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THE GEOGRAPHY OF DESPAIR: URBAN ENVIRONMENTAL INJUSTICE THROUGH INCOME-BASED RESIDENTIAL ZONATION, GABORONE CITY, BOTSWANA

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Abstract: Urban inter-race environmental injustice is a well-researched field particularly in the northern hemisphere. However, few studies have addressed intra-race urban environmental injustice especially within a developing country setting. An appreciation of the type and extent of this injustice is needed to help policymakers and city planners curb and mitigate its negative effects at this infancy stage before getting worse with economic development. The goal of this paper is to determine the presence and extent of environmental injustice in Gaborone city. To reach this goal, the paper inventories hazardous facilities and also determines the spatial variability of exposure to hazardous facilities with socioeconomic status across the city. The paper finds no relationship between income-based residential area zoning and location of hazardous facilities in the city although these facilities tend to be closer to residential areas in low income municipalities. The paper discusses policies that city planners could adopt to prevent and also minimize the effects of this exposure.

Keywords: Environmental injustice; urban; developing countries; Gaborone

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INTRODUCTION

Sustainable development is a highly contested concept, thus complex and normative (Jacobs, 1999; Langhelle, 2000). The concept came about as a result of the growing awareness of the global links between environmental problems, socio-economic issues (to do with poverty and inequality) and concerns about a healthy future for humanity (Hopwood *et al*., 2005). Sustainable development was placed on the international agenda with the release of the report Our Common Future by the World Commission on Environment and Development in 1987 (Langhelle, 1999), which is generally taken to represent the key statement of sustainable development (Kirkby *et al*., 1995). Thus it has become the key principle underpinning environment and development policies at both national and international levels (Jacobs, 1999; Lafferty, 1996; Lafferty & Langhelle, 1999). Therefore, social justice constitutes an inherent part of the conception of sustainable development.

Hence, the inseparability of environmental quality and human equality implies that the issue of environmental quality is inextricably linked to that of human equality. For instance, wherever in the world environmental despoliation and degradation is happening, it is almost always linked to questions of social justice, equity, rights and people's quality of life (Agyeman, 2008). Torras & Boyce (1998) noted that countries such as Sweden, Denmark, Norway and Finland, with a more equal income distribution, greater civil liberties and political rights, and higher literacy levels tend to have higher environmental well-being than those with less equal income distributions, fewer rights, and civil liberties, and lower levels of literacy. Similarly, in a survey of the 50 US states, Boyce *et al*., (1999) found that states (predominantly southern) with greater inequalities had less stringent environmental policies, greater levels of environmental stress and higher rates of infant mortality and premature deaths. At an even more local level, a study by Morello-Frosch (1997) of counties in California showed that highly segregated counties in terms of income, class and race had higher levels of hazardous air pollutants.

Therefore, concomitant to sustainable development is environmental justice. Environmental justice is based on the principle that all people have a right to be protected from environmental pollution and to live in and enjoy a clean and healthful environment (Mennis, 2002). Agyeman & Evans (2003) noted that environmental justice is the equal protection and meaningful involvement of all people with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies and the equitable distribution of environmental benefits. Thus environmental justice is an issue that has an inherent spatial component – environmental justice is usually defined according to the spatial relationship between the distribution of population and its character and the location of environmentally hazardous facilities (Bullard, 1994; Bryant, 1995).

Although environmental justice studies have explored the socio-spatial distributions of hazardous industries and provided substantial evidence of a disproportionate presence of toxic industries and waste sites in many minority and low income communities in urban areas (e.g., Szasz & Meuser, 1997; Morello-Frosch *et al*., 2001; Bowen, 2002). The results have been mixed. For instance, some researchers have found evidence of income and/or poverty based environmental inequality (Morello-Frosch, *et al*., 2001; Downey, 2003), while others have not (Bowen *et al*., 1995; Brown *et al*., 1997). Furthermore, minimal work has addressed environmental justice in developing countries although these countries have weaker legal and technical resources, so hazardous exposures tend to be less controlled and therefore more intense (Banerjee, 1995, Loewenson, 1998; Loewenson, 1999)

Consequently, this paper attempts to contribute to knowledge on urban environmental injustice within a developing country setting. The paper aims to evaluate the relationship between income-based residential zoning and the location of environmental hazardous facilities in Gaborone city. Specifically the paper aims to; i) Map environmental hazardous facilities locations within Gaborone, ii) Determine spatial differences in exposure to environmental hazardous facilities across income differentiated residential zoning areas in the city. The paper also seeks to infer the scale of environmental injustice in Gaborone from 1 and 2.

