Effect of a Fast-Growing Consumer Culture on Waste Profile in Sub-Saharan African Cities

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ABSTRACT

Africa has the highest rate of urbanization and economic growth. These trends drive growth in demand for consumer goods, a trend expressing itself by a shift in provisioning from traditional markets to supermarkets. This is emphasized by the fast spread of supermarkets. With these changes in consumption come an increase in quantity and variety of waste generated. Prior studies show insufficient infrastructure and investment in waste management.
To inform waste management planning, metabolic flow models have been developed to describe food acquisition from a traditional market vs. a supermarket. Consumer food flows are formulated based on cultural profiling and quantified via the daily nutritional requirements of a healthy person. The waste profiles are obtained by reading from packaging and processing data. With transition towards supermarket consumption, the post-consumer waste contains more inorganic material i.e. packaging and a portion of organic waste shifts to the supply chain where food is processed.

1 INTRODUCTION

Urban environments around the world are expanding at an ever increasing rate today. The world population is expected to increase by 2.3 billion between 2011 and 2050 whilst the urban population is expected to increase by 2.6 billion in the same period (UNDESA, 2012). This means that the urban areas are expected to absorb all the population growth while at the same time taking in some of the rural population. Most of this growth is expected in cities in less developed regions.

Africa has only about 40% of its population living in urban areas, making it the least urbanized continent. However with an annual rate of urban population growth at 3.09% its urban population is the fastest growing in the world. This high rate of urbanization exceeds the rate of population growth rate of 2.11% per annum. This shows that the urban areas are also taking up some of the rural population. With an increase in urbanization in cities in Africa, there is an increase in the impact that these cities have on the environment .

The growth of African cities is further reinforced by recent high economic growth rate, measured in terms of growth in gross domestic product (GDP). This is increasing at a rate of 5-6% per annum which is well above the average global economic growth rate of 2% per annum (Hatch, et al., 2011). This makes Africa the fastest growing continent in the world. Poverty in Sub-Saharan Africa has reduced rapidly from 40% in 1980 to 30% in 2008 and is expected to fall to 20 percent by 2020 (Hatch, et al., 2011). The proportion of the working population has increased and this has led to an increase in incomes, giving rise to an emerging middle class that is more demanding. The increase in incomes has led to increase in spending power and diversification of consumption patterns and lifestyles. This has been further emphasized by the increase in globalization and trade.

1.1 Rise of Supermarkets

The rise of supermarkets has been happening since the mid-1990s and there has been a rapid rise in the number of supermarkets especially in developing countries. Supermarketization has been described in reference to developing countries as the rapid spread of supermarkets (Reardon, et al., 2005). In Africa, supermarkets are growing at a fast pace, especially in eastern and southern Africa (Reardon, et al., 2003). South Africa has seen a rapid rise in the number of supermarkets and Kenya and other countries are following suit (Traill, 2006). The rapid rise has been made possible by increasing urbanization and the rise of the middle class (Weatherspoon & Reardon, 2003). This increase has been made possible by growth in GDP and distribution of incomes (Traill, 2006).

Table 1. Showing change in supermarket share with changes in urbanization and income per capita

Country	Kenya		South Africa	
Year	2002	2015	2002	2015
Income per capita (US$)	393	497	2299	3340
Urbanization (%)	38.2	51.8	56.5	62.7
Market share (%)	10	15	55	65

The increase in the incomes and urbanisation leads to an increase in the market share of supermarkets as can be seen in Table 1 above.

The opportunity to offer cheaper and wider variety of foods has favoured the growth of supermarkets in Africa (D'Haese & Huylenbroeck, 2005). This is of particular interest in African cities as this has led to a diversification in the food items consumed.

Supermarkets initially used to be a place where only the rich people shopped, however, over the past decade or so they have spread from the wealthy suburbs of cities to the poorer areas and now cater for the urban poor (Weatherspoon & Reardon, 2003).

