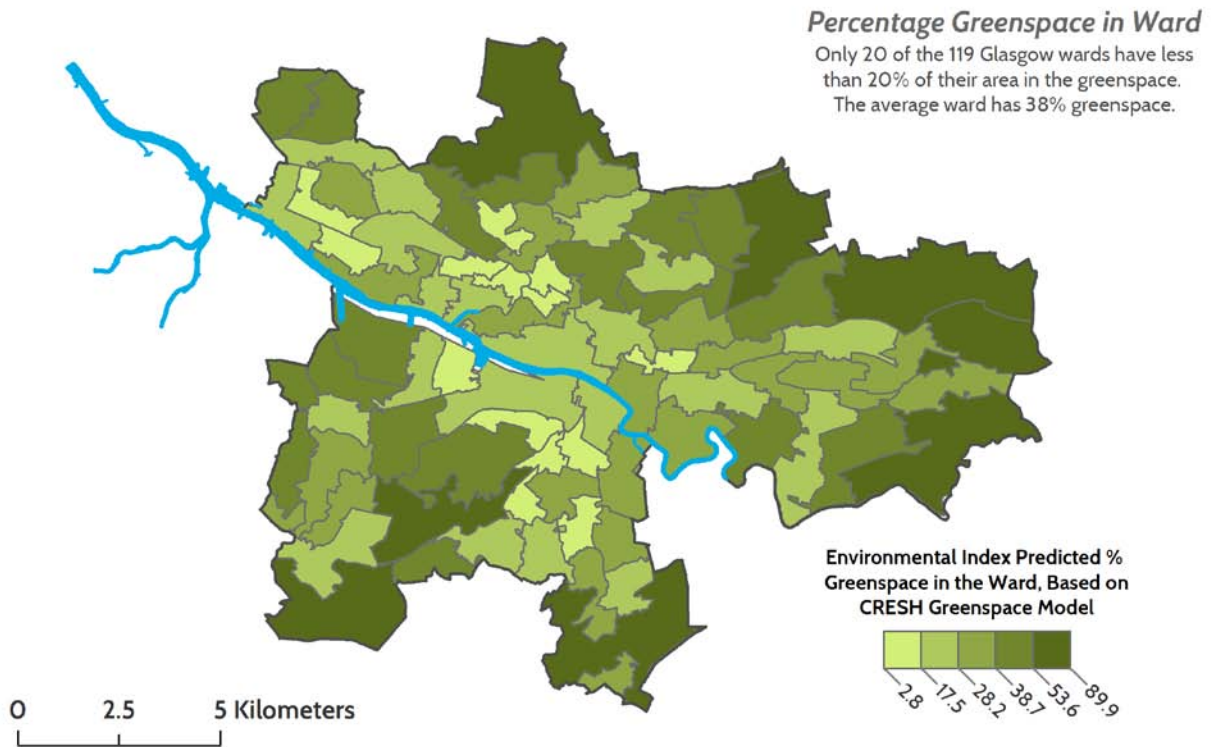


Figure 18 – Percentage Greenspace in Ward. Data Sources: UK Ordnance Survey (basemap layers); Developing Summary Measures of Health-Related Multiple Physical Environmental Deprivation for Epidemiological Research, Richardson, et al, 2010 (CRESH model data).

