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URBAN CITIES AND WASTE GENERATION IN DEVELOPING COUNTRIES: A GIS EVALUATION OF TWO CITIES IN BURKINA FASO

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Abstract: Cities in developing countries are faced waste management challenges in terms of quantity and quality. Most of the time, solid and liquid wastes are dumped on street and open spaces. Uncontrolled waste dumped has led to diverse kind of health problems. The purpose of this article is to characterize urban cities and evaluate their waste generation using the Geographical Information System (GIS). The focus is on two cities in Burkina Faso. Specific variables which were considered during the survey include urban fabric, grey water outlets and household garbage dumps sites/techniques. The study shows that in the two cities, the most dominant urban fabric is low standard of living (about 64% of housing in Fada and 62% of housing in Pouytenga). The urban fabric is also characterized by the existence of empty spaces. Overall, the average density of grey water discharge points is 0.85 points and 5.7 points per ha of street in Fada N'Gourma and Pouytenga respectively. The average density of solid waste dumps is 1.45 waste dumps per ha street and 7 waste dumps per ha street in Fada N'Gourma and Pouytenga respectively. In case of urgent waste management intervention, the priority areas for speedy intervention are area **10** in Fada N'Gourma, areas **2** and **5** in Pouytenga. GIS applied to waste management can be a decision making tool for urban planners in developing country.

Keywords: Developing countries, Discharges, Fada N'Gourma, GIS, Pouytenga, Wastes

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INTRODUCTION

Globalisation has brought some troubling concerns for developing world, especially developing countries in Africa. One of the concerns is its impact on urbanization and the ramification that go with it. Urbanization is due to rural – urban migrations, natural population increases, engulfing of peripheral rural settlements by urban expansion. In Africa, the unprecedented urban growth is increasing consequences that go with it. One key challenger is waste management (Achankeng, 2003). The consequences of urbanization in cities in developing countries are (i) increase of household incomes leading to changes in life style and consumption patterns, (ii) increase in waste generation: quantity and variety. So, African countries are faced with waste management issues: waste quantity and quality problems (Achankeng, 2003; Medina, 1999; Troschinetz & Mihelcic, 2009). Most of urban cities' households discharge waste on the street. Uncollected or illegally dumped wastes constitute a disaster for human health and the environment degradation. Some authors attribute the prevalence of diseases parasites (malaria, cholera, diarrhea etc) to unsanitary conditions (Abul, 2010; Dongo *et al.*, 2008; Garfi *et al.*, 2009; Medina, 1999; Ngnikam *et al.*, 2011). Urban cities in developing countries have to deal with solid waste and wastewater if the cities are to be sustained and also for the health of urban dwellers. The expanding urbanization in developing countries dramatically affects every environmental resources including but not limited to water resources quality (physical, chemical, biological pollution) and quantity (Ducrot *et al.*, 2004; Yiougo *et al.*, 2011).

To tackle waste generation menace, many ministries and urban councils have been established to address waste management issues in developing countries' urban cities. Municipal solid waste is materials that are discarded by household for which municipalities are responsible for collection, transport and final disposal (Medina, 1999; Parrot *et al.*, 2009). Wastewater is any water that has been used and is unfit for further use except they are recycled, the technology of which elude many developing countries. Wastewater is applied to all waters originating in toilets, showers, sinks, washing areas (Tilley *et al.*, 2008).

More than 90% of information required for a city's administration has a spatial component, such as parcels of land, road networks, utility infrastructure, emergency services, garbage collection and recreational areas thereby making geo-spatial information a very important concept in waste management, administration, decision making and planning. The instrumentality of Geographical Information Systems (GIS) is, therefore, seen as essential technology for urban management (Bishop *et al.*, 2000, Kontos *et al.*, 2003). The objective of this study is to characterize and evaluate the waste generation in urban cities in developing countries using the instrumentality of GIS. Two mid-size cities: Fada N'Gourma and Pouytenga in Burkina Faso, West Africa, are chosen as the sample study sites.