1.2 Food trends

The fast growth of the supermarket sector has transformed the agrifood markets (Reardon, et al., 2004). One of the reasons for the fast growth of the supermarkets in Africa is the willingness of the people to adopt the western culture of shopping encouraged by the globalization of the media and advertising (Traill, 2006). With urbanization, there is a shift in the provisioning from the traditional open markets to the supermarkets. With this shift in provisioning, there is also a shift in the diet of consumers. Urban consumers are now moving towards the consumption of more highly processed foods and drinks (Kearney, 2010).
This is because the urban population lacks time to shop and the prepare meals, have higher incomes and are more mobile (Neven, et al., 2006). Also with urbanization, there is trade liberalization and with the injection of foreign direct investment into developing countries, the number of supermarkets is spreading and the urban population of developing countries is adopting a more western lifestyle.

1.3 Waste trends

With these changes in diet and consumption patterns there could be a change in the waste profiles of the population. This paper presents models of food consumption patterns for different types of African urban consumers in order to analyse the effects which the changing consumption patterns could have on the resulting waste profiles. This paper is part of a broader study that seeks to illustrate how the fast growing consumer culture in urban Africa affects waste management and the current waste management practices.

2 METHODOLOGY

In this study, metabolic flow models are developed to describe the food flow from the farm, sometimes via packaging or processing, to the retail outlet (i.e. traditional market or supermarket), then to the consumer household and finally to disposal, i.e. post-consumer waste. In order to develop these models, consumer food demands are formulated. From the consumer food flows, the amount and composition of the waste associated with food consumption can be determined.

2.1 Urban Food Consumption System

In order to track the urban food consumption flows, a material flow analysis is done. Figure 1 below shows the system boundary for the flow of food from the grocery store to final disposal in an urban setting.

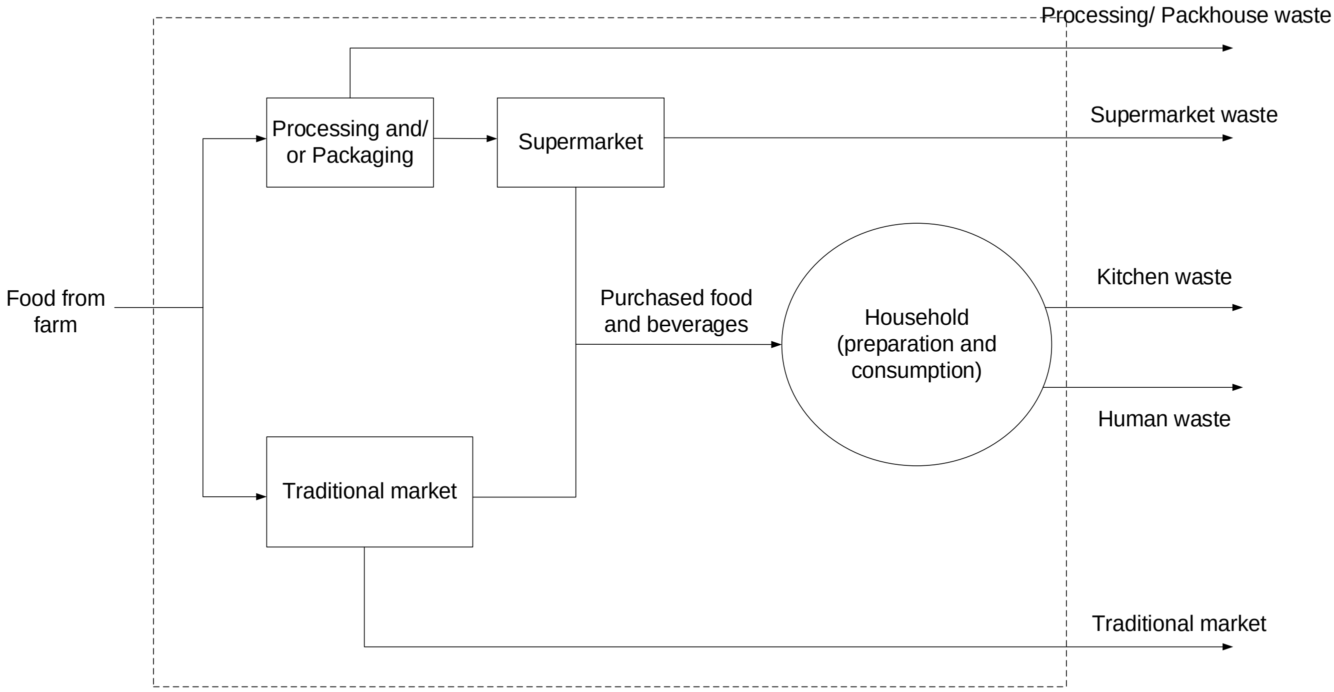

Figure 1: The system boundary

The following assumptions are made for this mass balance;