MATERIALS AND METHODS

Study Area

Gaborone city, Botswana and its periphery (**Fig. 1**) typify a growing debate regarding the tradeoffs between socioeconomic growth and development and their impacts on social welfare. The city is one of the fastest-growing cities in sub-Saharan Africa, having grown from a small town to an international city in the past 30 years (Ssegawa *et al*., 2002). In the 1960s, the original planners of Gaborone expected it to grow to a maximum size of 20,000 people, but its population now stands at 186,007 with an annual growth rate of 3.37 percent (Central Statistics Office of Botswana, 2001). Although the city's population seems small by international standards, its problems with resources – especially land – resulting from its rapid growth differ from large cities

only in magnitude, not in kind (Molebatsi, 1996; Mosha, 1996).

Gaborone city is nestled between tribal territories and private agricultural land (i.e., commercial agriculture) on its northern, eastern, and southern sides. It has two nature conservation reserves within its periphery and close to Botswana's border with South Africa, which restrict potential expansion to the south and east of the city. As migration of unskilled labour from rural areas into the city has increased demand for housing, Gaborone has almost exhausted its buildable area. With a projected population of 313 000 by 2031 (Central Statistics Office of Botswana, 2001), the competition for land between residential, industry, and waste management is set to intensify (Batisani & Yarnal, 2011).

At the eve of independence of Botswana, a first master plan for the future capital was prepared in 1963. It was designed for an administrative function with maximum of 20,000 inhabitants by the end of its planning horizon in 1983. Essentially, the plan was characterised by a comparatively low-density form of development based on the Garden City model with generous provision of pedestrian walkways, open spaces and closely tied neighbourhood units.

