

The burden of waste in 21st-century Africa

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ABSTRACT

It is well known that the development of a country rests on the creation of jobs and the distribution of wealth among its population. Today many African countries are facing such an opportunity with enthusiasm, and this is giving a positive impulse to lifestyles and socio-cultural activities. However, as recent history from other parts of the world shows, the downside of this process is the wide-ranging impacts of the increasing demands of water, energy and raw materials to feed the new economy, as well as the huge quantities of waste produced by new activities and new consumers.

A further concern is the African population growth. Between 2017 and 2050, 1.3 billion people will be located mainly in urban areas, with an expected waste production of 244 million tonnes by 2025, which, if not properly managed, may negatively affect the environment and dramatically downsize the advantages of economic development. In case of inappropriate waste management, the cost to society exceeds the financial cost per capita by a factor of 5-10. The protection of the environment is an urgent issue in Africa, because of the general lack of attention to the impacts human activities have on natural resources. This paper looks at waste management and at the related threats and challenges that the continent is going to face due to its fast economic growth, with the aim of raising awareness on what may be called 'fake' progress.

Keywords

Africa, waste, pollution, environment, sustainable development

Environmental policies in Africa

Sustainable development should promote the economic growth of a country and at the same time avert the negative drawbacks of fast transformations that entail high social and environmental impacts. Africa as a whole is facing a major change, due to the investments of foreign countries in the industrial and agricultural sectors and to land grabbing (Hickel 2017; Hall 2011; Zafar 2007). Besides the need of materials, the role of both water and energy is critical in the development process: daily life benefits from them, but agriculture, manufacturing, transportation, construction, health and social services also depend on the access to water and energy. Water is also necessary for energy production, particularly for renewable energy as in the case of hydropower (Chen and Swain 2014), but it can also be a cause of trans-boundary conflicts (Zeitoun and Warner 2006). The population growth and the urbanization are the other pressures affecting the African environment, particularly because of the huge amount of waste produced and the lack of appropriate solid waste management policies (and strategies).

Waste management is a public health priority. Different types of environmental policies

have been adopted in many African countries, as suggested by internationally implemented strategies, both at continental and regional level (see table 1), but the great uncertainty is how these policies will be carried out, how the progress will be monitored, and the objectives achieved.

I/C	Policy	Commitment
C	Agenda 2063: The Africa We Want (2013)	Building a prosperous Africa based on inclusive growth and sustainable development, outlining ten aspirations to guide the continent's transformation
C	Libreville Declaration on Health and Environment in Africa (2008)	Protecting human health from environmental degradation
C	Bamako Convention (1991)	Ban on the import of hazardous waste into Africa and control of its transboundary movement within Africa
I	Minamata Convention (2013)	Control on Mercury
I	Stockholm Convention (2001)	Ban and control of Persistent Organic Pollutants (POPs)
I	United Nations Framework Convention on Climate (1992)	Climate change adaptation and mitigation
I	Basel Convention (1992)	Control of Transboundary Movements of Hazardous Wastes and Their Disposal
I	Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1974)	Preventing indiscriminate disposal at sea of wastes that could be liable for creating hazards to human health, harming living resources and marine life, damaging amenities, or interfering with other legitimate uses of the sea

Table 1. Main international (I) and continental (C) policies adopted for environmental protection in Africa.

The *Agenda 2063* is a fifty-year-long strategic plan (2013-2063) to guide the socio-economic transformation of the African continent through specific goals, aspiring to build a prosperous Africa based on inclusive growth and sustainable development. African cities should be recycling at least 50% of the waste they generate by 2023 (African Union Commission, 2015) but that goal is expected to be achieved only by implementing specific policies and investments on energy production and distribution, and on waste recycling industrial development. On the other hand, a proper and reliable baseline data is necessary to monitor the progress against that goal, a factor which is almost missing in Africa.