- All edible portion of food purchased is consumed and none thrown away. This assumption is acknowledged to be unrealistic, but serves to illustrate the effect of processing and packaging.
- The total of food consumed equals food used by the human body and excreted.
- Human waste is not considered in this study and thus is ignored, as the interest is on changes in solid waste profiles.
- For processed food (supermarket) provisioning, all inedible components of the produce that does not appear in household waste (e.g. peels, tops, roots) is removed during the processing or packaging step in the supermarket supply chain.

A model is generated based on a theoretical consumer. In order to obtain the food profile for the theoretical consumer, a theoretical diet of what the consumer eats on a daily basis is generated as described below.

2.1.1 Daily Energy Requirement

Food is a source of energy for living organisms. Living organisms take in food and break it down for growth and energy and in the process release waste. The human body is capable of utilizing the chemical energy that is stored in food (World Health Organization, 1974). This is a process called metabolism.
The recommended daily intakes of energy and nutrients have been documented in literature and will be used in order to specify the required energy intake for the diets. This information is also used for other purposes e.g. by policy planners when tackling food insecurity and also in the assessment of health. The energy obtained from food is often measured in kilocalories. A kilocalorie is defined as the heat required to raise the temperature of water from 15℃ to 16℃. The energy content of different food values is shown in Table 2 below;

Table 2. Showing energy content of different food values

Food value	Energy (kcal/g)
Carbohydrates	4
Fat	9
Protein	4
Alcohol	7

Different people require different amounts of energy based on occupation, age and size. In order to simplify the task of calculating the daily energy requirement, it is convenient to calculate the different amounts of energy in relation to a reference man and woman 25 years of age and weighing 65kg and 55kg respectively. In getting the recommended requirements, the following assumptions were made;

- One spends 8 hours a day doing each of work, sleep and non-occupational activities and
- the reference man is a moderately active man

The energy required for various activities during the day was then obtained and is shown in Table 3 below.

Table 3. Showing energy requirement per activity

Activity	Energy requirement
Work	175 kcal/h
Non-occupational activities	87.5-187.5 kcal/h
Rest	60 kcal/h

From this information the amount of energy required by the theoretical consumer will be calculated. In this research the consumer has been taken to be a moderately active male of about 25 years.
The total amount of energy required was calculated as follows.

$$Energy\ = Energy\ requirement * Time\ taken \qquad (1)$$

The total daily energy requirements is shown in the Table 4 below.

Table 4. Showing total daily energy requirement

Activity	Energy (kcal/day)
Work	1400
Non-occupational activities	1100
Rest	480
Total	2980

The table above shows the recommended daily energy intake for the moderately active reference man of 25 years old and 65 kg. This was used as the reference man in this study.

The next step will be to obtain the energy values of the foods that are consumed by the reference man. This will be obtained from various sources which include:

- World Health Organization (WHO) nutritional information
- Food Consumption surveys
- USDA national nutrient database
- World Food Dietary Assessment System

In this study, the diets formulated for the food consumption model are subjective to the author and are made up in order to illustrate the effect of food consumption choice on waste.

2.2 Generation of Diet

2.2.1 Urban Diets

As discussed in the introduction, urbanization is on the rise in African cities due to the natural increase in urban population as well as rural-urban migration. The increase in the urban population leads to an increase in demand for food. The increase urbanization not only leads to increase in quantity of food demanded, but also an increase in the variety of food purchased. The latter usually preceded by increase in incomes. In this study it is necessary to know the quantity and composition of the food purchased with this increase in urbanization and incomes. Different factors affect the choice of food consumed and how these factors affect food eaten has been documented extensively in literature. In order to obtain information on food consumption, surveys are usually performed. These could be done at different levels i.e. national, city or household level. However, for the purposes of this study, illustrative typical consumers are profiled, using results from literature and generating a daily diet that provides the targeted energy amount. For the purposes of this paper, a student and a vegetarian diet will be profiled.