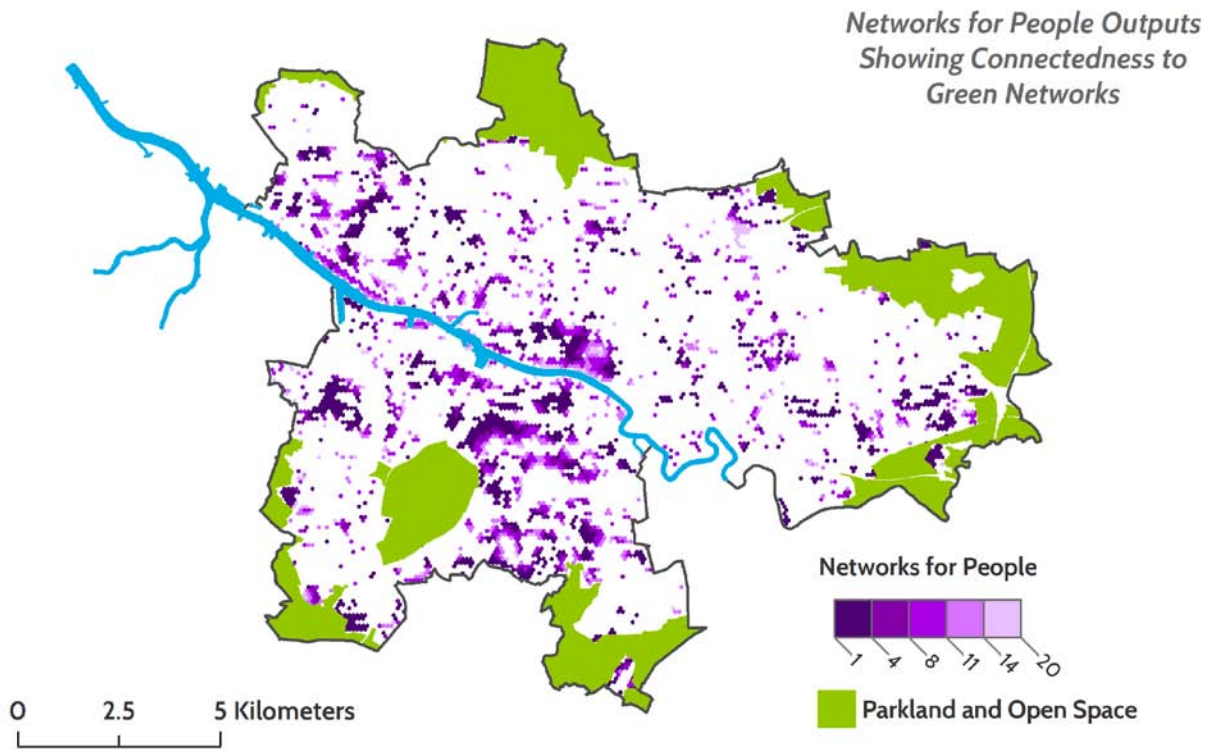


Figure 19 – Networks for People Outputs, showing connectivity to Greenspace. Data Sources: UK Ordnance Survey (basemap layers); Glasgow and Clyde Valley Green Network Partnership, 2011 (model output of green network). The lower the NfP score, the more disconnected that 100 m cell is from the Green Network.

Based on these two analyses and my own observations of the greenspace data from the Planning Advice Notice 65 (PAN 65) and Integrated Habitat Network (IHN) datasets, [79, 80] Glasgow appears well-provisioned with greenspace, and moreover, the less affluent areas often have more accessible greenspace and a higher proportion of greenspace than the more affluent areas. However, neither of these analyses takes into account the quality or usability of the greenspace for any beneficial purpose [81, 82]. Oftentimes the so-called greenspace is little more than a dumping ground for old sofas and rubbish, or else is viewed as a dangerous place to the local residents, who do not make use of it. In some cases it is just an impassible overgrown area with no amenities, or for some other reason is not user-friendly. There is a survey currently being undertaken to assess greenspace quality, but it is only partially completed at this time. Without an assessment of quality, it would be very difficult to base any greenspace access score on geographic access or quantity of greenspace alone, and therefore this would be rather meaningless as an indicator to incorporate into the PARDLI scores. However, since this inventory is a work in progress, it is hoped that by the time the Priority Areas are looked at in a detailed format, the greenspace quality data will be available for use.

Findings

The spatial analysis of disease and other health metrics by Data Zones within Glasgow shows that some neighbourhoods, and therefore some populations, suffer from poor health and low life expectancy disproportionately more than others. Many of these areas correspond spatially to areas of high deprivation and areas with excessive vacant and derelict land - often former environmentally-noxious land uses - making these populations vulnerable in more ways than one. The areas of highest deprivation and worst health deciles spatially correspond almost totally with the location of the VDL.

When looking at the results of the cluster analysis using Moran's I for cancer hospitalization rates as an example, the clusters of DZs having high rates that are surrounded by other DZs with high rates also correspond to these areas of particularly high deprivation. Likewise with the GWR analysis, in some areas the regression models predict much lower rates than the actual observed values. In certain DZs the observed rate of cases is more than 2.5 standard deviations above the predicted, based on the regression relationship with deprivation rank, and therefore the reality of the cancer hospitalization rates in these areas is much worse than what would be predicted based on deprivation alone.