Policies at regional level (e.g.: *East African Community Development Strategy*, 2011; *Southern African Development Community: Regional Indicative Strategic Development Plan*, 2001; *Economic Community of West African States: E-waste regional strategy*, 2012; *Regional strategy on chemicals management and hazardous waste*, 2015; *Plastic Waste Management Strategy*, 2016) have been set to reduce or control specific waste streams as for plastic waste (twenty-nine countries in Africa adopted some sort of regulation against plastics), for E-waste (request of a certificate of conformity for the electronic devices donated from more affluent countries) and for chemicals and hazardous waste.

Despite this, most of the policies adopted so far are just on paper and no significant improvement on solid waste management has been observed (UNEP 2018): open dumps, waste accumulation on the roads, and open burning are widespread practices for getting rid of garbage. The consequences are huge environmental and health impacts related to waste littering, insufficient quantity and quality of drinking water, rapidly worsening air quality, degradation of the urban environment, impurity of the streets, river pollution and, in general, climate change. Particularly, at uncontrolled dumpsites there is a potential of health hazard to scavengers (usually children), for the spread of infectious diseases, for the highly toxic smoke, and for the odours emanating from decomposing waste (figures 1a and 1b). Impacts on the environment due to air, water, and soil pollutions and associated health risks ultimately concern the economy, too.



Figures 1a and 1b. Impacts of inappropriate waste management in Bissau and Yaoundé (2015).

Factors affecting the effective implementation of proper plans and strategies can be recognised in the followings:

- political instability with failure of long-term Municipal Solid Waste (MSW) management actions;
- MSW management is not always a high priority for local and national policy makers and planners;
- a limited awareness of administrations with regard to the basic needs of the population and a lack of willingness to promote appropriate actions;
- ineffective institutional structures and pervasive corruption;
- inappropriate international and/or local public funding and loans which support projects in the short-term, thus preventing the successful transfer of the project to the local authorities in the long term;
- implementation of technologies of the highest standards, the operations of which are subsequently prevented because of lack of spare parts and/or well-trained personnel.

Above all, Africa is still poorly equipped to provide appropriate technical education at the different levels: universities often have no competences or are not organised to train qualified

technicians (due to shortage of specific courses and research laboratories); insufficient specifically driven courses for operators (management and maintenance); scarce education on environmental issues in the primary and secondary school (people grow up even now without proper awareness of environmental pollution and MSW practices; see Lavagnolo and Grossule 2018).

Population growth, waste production and composition

In order to understand the relevance of the issue of MSW management, it is necessary to discuss the African population growth: of the 2.2 billion of people who may be added globally between 2017 and 2050, 1.3 billion will be located in Africa, mainly in urban areas. When there is increasing urbanization in a country, its economic wealth also increases, due to a higher consumption of goods and more services, which results in the generation of more waste, since solid waste is the result of a consumer-based economic lifestyle. This becomes indeed a source of high concern for the municipalities, since MSW management in Africa usually falls into the local governments' competencies (Lavagnolo 2019). Waste production in Africa is currently lower than in more developed countries, but the forecast of the population growth is expected to be so remarkable that it will increase the burden on already strained waste infrastructure (UNEP 2018).

What is more, reliable data on waste production and composition in Africa are almost not existent, due to limited and/or disorganised waste collection and, when present, the related information is often scattered among different stakeholders (NGOs, WHO, public and private companies, local and national administrations, universities). Rapid unplanned population growth in cities, mainly concentrated in slums and poor neighbourhoods, markedly impact on this situation. In most cases, waste collection does not cover all urban areas and frequently neglects rural areas. Moreover, the various streams of valuable materials are managed by the informal sector, thus resulting in a lack of information in the official data (Lavagnolo 2019).

Data from literature (Hoorweg et al. 2014; UNEP 2018) and from authors' experience suggest to consider, in the low-income countries, a current waste production of 0.6 kg per capita per day, but due to the most developed economies (North African countries and South Africa) and to tourism in some island states, the waste average production in Africa can be evaluated in 0.78 kg per capita per day (vs a global production of 1.24 kg per day). However, in the per capita waste generation there are considerable spatial differences passing from 0.09 kg per day in Ghana to 2.98 kg per day in Seychelles. Considering the population growth, the total annual waste production in Africa (particularly due to Sub-Saharan Africa) is expected to grow from 125 million tonnes to 244 million tonnes by 2025, resulting in a considerable contribution to the global impact on the environment (Hoorweg et al. 2014).