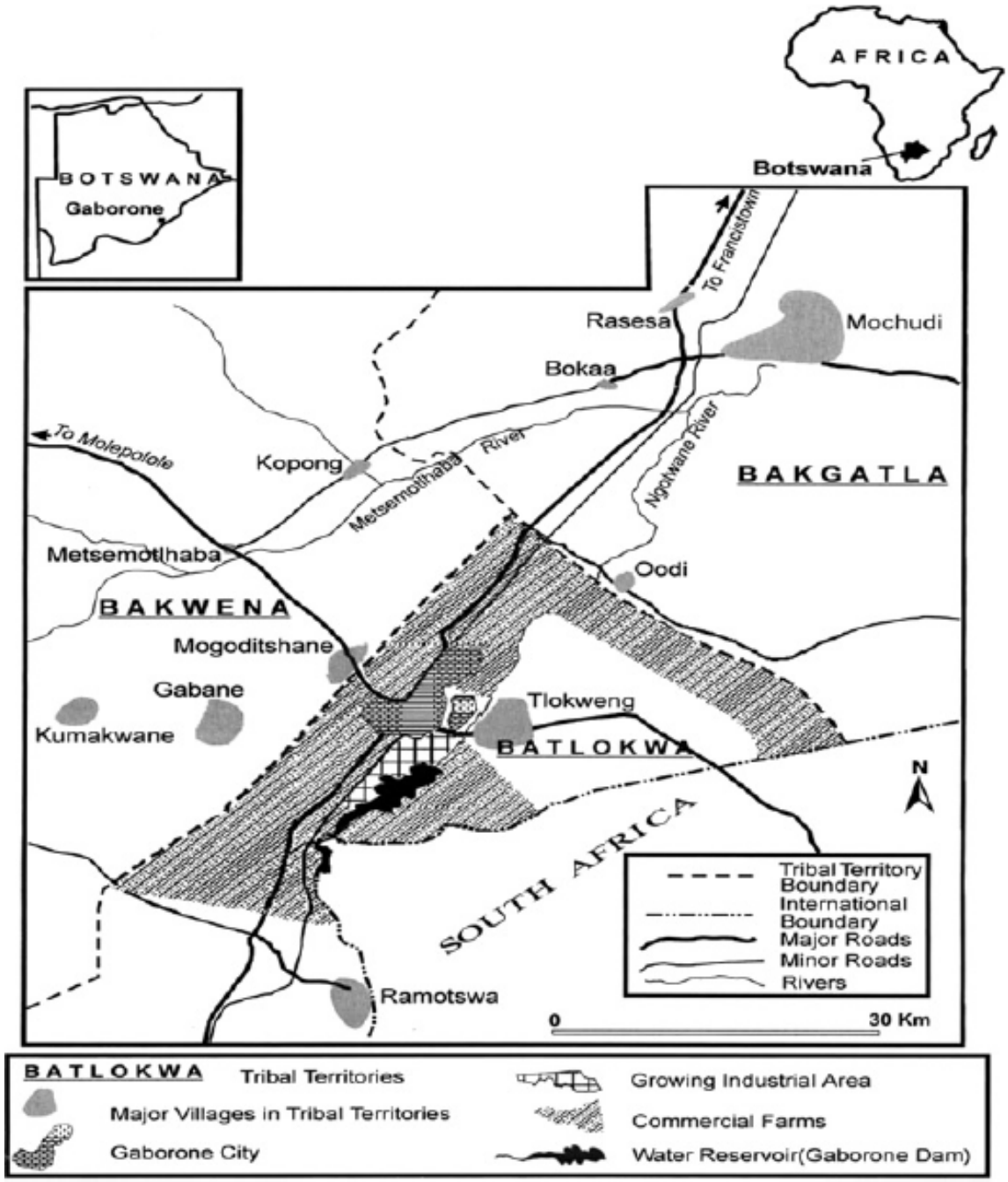

Fig.1 Greater Gaborone area and its location (Batisani & Yarnal, 2011).

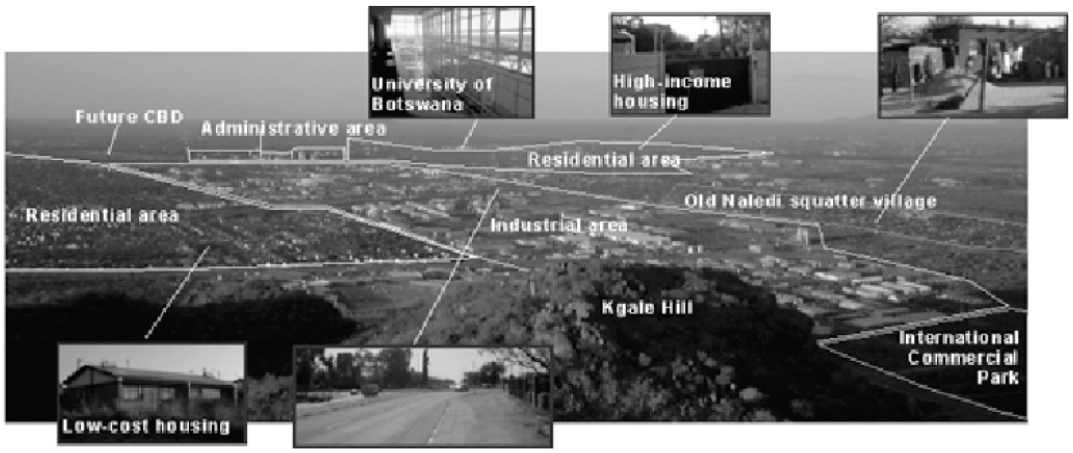

Fig. 2 Income-based residential zoning in Gaborone city (Keiner & Cavric, 2003)