The descriptive statistics show the difference in amount of vacant and derelict land, health outcomes, and life expectancy, as differentiated by High, Medium, and Low Deprivation DZs. [Table 1; Figures 20-23] As shown in the tables and graphs, there are 3.7 hectares of vacant and derelict land per 1,000 population in High Deprivation DZs, as opposed to 1.2 hectares of VDL per 1,000 population in Low Deprivation DZs. Likewise, Male Life Expectancy averages 66.5 years in High Deprivation DZs, while it is 75.8 years on average in Low Deprivation DZs. Hospitalization rates for cancer and respiratory disease and the percentage of low birth weight infants are correspondingly much higher in High Deprivation DZs, as well.

By calculating the Odds Ratios and Relative Risks, it can be seen that the differences in these health variables between the High Deprivation DZs and the other DZs are statistically significant. [Table 2] Odds ratios and relative risk estimates are both ways of comparing data from two different populations in order to obtain a quantitative evaluation of real significance in the differences between the two groups. Odds ratios are a surprisingly simple, yet powerful way to show statistical associations in health. They are particularly helpful in demonstrating health inequalities. The Odds Ratio is the odds of disease or health outcome among exposed individuals (in this case, people living in a High Deprivation DZ) divided by the odds of the disease or health outcome among the unexposed (in this case, people living in a DZ that is not High Deprivation).

Relative Risk is the probability that a member of an exposed group (in this case, people living in a High Deprivation DZ) will develop a disease or have a specific health outcome relative to the probability that a member of an unexposed group (in this case, people living in a DZ that is not High Deprivation) will develop that same disease or experience that health outcome.

Results of the OR analysis show that populations in High Deprivation DZs are much more likely to be hospitalized for respiratory disease (5.5 times more likely) or cancer (30% more likely), and much more likely to have low birth weight infants (60% more likely), than those not living in High Deprivation DZs. The analysis of risk factors for unfavourable health outcomes is based on a comparison between cases and non-cases in High Deprivation DZs, and cases and non-cases in non-High Deprivation DZs. All results are at the 95% Confidence Level, with $p < 0.0001$. The Relative Risk analysis provides very similar results to the OR analysis, most probably due to the fact that the numbers of occurrences of the health outcomes were relatively rare in contrast to the numbers of the unaffected population.

The creation of the PARDLI results in five areas in the highest scoring categories for deprivation, health outcomes, and proximity to VDL. There is a high degree of spatial correspondence between the areas with concentrations of VDL and the DZs with the highest PARDLI scores. [Figure 24]

<i>SIMD Data Zones</i>	<i># Data Zones</i>	<i>Population</i>	<i>Vacant & Derelict Hectares per 1,000 Pop</i>	<i>% Total VDL Hectares</i>	<i>Cancer Hospitalization Rates/100,000</i>	<i>Respiratory Hospitalization Rates/100,000</i>	<i>% Low Birth Weight of Total Live Births</i>	<i>MLE by IDZ</i>	<i>Male Life Expectancy Range</i>
High Deprivation	375	298,224	3.7	69	3,807	2,571	3.55	66.5	62.5-74.7
Medium Deprivation	180	139,325	2.5	23	2,852	1,637	2.87	73.2	67.4-77.4
Low Deprivation	139	99,775	1.2	8	2,781	999	1.55	75.8	69.9-80.0
SUM/AVG.	694	537,324	2.4 Mean	100%	2,872 Mean	2,014 Mean	2.9 Mean	71.3 Mean	62.3-80.0

Table 1 – Descriptive Statistics for High, Medium, and Low Deprivation Areas in Glasgow