Another key factor influencing the management of waste (from collection to final disposal) is its composition. MSW can be defined by the percentages of its different fractions

like organic, paper, plastic, glass, metal, and others (as mixed residues). The uncontrolled management of the putrescible organic fraction is considered to be the major responsible of the impact on climate change, water and soil pollution. The putrescible organic content of MSW is generally higher in DCs than in industrialized countries; conversely, plastic percentage, which is one of main concern of the citizens worldwide, is not so different.

In figure 2, the average composition of waste in major African cities is illustrated, in comparison to the global one (UNEP 2018). Besides the difficulties in obtaining data, important differences in waste composition and quantities may be due to the agriculture sector, climate and its seasonal variations (Lavagnolo 2019).

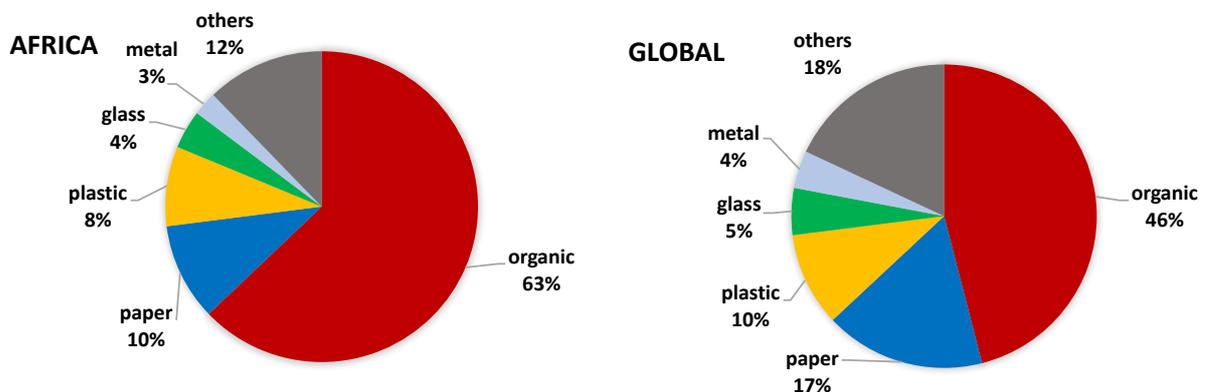


Figure 2. Composition of waste in some African cities and globally.

Impacts of poor waste management

Despite the fact that in developing countries the available budget for waste management is mainly used for waste collection, the most of the waste collection services in Africa are inadequate, with an average waste collection of 45% in Sub-Saharan Africa. More than 90% of the waste generated in Africa is disposed of to land, typically (47%) to uncontrolled dumpsites (UNEP 2018): 19 of the world's 50 biggest dumpsites are in Africa. 9% of the waste generated in Africa is open burned, while only 4% is recycled, often by informal actors (as with reuse). Open burning is the result of a lack of awareness of alternative disposal options, high levels of poverty, and lack of environmental regulation or enforcement.

Another factor to be taken into account is that, in the developing countries, the many actors involved in waste management (local administrations, informal sector, CBOs, different NGOs, private companies) are often working in the same place, implementing different projects in the same sector (collection, transport, or treatment) but with different approaches and criteria (sometimes opposite), resulting in confused and unsuccessful activities. "The undefined roles, mandates and boundaries among the actors can pose challenges, however, resulting in resource duplication and lack of leadership and ownership" (UNEP 2018, 29).