2.2.2 Mass Flow of Food

The next step is to obtain the mass flows of the food that makes up the diet. This will be done by generating a simple mass balance spreadsheet of the food consumed on a daily basis. The daily consumption is formulated based on the recommended daily energy requirement of a healthy human being. An example of a formulated diet is shown in the table below.

Table 5. Showing example of diet used to generate mass flow

Breakfast	Unit	Amount	Mass (g)	Energy (kcal)
Maize-meal porridge soft without sugar/milk	cup	1	300	109
Sugars, granulated white	teaspoon	1	4.2	16.3
Milk	cup	1	244	149
Bread, whole wheat	Slices	2	56	138
margarine	pat (1" sq, 1/3" high)	1	5	35.9
lunch	Unit	Amount	Mass (g)	Energy (kcal)
Stiff-maize meal	Plate	1	450	557
Fish fried	small	1	135	311
Salt	teaspoons	2	12	0
Sunflower oil	table spoons	1	14	124
Tomatoes	unit	1	123	22.1
Onions	unit	1	110	44
Carrots	unit	1	61	25.01
Peppers, sweet, green, raw	unit	1	119	23.8
Orange juice from oranges	unit	2	262	123
Sugars, granulated white	teaspoons	2	8.4	32.5
Supper	Unit	Amount	Mass (g)	Energy (kcal)
Rice	cup	2	316	411
Pumpkin	cup	1	245	49
Chicken, broilers or fryers, breast, meat and skin, cooked, roasted	1/2 breast	2	196	386
Tomatoes	unit	1	123	22.1
Onions	unit	1	110	44
Carrots	unit	1	61	25.0
Peppers, sweet, green, raw	unit	2	238	48
Salt	teaspoons	0.5	3	0
			Total	2700

This is done for different types of diets for different consumers. Once the mass flow of the daily food consumption is obtained, the profile of the waste generated is obtained based on whether this food is purchased from the market or the supermarket. The waste generated will be calculated at two points; on the supplier side i.e. .before the food is sold to the consumer and on the consumer side i.e. the consumer's waste. From the information gathered the waste profile for the consumer from both market and supermarket consumption is obtained.

2.3 Waste Profiles

Waste varies from place to place and there are several factors that affect the quantity and type of waste generated. The main objective of this study is to analyse the effect of change in food provisioning on the waste generated. The waste generated that is associated with purchase from the traditional market and the supermarket is thus obtained. This is attained by obtaining the weight of packaging material, mainly in the case of supermarket provisioning and the weight of the inedible portion of the food, mainly in the case of purchase from the traditional market.

The waste associated with the choice of provisioning is obtained by calculating the amount of waste associated with food consumption from each of the different provisioning. In estimating the amount of waste generated, it is important to note the following assumptions and comments made;

- Only the inedible part of food purchased and packaging is considered as waste
- Food purchased but thrown away is not calculated
- The food packaging is based on supermarkets in South Africa
- The model does not account for re-use of packaging in individual households nor for waste reduction practices such as composting.

Information on the inedible part of food purchased was obtained from various sources which include the USDA national nutrient database and the World Food Dietary Assessment system. The weight of different food packaging was weighed on a laboratory grade weighing scale. The waste flows of packaging are tabulated as a waste ratio calculated by the formula;

$$Waste\ ratio = \frac{Weight\ of\ packaging}{Net\ weight\ of\ food\ purchased} \quad (2)$$

This information was then tabulated for further analysis. The type of material from which the packaging used is made is also recorded.

The inedible portion of food purchased is calculated from the percentage weight of the inedible portion of the food. This is illustrated in the formula below;

$$Y = \frac{X}{1-U} - X \quad (3)$$

Where: X is the edible portion of the food purchased in g
U is the weight fraction of the inedible portion.