Older residential zones for high-income groups have plot sizes of 2,500 m² and more with vast single storey houses covering only between 100-150 m² of the plot, which gives very low ratios of sum of all floor spaces to plot area (0.4 to 0.6). Even with the revised maximum plot size, the high-income categories are still limited only to a maximum of 1000 m². On those plots, building coverage is approximately around 10–20%. While the low-income plot size is 300 m² (Mosha, 1996; Keiner & Cavric, 2003) (**Fig. 2**). Equally important, the plan contained one significant feature, which today would be regarded as inappropriate. Firstly, housing development was polarized with high and medium income on one side of the town and low income on the other (Keiner & Cavric, 2003). As the plot size is sold on per m² basis, invariably the high earning segment of the society reside in high and medium income areas and the opposite is true for the low income. Furthermore, only residential zones for government staff were planned in the decade 1965–75 with the in-migrating rural population ignored for a long time. This situation led to unplanned squatter settlement (for example, Old Naledi) and also to a segregation of social classes and income groups in Gaborone's residential areas (Mosha, 1996).

Data

An inventory of types of environmental hazardous facilities and their locations within the city was obtained from the National Environment Laboratory (Gaborone). The spatial locations of these facilities were then georeferenced using Global Positioning System (GPS) and mapped into the base map of Gaborone. All the data layers and subsequently the figures are in WGS84 datum and coordinate system.

The railway that transverses across the city is the original Rhodesia to Mafikeng (South Africa) built by Cecil Rhodes in 1894. At the time of its construction the place where Gaborone city is was wilderness with no settlement. The relationship between transportation and land use has been much discussed including co-development, and the idea that just as transport drives land use, land use drives transport infrastructure when there is an existing place and transport network. The converse does not hold, there may be transport network serving 'placeless' areas, which are not developed, as the network may be serving places at its ends, but traversing undeveloped land to connect them. This is the Gaborone city and its railway scenario. Thus transport can lead or follow land use, but land use must follow some (however primitive) transport network (Levinson, 2008).

Analysis

The environmental hazardous facilities layer was overlaid with the city residential layer in ArcGIS (ESRI, v.9.1). Subsequently distance buffers between the facilities and residential areas were created at 200m and 300m to determine the distance of the hazardous facilities to the residential areas across different land use zones (Low, Medium and High income). The assumption being that any residential unit within the specified buffer distance would be affected by the environmental hazards from the facility. The radius of circular buffers in environmental justice studies have ranged from 100 yards (Sheppard *et al*., 1999) to 3 miles (Mohai & Saha, 2006). Instead of using a single radius or buffer, several studies have also constructed two or more circular rings at increasing distances from environmental hazard sources (e.g., Neumann *et al*., 1998; Perlin *et al*., 1999; Sheppard *et al*., 1999; Atlas *et al*., 2002; Perlin *et al*., 2001; Pastor *et al*., 2004; Walker *et al*., 2005). Houston *et al*. (2004; 2006), Ong *et al*. (2006), and Zhu *et al*. (2002) noted that relative concentration of hazardous emissions declines by as much as sixty percent at 100 meters downwind, drops to near background levels at about 200 m, and are

indistinguishable from background ambient concentrations at 300 meters. Nevertheless, the determination of the number of buffers to use and choice of radii for each buffer remain ambiguous (Zandbergen & Chakraborty, 2006).

RESULTS

Table 1 shows the occurrence and spatial distribution of hazardous facilities across different income municipalities. Fuel facilities are the predominant and occur mostly in low and medium income municipalities. Most industrial facilities are found in the low/medium income municipalities of Broadhurst, and Gaborone West and the high income municipalities of Gaborone Central and Gaborone North have no industrial facilities. Hazardous facilities such as fuel depots, paint processing and packaging industries, medical stores, chemicals manufactures, cement manufacturing, and processing plants are concentrated on medium/low income municipality of Gaborone West, while beverage breweries, soap manufacturing industries, natural gas processing and packaging plants, power transformers, and a few petrol filling stations are located in Broadhurst, another medium/low income municipality. Low risk facilities such as hospitals and research chemical laboratories are in the high income municipality of Gaborone Central. Gaborone North, another high income municipality is a take-off flight route for the airport on the outskirts of the city whereas the north-south railway lines passes through most municipalities (**Fig. 3**).