Percent Vacant and Derelict Land

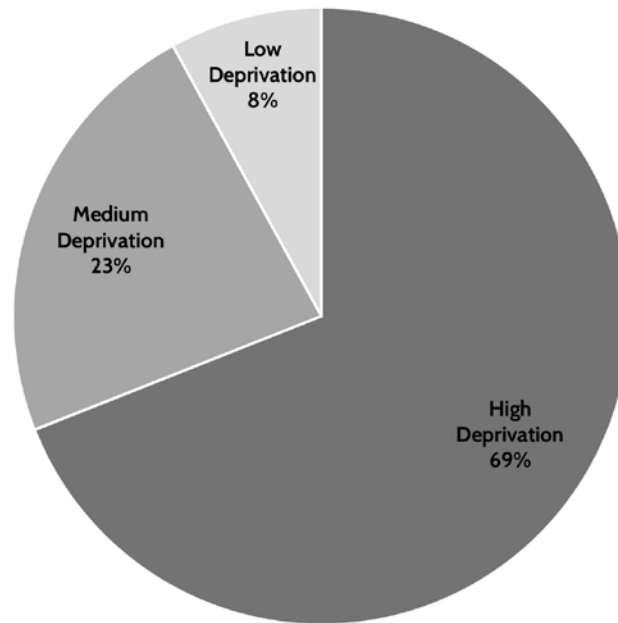


Figure 20 – The Breakdown of Vacant and Derelict Land in Glasgow, by High, Medium, and Low Deprivation Areas

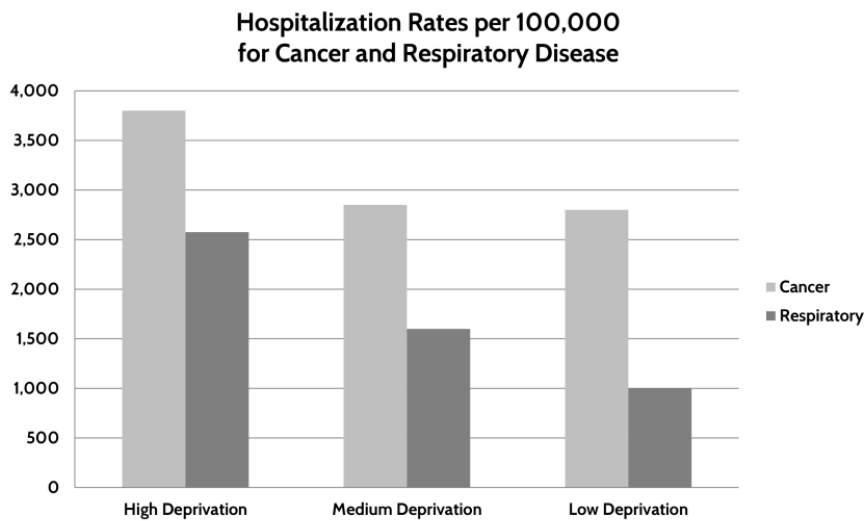


Figure 21 – Hospitalization Rates per 100,000 in Glasgow for Cancer and Respiratory Diseases, by High, Medium, and Low Deprivation Areas

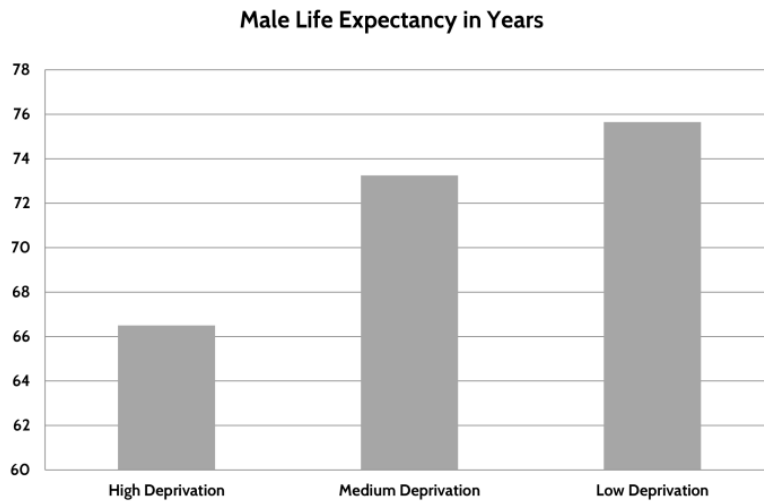


Figure 22 – Male Life Expectancy in Glasgow by High, Medium, and Low Deprivation Areas