3 RESULTS AND DISCUSSION

The effect of consumption choice on the waste profile is discussed in this section. The results from the consumption models of a pure market and pure supermarket consumer are shown and discussed below.

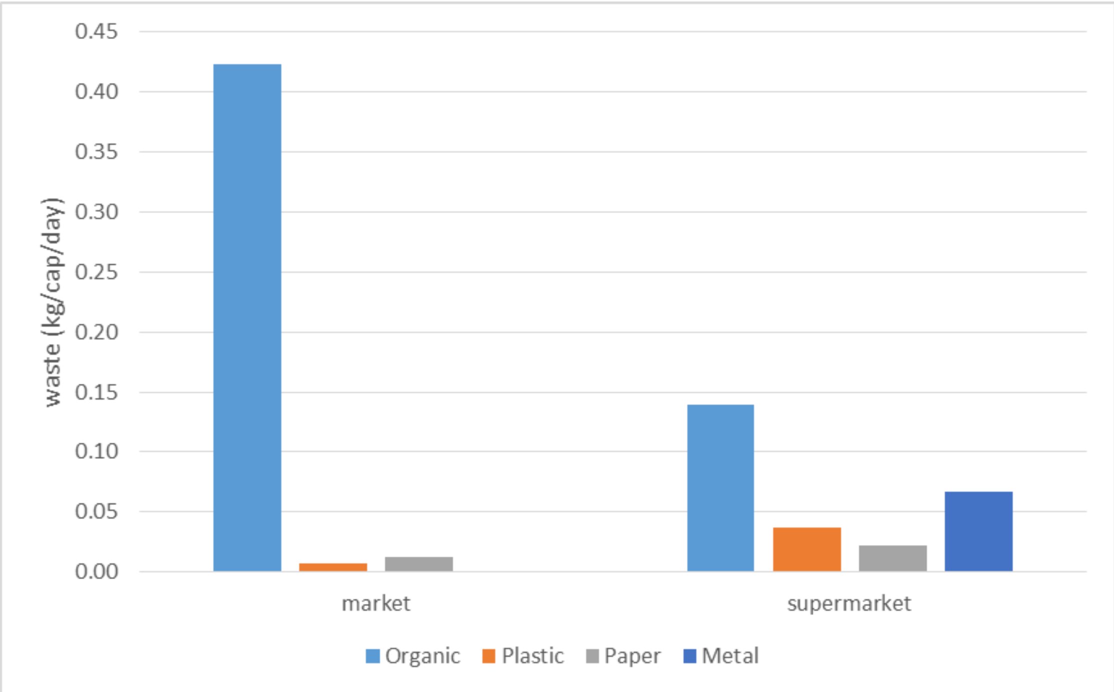

Figure 2: Showing market vs supermarket provisioning post-consumer waste for student diet

The effect of consumption choice on the waste profile is shown in the figure above. The figure compares the different quantities of the components of waste associated with household food consumption. The comparison is done between a pure market and a pure supermarket consumer. The amount of organic waste generated from the pure market consumer is 0.42 kg/day which is more than the 0.14 kg/day generated by the pure super market consumer. The inorganic fraction of the post-consumer waste generated is higher for the pure supermarket consumer than for the market consumer.

The reason for the difference in the waste profiles is attributed to the difference in packaging and level of processing of the food in the two different outlets. In the market, the food is not processed or packaged and majority of it purchased with the inedible portion while in the super market the food has been processed and thus most of the inedible organic portion has been removed. This waste shifts to the supply chain waste. The inorganic fraction of the waste is more for the supermarket consumer due to the additional packaging before the food is sold in the supermarkets. This is illustrated in the table below.

Table 6. Showing mass flows of post-consumer food waste

Material	Market (kg/day)	Supermarket (kg/day)
Organic	0.42	0.14
Plastic	0.01	0.04
Paper	0.01	0.02
Metal	0.00	0.07
Total	0.44	0.27

From the table above it can be seen that there is a reduction in the organic waste from 0.42 kg/day to 0.14 kg/day when the consumer purchases from the supermarket rather than the traditional market. There is an increase in the inorganics from 0.02 kg/day to 0.13 kg/day. The increase in the inorganics can be attributed to the increase in packaging.