Table 1. Hazardous facility location by municipality and hazard potential

Municipality	Predominant income category	Facility	Hazard type
Broadhurst	low/medium/high		
		Propane gas manufacturers)	Prone to fires Pollution from toxic gases
		Liquid air manufacturers	Prone to fires Pollution from toxic gases
		Brewery	Toxic gases and chemicals
		Soap manufacturing industry	Toxic gases and chemicals
		Fuel depot	Fire hazard Toxic gases
		Power transformers	Radiation Electrocution
Gaborone Central	low/medium/high		
		University of Botswana laboratories	Toxic gases and chemicals
		Princess Marina hospital	Radio- active machines Clinical waste
		Petrol station	Fire hazard Toxic gases
Gaborone West	low/medium		
		Fuel depot	Fire hazard Toxic gases
		Paint manufacturers	Flammable and toxic gases
		Central medical stores	Flammable and toxic substances
Borakanelo	low		
		Railway station	Noise Flammable and toxic gases
		Chemicals store	Flammable and toxic substances
		Fuel depot	Fire hazard Toxic gases
Gaborone North	medium/high		
		Airport	Aeroplane crashes causing casualties on the ground Fire hazard Toxic gases Noise Communicable diseases

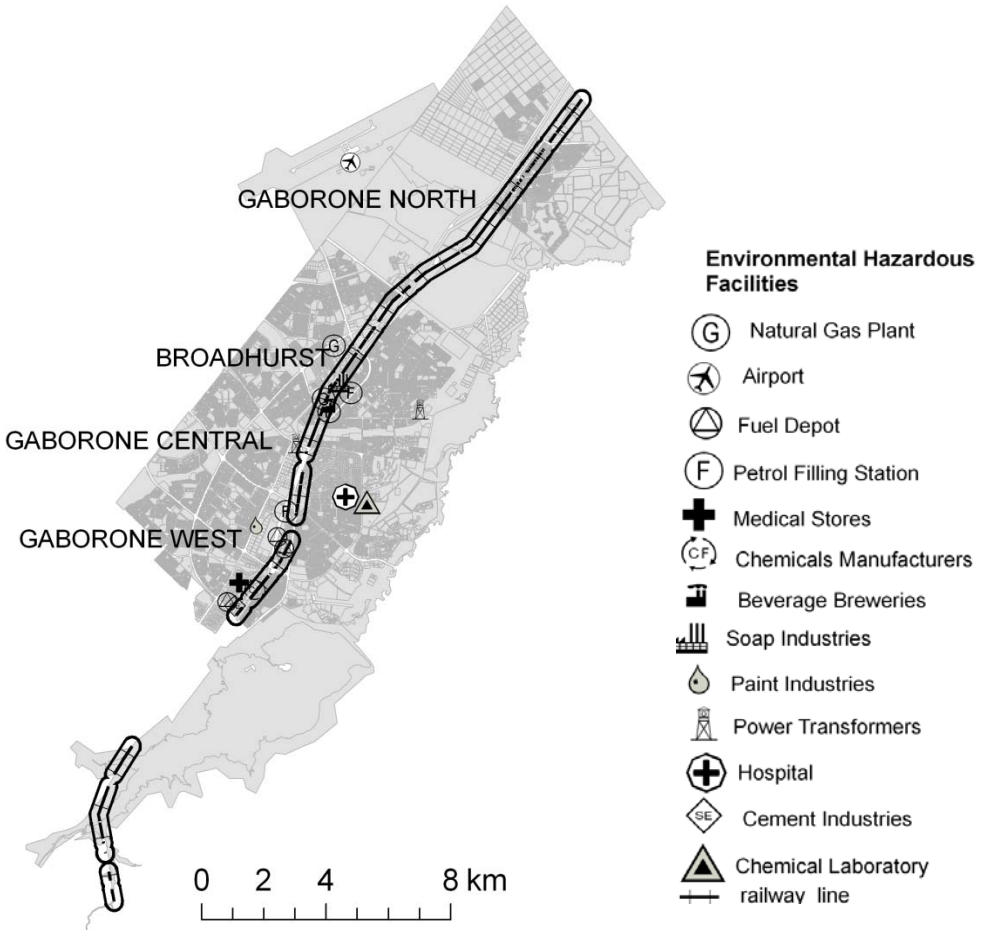

Fig. 3 Distribution of Hazardous facilities around the city.