MATERIAL AND METHODS

Study areas

Burkina Faso is located in West Africa. The climate is Soudan-Sahelian. The temperature is between 16°C to 45°C and the rainfall is between 350 mm to 1000 mm. The capital is Ouagadougou. Study areas are two mid-size cities name Fada N'Gourma (approximately 11.2 km^2 in area) and Pouytenga (approximately 7.6 km^2 in area) located in East part of Burkina. The number of inhabitant is about 60 000 in Pouytenga and 40 000 in Fada N'Gourma. Administratively, Fada is structured into 11 council areas and Pouytenga into 5 council areas. In Burkina Faso, Local Government authorities are in charge of solid waste management in urban cities while the National Agency of Water and Sanitation (ONEA) is in charge of wastewater management. Since 2006, Fada local government initiated and adopted its own Strategy Plan for Solid Waste Management (SPSWM) for the management of solid wastes while ONEA developed and maintained Sanitation Strategy Plan (SSP) for wastewater management in the city. SPSMW is based on two solid waste collection systems. The pre-collection is made at household level by local NGOs who bring waste to transfer station while the urban council collects the wastes from transfer station for the onward disposal to the landfill site. There are some local female members of the Non-Governmental Organizations (NGOs) who are engaged in solid waste pre-collection, collection and disposal to the transfer station. However, the secondary collection from the transfer station to the designated sanitary landfill site is done by the city council officials. Contrarily, the Pouytenga city has no any strategy or plan of waste management. This study, therefore, aims at comparing the waste outlets point in these two different cities using the instrumentality of GIS in exploring and evaluating the waste generation, disposal and management within the cities.

Data collection: geographical survey

Spatial surveys of the two cities were conducted with the aid of Global Position System (GPS) device. Specific variables which were considered during the survey include grey water outlets and household garbage dumps sites/techniques. The survey targeted at

Table 1. Housing characterization criteria

Housing Standards	Description	Characterization of the houses
High standard houses	Main building and enclosing wall are constructed with solid and high standard building materials- the buildings are well fenced with necessary amenities (pipe-borne water, electricity, telephone services, etc) and provision of waste/grey water disposal facilities.	Community or the area are characterized as high standard neighborhood it the area has than 50% of the buildings which are of high standard of accommodation.
Medium standard houses	Main building is constructed with solid materials or improved mud, there is running water and / or electricity. There may or may not be any provision for waste disposal facilities	Neighborhood with more than 50% of the buildings are of middle standard of living housing
Low standard houses	Main building is constructed with mud, no running water norelectricity and there is no waste disposable plan	Neighborhood with more than 50% of the buildings are of low standard of living housing

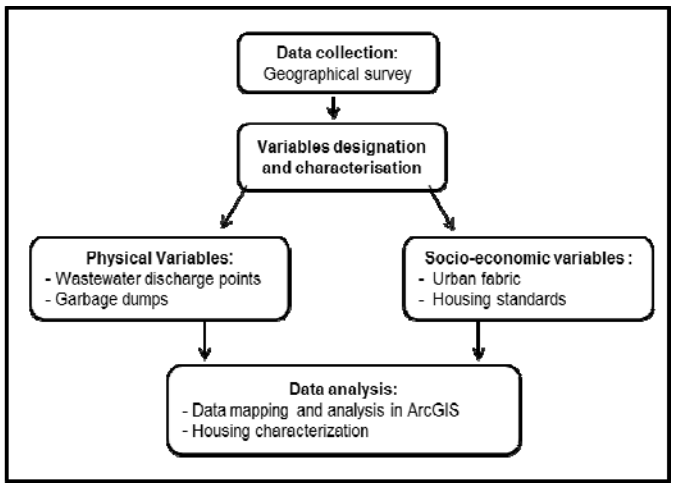

Fig. 1 Flow chart of the methodology.

(i) characterization of the urban fabric by identifying the dominant standard of living housing with the cadastral map of cities according to the criteria presented in **Table 1**; (ii) identification and characterization of different outlets including wastewater discharge points and household garbage dumps (**Fig. 1**). The output of the survey resulted in (i) geo-referencing of the discharge points of wastewater and garbage dumps throughout the cities of Fada N'Gourma and Pouytenga; (ii) the estimation of the volume of discharges; and (iii) spatial evaluation of the housing characteristics as they influence waste generation in the study sites.

Data Analysis

Data has been represented on the base map of cities by using ArcView GIS version 3.2a. The analysis was done by the number of waste (solid and liquid) outlet per street hectare (ha) knowing that 30% of urban space is reserved for streets and roads in developing country (Dongo *et al.*, 2008).