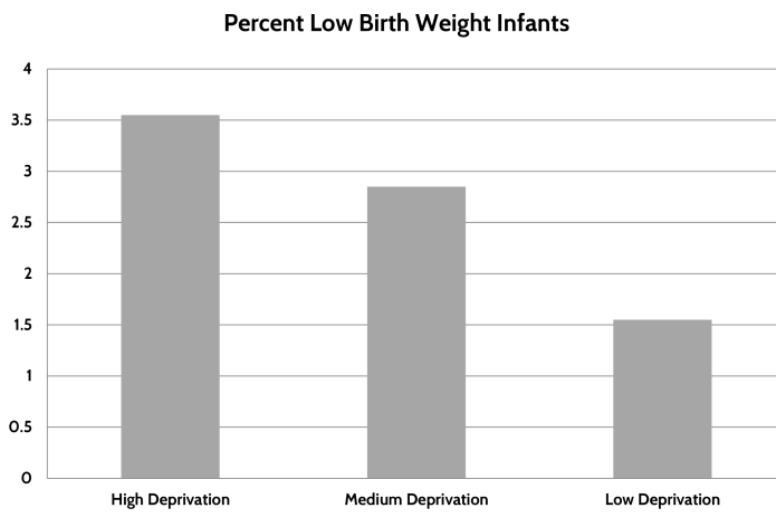


Figure 23 – Percentage of Low Birth Weight Infants in Glasgow, by High, Medium, and Low Deprivation Areas

Health Outcome	Odds Ratio	Relative Risk
Respiratory Hospitalization	5.5	5.1
Cancer Hospitalization	1.3	1.3
Low Birth Weight Infants	1.6	1.5