Fig. 3 Hazardous facilities in Gaborone West at various buffer distances from residential areas.

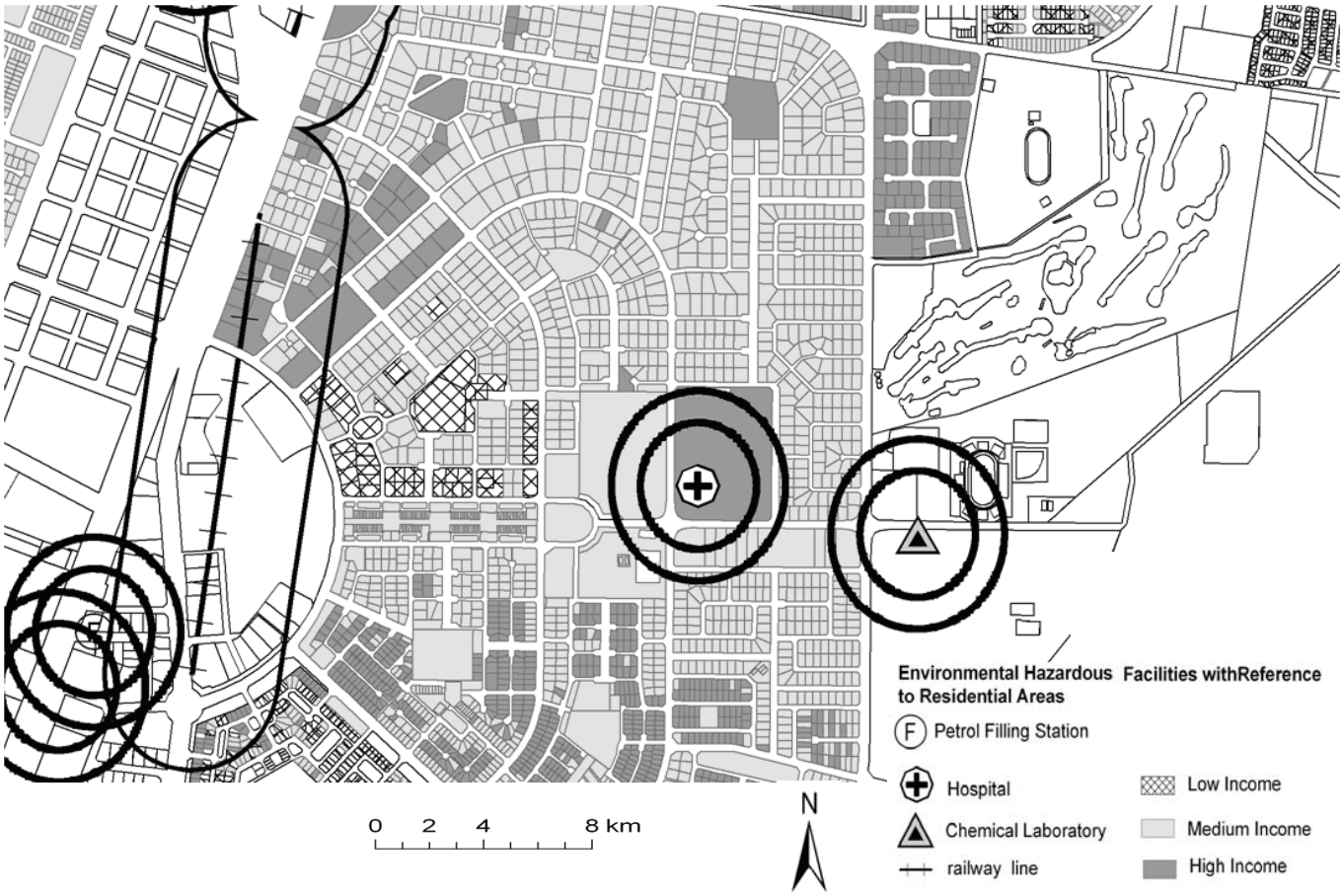

Fig. 4 Hazardous facilities in Gaborone Central at various buffer distances from residential areas.