RESULTS AND DISCUSSION

Urban fabric characteristic

Characterization of the urban fabric shows a dominance of low standard of living in 7 areas (**1**, **3**, **6**, **7**, **8**, **9** and **11**) in Fada N'Gourma and 4 areas (**1**, **2**, **4** and **5**) in Pouytenga. Then generally, in the two cities, the most dominant urban fabric is low standard of living (about 64% of housing in Fada and 62% of housing in Pouytenga). This is an indication that most of the communities in Fada N'Gourma have lower source of income and are highly exposed to the problems of environmental sanitation. The middle class includes three areas (**4**, **5** and **10**) in Fada and one area (**3**) in Pouytenga (28% of housing). Only one area (**2**) has more than 50% of high standing in Fada (57% of housing in area **2**); this area houses administrative structures and residential area built by State. In terms of building density, nearly 34% of the land plots of the city are not built in Fada. In Pouytenga, the occupancy rate of land plots is greater than 90% in areas **1**, **2**, **4** and **5** and less than 50% in Area **3**. Area **9** in Fada is the largest sector in terms of area but remains the less dense with 47% of the land plots that are not occupied. The open spaces are used for agriculture during the rainy season. Indeed, this area is the largest one in the city in terms of area and has recently undergone an expansion program. Area **2** in Pouytenga is the most dense (95% of the plots are constructed) and houses the largest market of the city.

Grey Water Discharges

Overall, the average density of grey water discharges points is 0.85 points and 5.7 points per ha of street in Fada N'Gourma and Pouytenga. Specifically, areas **10**, **11** and **1**, in the south-east of Fada are areas with higher density of wastewater discharge on the street. There are

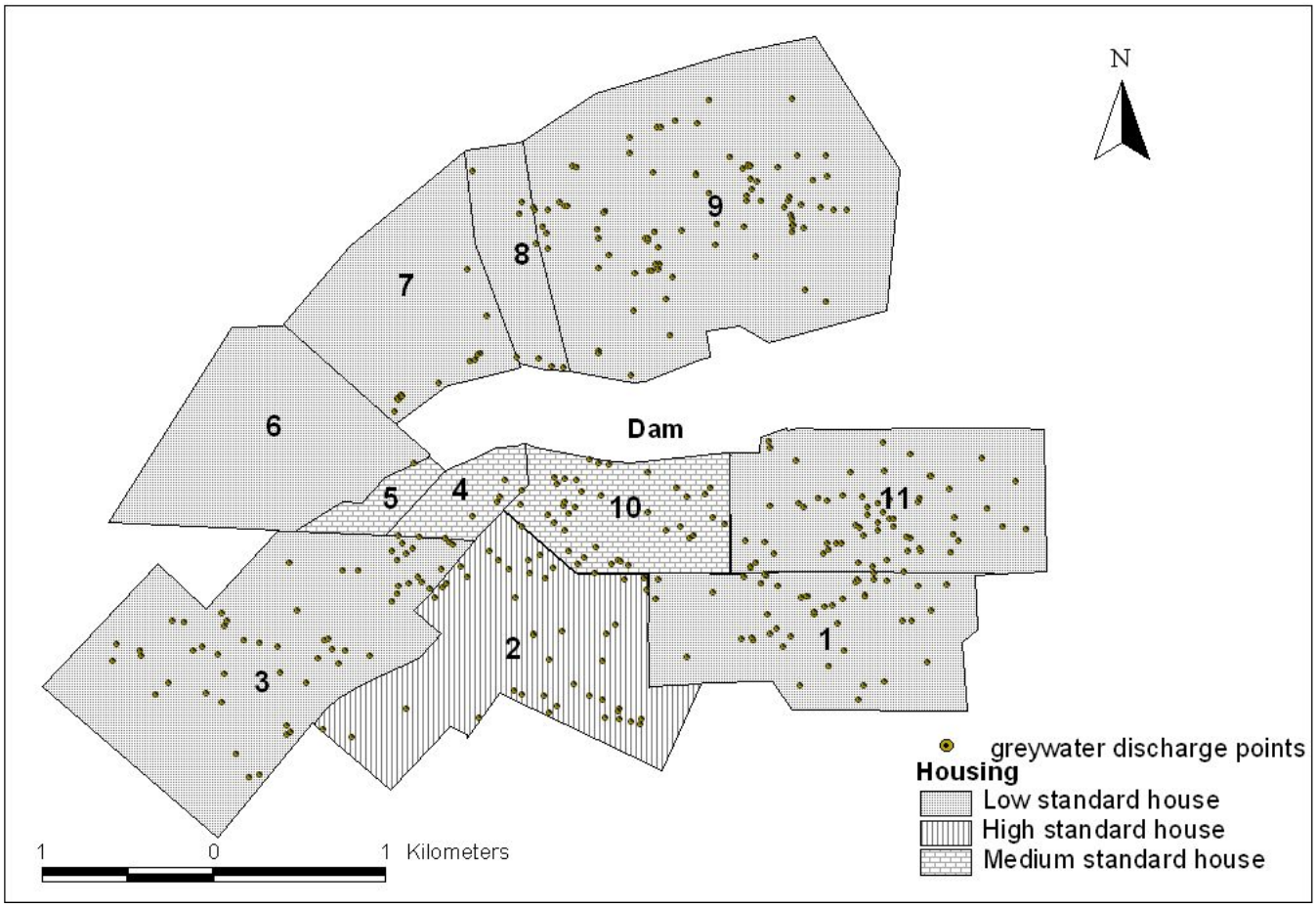

Fig. 2 Grey water discharge points in Fada.