Table 2 – Odds Ratios for Health Outcomes in Glasgow in High Deprivation Areas

95% CI, with $p = < 0.0001$

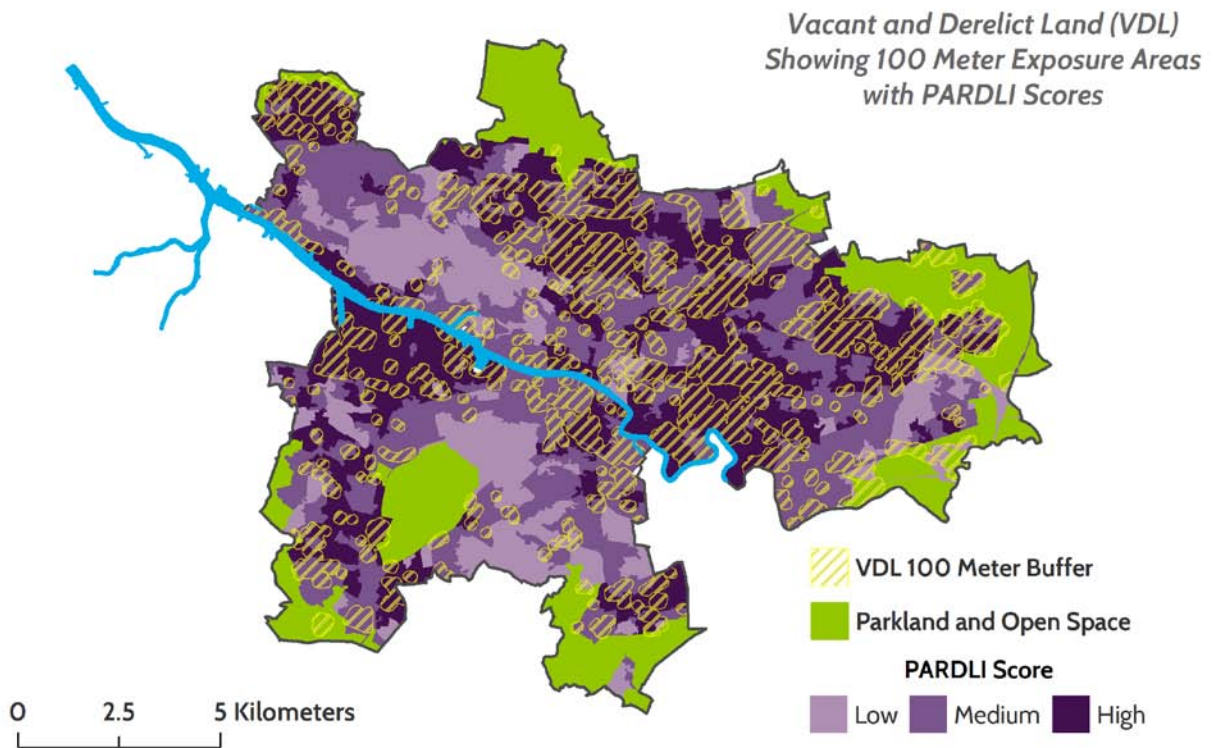


Figure 24 – Vacant and Derelict Land showing 100-meter Exposure Areas with PARDLI Scores. Data Sources: UK Ordnance Survey (basemap layers); Vacant and Derelict Land Survey, Scottish Government, 2012 (VDL data); Scottish Index of Multiple Deprivation, General Report and Technical Report, Scottish Government Census, 2009 (SIMD data).

Recommendations and Future Directions

The five Priority Areas as determined by the highest PARDLI scores will be analyzed further in terms of incorporating more detailed data in order to make cogent community-specific recommendations regarding the reuse of the VDL within each of these areas, as mentioned above. The methodology described in this paper can be applied to any other local authority in Scotland, and indeed, to any location where the VDL, health, and deprivation data exist. In countries not using a standardized index of deprivation, other salient variables could be substituted as proxies for deprivation, such as income or poverty levels.

For policy and planning initiatives, we need to start thinking differently about how best to serve these communities that have ended up in this analysis with the highest PARDLI scores. Perhaps it is worthwhile to examine the differences between re-use of VDL for “regeneration,” versus using it for “development,” and think more seriously about who usually benefits most from regeneration or development. In the parts of the city where VDL is most prevalent, it seems unlikely that there will be high interest from private investors to construct profit-making facilities (i.e., “development”). It might be better to acknowledge this and move on to realistic re-use concepts for the VDL, and plan for uses that would more directly benefit the surrounding community and serve their needs directly, as opposed to being held for a regional use or general tax-generating purpose. Regeneration for primarily community use can result in substantial gains in many aspects, including health and other more non-quantifiable benefits. It can also have an economic multiplier effect and may serve to bolster the local economy, and even have ripple and spill-over effects to neighbouring communities. Regeneration of this nature should not be discounted just because it does not involve constructing a commercial or residential building complex. There are also valid reasons for *not* encouraging housing to be built on VDL sites, as argued by Greenberg in “Should housing be built on former brownfield sites?” [83].

It is important for the community to not only participate and be involved in the decision-making process, but to actually take the lead on devising plans and implementation strategies for the VDL. This needs to be a bottom-up planning initiative, not one led by professional planners. This will better ensure community satisfaction with the eventual project, as well as serve to bolster capacity building in the community, so that the end product can be self-sustaining and successful, and engender a sense of community ownership and a source of local pride.

More than half of the VDL sites in Glasgow are in public ownership (572 out of 927 sites), representing approximately 783 out of the 1,300 total hectares of VDL. This means that Glasgow city government could effectively grant highly deprived communities more than 700 hectares of land to be used for community good. This might be urban agriculture in the form of communal gardens (as opposed to individual “allotments”). In New York City, and in other cities around the world, community gardens have proved to be an effective way to get some very positive constructive results without substantial financial outlays, and the health and other benefits of community gardens and urban agriculture have been well-documented [84 – 88].

Benefits include:

- Improvements in community cohesiveness and neighbourliness;
- Increases in healthy food options, especially where highly deprived communities are likely to be “food deserts”;
- Expansion of environmental awareness for children and youths;
- Provision of a strong geographic focal point for community cultural and educational activities;
- Improvements in neighbourhood aesthetics;
- Enhancement of property values;
- Reduction in crime rates, due to more “eyes on the street,” increased pride and involvement in the neighbourhood by residents, and created constructive opportunities and activities for children and youth;

- Development of community participation in other important issues, and energizing their activities.
- Promotion of community building, capacity building.