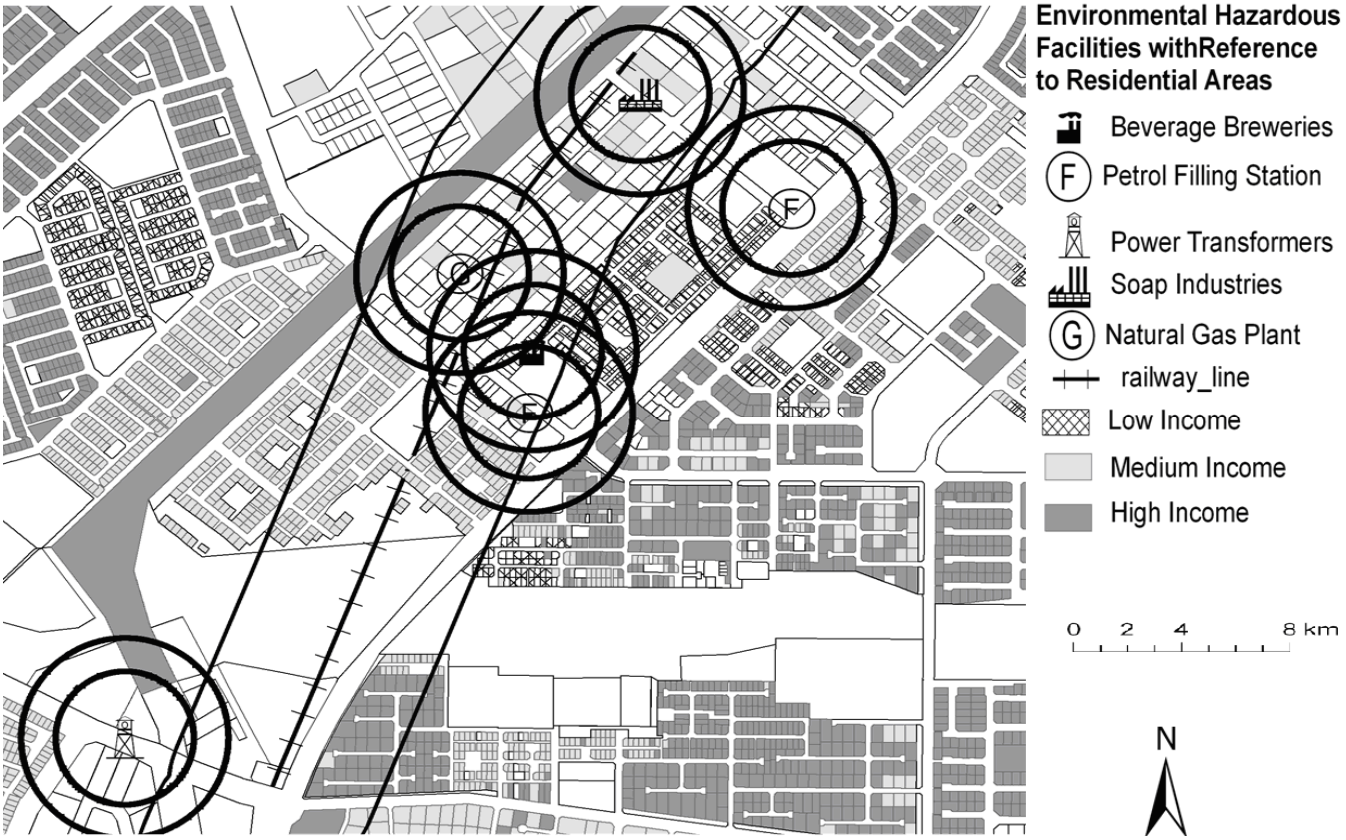

Fig. 5 Hazardous facilities in Broadhurst at various buffer distances from residential areas.