respectively 1.6, 1.3 and 1.1 points/ha of waste water disposal respectively (**Fig. 2**). This confirms the data of the Strategic Sanitation Plan on the current status of wastewater management in Fada which stated that around 80% of households in Fada pump grey water into the street or yard in 2006 (ONEA, 2006). In Fada, all grey water discharges occupy 1 100 m^2 of surface and 186 723 m^3 in volume.

In Pouytenga, areas **2** and **5** are those with the higher density of wastewater discharges points which are 9.5 points/ha and 8.2 points/ha respectively. In comparison with results obtained by Yonkeu (2005), there is an increase of the number of grey water discharge points from 215 in 2002 to 1304 in 2010. This increase affects all areas of the city. It should be noted that from 2002 to 2010 the sewage disposal output coverage in area **3** has increased from 89.41/ha to 452.7/ha. In terms of density of surface streets, it was 0.3 points / ha in 2002 and about 5 points / ha in 2010. The density of grey water discharge is the largest in area **2** of the city both in 2002 and 2010 (**Table 2**).

Solid waste discharges in the two cities

The average density of solid waste dumps is 1.45 waste dumps per ha street and 7 waste dumps per ha street in Fada N'Gourma and Pouytenga respectively. In Fada, the area with largest concentration of garbage dumps is the area 10 with 4 dumps of garbage per ha street (**Fig. 3**). This area houses the Central Business District of the city including the big market and bus stations. In case of intervention, area **10** would be given priority over other areas of the city. The area with the lowest density is the area **9** (0.32 point/ ha). Area **9** is traditional one and is mainly inhabited by farmers. This information confirms the results of solid waste current management status that claim that in area **9**, the majority of households send their garbage to the fields (CAGEC, 2006). All of these dumps occupy 12 600 m^2 in area and 2,627,312 m^3in volume.

Table 2. Number of grey water discharges points in Pouytenga in 2002 and 2010

Area	Number of wastewater discharges points (2002)[a]	Number of wastewater discharges points (2010)
1	31	72
2	109	204
3	10	802
4	23	147
5	42	79
Total	215	1304