Policy and planning recommendations for re-use of VDL by community members or organizations can include such strategies as:

- Creating a database of publicly-owned vacant sites that are accessible from the street, and making this list available to the public;
- Developing a signage program for each of these sites advising community members who to call to discuss community-led use of the site. These could be simple hand-lettered signs, similar to the ones put up on VDL sites in NYC by the non-profit group known as 596 Acres (which refers to the amount of VDL in Brooklyn, NYC) [89, 90];
- Establishing a standard protocol for leasing the land to a community group, and have a small support team within government to help with logistics of community-led use of the vacant land;
- Thinking more flexibly about appropriate uses, whether temporary or permanent. Community uses could be urban agriculture, passive or active recreation spaces, market spaces for weekly “flea” markets or farmers’ markets, and cleaned up natural areas that might connect with other open space networks;
- Allow and facilitate true community planning. Rather than top-down planning for the vacant space, community participation (and even community initiation of the project) at the earliest stages would be more likely to ensure community “buy-in” to the decisions and community involvement in the continued success of the use to which the land is put;
- Consider small grants of money for community-led groups to create containerized gardening on sites that may be contaminated, and that can be moved to another vacant site if the gardening site is eventually required for brownfields remediation and housing development;
- Using the land temporarily for urban forestation projects. These urban forestry plantings could help clean up contamination through phyto-remediation, help restore endangered tree species, and create economic benefit, while leaving land available for future housing development or other community use. Urban forestation can also be a permanent use [54].

As in Glasgow, much of New York City’s vacant land is located in the poorer neighbourhoods. A major issue in NYC with re-use of vacant and derelict land for development is the displacement of poor people through gentrification. Ironically, this has often occurred in areas where community gardens have improved property values, enhanced neighbourhood aesthetics, and reduced crime rates sufficiently to interest developers in investing in the neighbourhood, whereby the community rightfully feels as though their hard work has sown the seeds of their own destruction [91, 92]. Policies must be in place for community-led improvements in vacant and derelict land to benefit the community and not punish them.

Actively promoting the re-use of vacant and derelict land in high deprivation areas with vulnerable populations will have long-term beneficial use to the residents, and is an important step in combating health inequities and environmental injustice in these communities.

“[A] society that allows such a pattern of coincidence [between poor populations and poor environment] to persist has failed to equally protect its citizens. This failure, itself, constitutes an environmental injustice. Whether the result of...putting economic profits over the health of people, or benign neglect, this disproportionate risk can and does lead to disastrous results,” [93].

Acknowledgements

This research is part of a larger project involving a comparison of Glasgow and New York City regarding the relationship between environmental health justice and the built environment. I conducted most of the research reported in this paper while a Fulbright Distinguished Chair at the Glasgow Urban Laboratory, a collaboration of the Mackintosh School of Architecture and the Glasgow City Council. I would like to thank everyone connected with those institutions, but especially Julia Radcliffe and Brian Evans of the Glasgow Urban Lab; Alistair MacDonald, Gerry Grams, Jamie Arnott, and Cathy Johnston of the Glasgow City Council Development and Regeneration Services (GCC DRS), and Jim Gordon and Fiona Hunter from the DRS GIS unit. There were many other people who were helpful during my 6 months in Glasgow, including the staff at the Glasgow Centre for Population Health; Anne Ellaway, of the U.K. Medical Research Council; Alastair Corbett, of the Glasgow and Clyde Valley Green Network Partnership; Jamie Pearce, of the Centre for Research on Environment, Society, and Health, the School of GeoSciences at the University of Edinburgh; and many of the faculty at the University of Glasgow, Strathclyde University in Glasgow, and of course, all of my colleagues (and the students) at the Mackintosh School of Architecture/Glasgow School of Art.

I would also like to thank my colleagues at my home institution of City University of New York, especially Andrew Maroko, Stefan Becker, and Brian Morgan, who “held down the fort” with the GISc Program and the Urban GISc Lab, and taught my courses whilst I was in Glasgow for six months. My deep appreciation and admiration also goes to my CUNY doctoral student, Gretchen Culp, cartographer extraordinaire, for translating my working maps into publication-quality art.

Most of all, I would like to acknowledge the US-UK Fulbright Commission, and the efforts of their London-based staff, who gave me this unique opportunity to immerse myself in Glaswegian culture and environment, which provided me with access to the human and data resources that were necessary for this study to take place.

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