Most hazardous facilities that include power transformers, natural gas plants, soap industries, beverage breweries and petrol filling stations are found in the low income Broadhurst municipality within 300m (**Fig. 5**).

While Gaborone North, consisting mainly of medium to high income residential areas, has only two hazardous facilities, the railway line and the airport. The 200m and 300m buffer zones do not apply for the airport because of the airport clearing zone. Nevertheless, take-off and land routes are likely to pass through most parts of the city during airplane take-off and landing times as the flight path passes through this area. The impact from the rail road seemed to affect only the medium income residents in this area (**Fig. 6**).

Discussion

The results seem not to support the assertion that environmental hazardous facilities are often concentrated more in areas of low income communities than in medium or high income ones. Nonetheless, hazardous facilities seem to be closer to residential areas in low income municipalities. Many observers (e.g. Boer *et al*., 1997; Szasz & Meuser, 1997; Sadd *et al*., 1999) observed that low income areas often have high exposure to air pollution from stationary sources, while high-income neighbourhoods have successfully avoided exposure to unwanted land uses. Hence, lower-middle class neighbourhoods tend to be the most vulnerable. This phenomenon is especially true in Los Angeles County, California where the most impacted neighbourhoods are working class (usually Latino) communities close to industrial zones (Boer *et al*., 1997). Finding affordable housing close to work (factories) has often been cited as the explanation for the status core. Nevertheless, there is no definite trend for such scenario in Gaborone city.

Although most facilities are dispersed across the income based zoned municipalities, it is observed that the power transformers at Broadhurst municipalities are in high and medium income areas. Wartenberg *et al*. (2010) noted that people living within 304.8m from High Voltage Electric Power Transmission Lines (HVTL), were more likely to be exposed to magnetic fields, and comprise of higher income, more educated and home owners. Possible explanations for these patterns include the desire for the open space created by the rights-of-way, the preference for new homes/subdivisions that are often located near HVTL, and moving closer to HVTL before Electromagnetic Fields (EMFs) were considered a risk. Gaborone Central shows evidence of these facilities being near high and medium income communities than low income ones. These facilities include the National hospital and the University of Botswana Research Laboratories.

The airport was found to be located far away from residential areas, but the landing and taking off paths are likely to pass over some parts of the city. Airport operation is a major source of community concerns due to aircraft noise emissions particularly in locations close to airports and aircraft flight tracks as it can cause sleep interference, which can develop into stress for nearby communities (El-Fadel *et al*., 2002). For instance, in India aircraft-induced noise levels in some residential areas located underneath the flight path was found to be more than 20 average peak noise levels (dBA) (Upadhyay *et al*., 1998). Airports location has been found to influence property prices. Burns (1989) suggested that the prices of houses beyond the 25 Noise Exposure Forecast (NEF) range were largely unaffected while within the 25 NEF contour, decreased on average by 10.7%. The railway line seemed to cover all municipalities as the city was planned around it. Rapoza (1999) found that train noise affects residential property prices at the distance of up to some 300 meters from its tracks and also that the greater the use of horns, the greater reduction in house value.

CONCLUSION

The purpose of this paper was to determine the presence and scale of urban environmental injustice within a developing country setting. The results show that although hazardous facilities are in the proximity of residential areas, their location does not show any municipality based pattern. To curb this public health hazard, urban planning, and environmental law must work together to understand how zoning reform can be used to decrease exposure to this facilities in the city. Mitigation measures need to be put in place to minimize impact on the exposed communities. For instance, walls could be built around the railway line near residential areas to muffle the noise coming from the train. Furthermore, lead metal sheaths could be placed around power transformers to prevent the radiation produced from reaching communities.

Fig. 6 Hazardous facilities in Gaborone North at various buffer distances from residential areas

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