The total post-consumer waste (food-related only) generated by the supermarket consumer is less than that of the market consumer i.e. 0.27 kg/day compared to 0.44 kg/day. This represents a 40 % reduction in total waste generated. This is because most of the inedible organic fraction of the waste has been removed during processing and it is assumed that all the edible portion of the food bought is eaten and none is thrown away. This inedible organic fraction is heavier than the added packaging. The model shows that this change in the location of the waste produced could result in less post-consumer waste generated in total.
A similar consumption model was done for different types of data and the results found are shown below for the vegetarian diet.

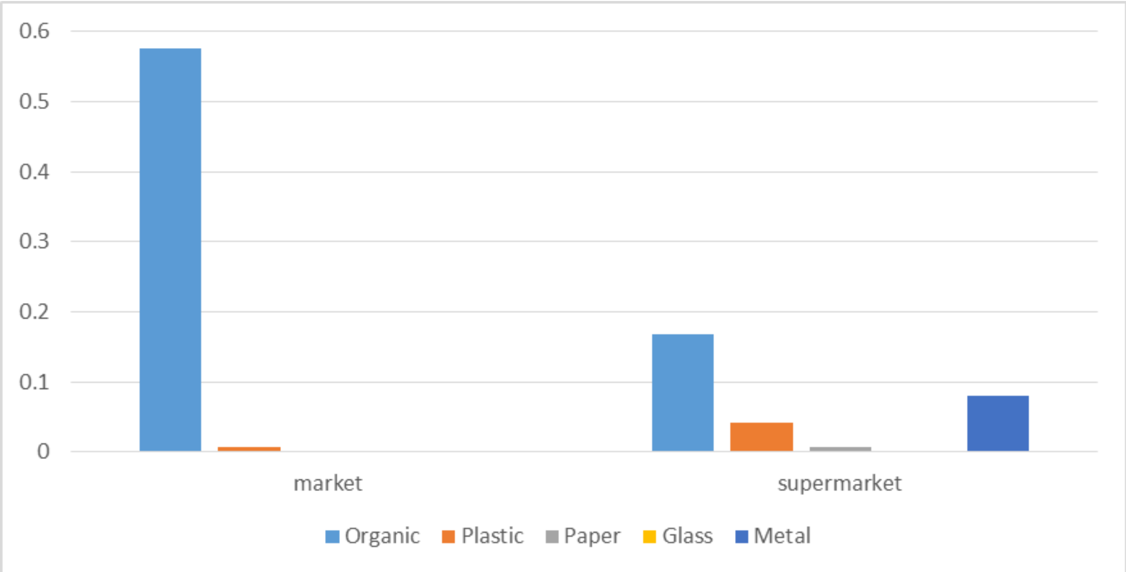

Figure 3: Showing market vs supermarket provisioning post-consumer waste for vegetarian diet

From the figure above a similar trend is observed where there is a reduction in the organic fraction of post-consumer waste and an increase in the inorganic fraction for the pure supermarket consumer. Here, the ratio of the supermarket's post-consumer waste to that of the market consumer is 0.5 showing a reduction in the total post-consumer waste generated by the supermarket consumer mainly due to a shift in the organic fraction to the supply chain.

4 CONCLUSIONS

The results quantitatively illustrate the difference in the waste profile of a pure market and pure supermarket consumer, for two kinds of diets, the student diet and the vegetarian diet. The supermarket consumer has more potentially recyclable inorganics in the post-consumer waste because of the higher level of packaging used by the supermarkets. There is also a shift of at least 2/3 of the organic fraction of the waste from the post-consumer waste to the supply chain waste. This is because the majority of the inedible part of the food consumed has been removed during processing. The food-related waste produced by the pure supermarket consumer is less than the waste produced by the traditional market consumer, under the zero-wastage assumption. This model suggests that the shift in the location of waste production, especially of the organic fraction, also leads to new waste management possibilities.

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