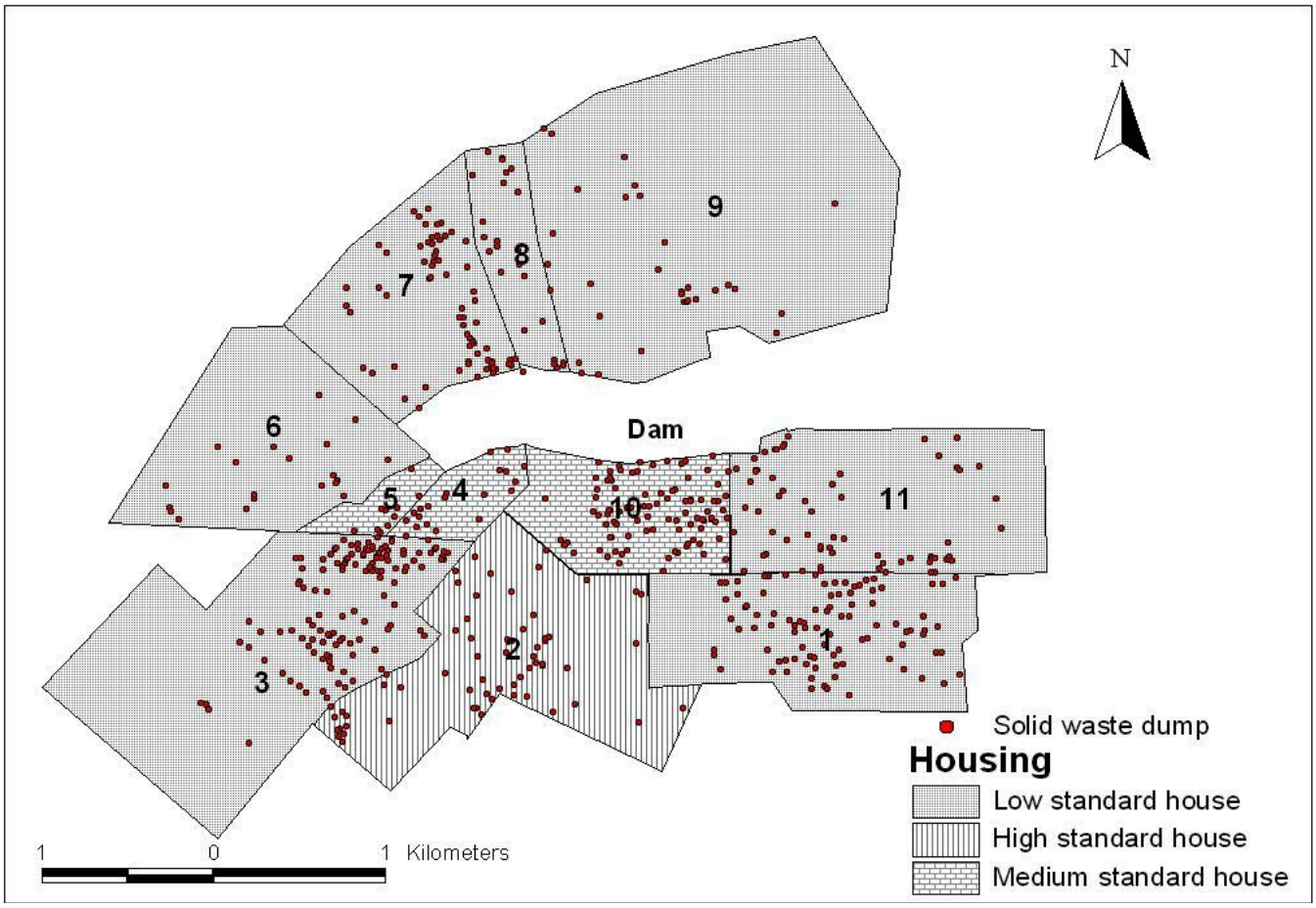

Fig. 3 Solid waste dumps in Fada.

Table 3. Number of dumps in 2002 and 2010 in Pouytenga

Area	Number of dumps (2002)[a]	Number of dumps (2010)
S1	63	98
S2	239	225
S3	45	941
S4	78	131
S5	94	96
Total	519	1491

In Pouytenga, areas **2** and **5** are those with a high density of dumps (11 dumps / ha for area **2** and 10 dumps / ha for area **5**). In terms of quantity, solid waste cover an area of approximately 7.5 ha or 0.5% of the area of the entire city with a volume of 18,509 m^3. Area **2** is the one with the largest amount of solid waste which is 10,701 m^3 or about 58% of the total volume of waste in the city. This area in Pouytenga accommodates the central market; therefore the centre is noted for most of the business activities. In comparison with 2002 data, the total number of garbage dumps increased from 519 in 2002 to 1491 in 2010 or about 3 times more dumps within 8 years. The increase mainly centres on areas **1, 3** and **4**. However, in terms of density of dumps, area **2** is denser than either 2002 or 2010 (**Table 3**).

CONCLUSION

In Fada, characterization of the urban fabric in Burkina Faso shows a dominance of the habitat of low standing (64%) in the two cities sampled for this study. In developing countries, cities are mostly villages that have developed through the construction of administrative area surrounding traditional neighborhoods. The urban fabric is also characterized by the existence of empty spaces (34% of land plots). Waste discharges (grey water and solid waste) occupy 3.5% of the area of the city streets. Indeed the inventory made by ONEA through the development of PSA shows that nearly 80% of households in Fada do not have excreta disposal (ONEA, 2006). The PSGOM notes that 46% of household waste is dumped in the street (CAGEC, 2006). These wastes outlets are places of proliferation of diseases vectors (flies, mosquitoes, rats etc). Area **10** in Fada which is the Central Business of the city has the highest density of garbage dumps and sewage outfalls.

As Fada, Pouytenga urban housing is mainly dominated by the low standard of housing (62% of housing). The occupancy rate of land plots is more than 90% in all areas except area **3** which has an occupancy rate of 50%. The city currently has about 1,304 outlets of grey water and 1,491 of solid waste dumps against 215 sewage outfalls and 519 garbage dumps counted in

2002 by Yonkeu (2005). Areas **2** and **5** with dominated by low standard of living household are those with the highest densities of wastewater discharges and dumps garbage. This justifies the need for the development and implementation of a strategy for waste management in the city of Pouytenga. For solid waste strategy management plan implementation, the place of solid waste dumps in the city can be used as garbage collection point and transported by dust-cart for final disposal.

In case of intervention, the priority areas to act are area **10** in Fada N'Gourma and area **2** and **5** in Pouytenga. GIS applied to waste management can be a decision making tool for urban planners in developing country.

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