A poor solid waste management strategy causes relevant impacts on the environment, public health, society and economy. Waste abandoned on the road or disposed in open dumps

is critical for the specific ecosystem when leaching into soil and water (causing oxygen depletion, metals dispersion, hazardous chemicals formation), or anaerobically bio-converted into hydrogen sulphide, carbon dioxide and methane (impacting on climate change), or burned (promoting dioxins, furans, particulate matters and carbon monoxide as main combustion products). Plastic is considered a hazard if it is improperly burned (because of the formation of chlorides, dioxins, and polycyclic aromatic hydrocarbons) or abandoned and then transported by the water streams into the ocean, most likely entering the food chain. Due to the high percentage of uncollected waste in Africa, plastic is much present in the marine litter: Egypt, Nigeria, South Africa, Algeria, and Morocco are estimated to be among the top 20 countries contributing to marine litter. The total mismanaged plastic waste in Africa is estimated at 4.4 million tonnes in 2010, out of 32 million tonnes globally (Jambeck et al. 2015).

The informal waste sector is very active in Africa, mainly devoted to recycling activity of valuable fractions (glass, plastic, components of electronic devices, metals) from kerbsides and dumpsites. Scavengers, mainly children, are subjected to chemical, biological, and physical health risks due to toxic gases inhalation, possible infections, cholera, typhoid, and diarrhoea from handling or sorting waste (particularly recovering electric and electronic components).

As already mentioned, MSW management (and environmental protection as a whole) is not a priority for most of the African governments, but the long-term impact of an inappropriate strategy will become a cost to society and its economy. The 'cost of inaction', defined as damage occurred to environment (lost productivity, flood damage, damage to business and tourism, remediation of polluted sites) and to human health is mainly due to health impacts of uncontrolled waste and the environmental impact of open dumps and burning.

To assess the 'cost of inaction', data baseline should be defined and costs must be placed in context – a task particularly difficult in Africa because of the already-mentioned lack of reliable data and information. Few studies explore the cost caused by the poor MSW management in Africa: in North African countries the average annual damage costs of environmental degradation ranges between 0.1-0.5 per cent of the GDP (Gross Domestic Products); in Morocco the groundwater pollution associated to dumpsite pollution was calculated at US\$ 25 million per year (Hussein 2018); in Tunisia the damage from inappropriate solid waste management was estimated at 0.15% of the GDP. Generally speaking, the cost to society exceeds the financial cost per capita of proper waste management by a factor of 5-10 (UNEP 2018).

Appropriate waste management strategies

An environmentally-sound waste management strategy is strongly required, with the goal of reducing the production of waste, improving the waste collection and recovery, and minimising the emissions and energy consumption. Alongside environmental sustainability, economic, social, and geographical aspects should be strongly integrated in any choice. Therefore, ap-

appropriate solutions should be purposely designed taking into consideration all these different local situations, which in Africa are considerably different from industrialised countries. In most of the cases, the direct transfer of strategies and technologies from industrialised countries to developing countries results in an inevitable failure. In the affluent countries several approaches have found a global consensus and broad application, such as the waste management hierarchy, zero-waste and the 3Rs (Reduce, Reuse, Recycle), which are an integral part of the Circular Economy concept (Ellen MacArthur Foundation 2013). In particular, these strategies are based on a hierarchy of alternatives for managing the waste, from the most favourite to the least favourite ones (for example, from reuse to landfilling). The aim is to minimise the waste disposal and the use of raw materials, maximising the recovery of valuable material from waste. Although circular economy represents a promising future paradigm, the circumstances are often premature for the application of the 3R strategy in Africa.

The 3S strategy (Sanitisation, Subsistence economy, and Sustainable landfilling) may represent a more appropriate solution (Lavagnolo and Grossule 2018). The 3S approach is conceived as an integrated concept, which highlights the need to combine three inseparable requirements: the improvement of the standards of living by assuring safe collection and management of the waste (Sanitation); the use of appropriate technologies, designed to provide new business opportunities (Subsistence economy); the safe disposal of residues (Sustainable landfill).



Figure 3. Graphical scheme of the 3S model proposed as a strategic tool to address the actual requirements of waste management in areas with economic constraints (Lavagnolo and Grossule 2018)

The choice of the appropriate technologies represents a crucial aspect for the successful operation of the waste management system. In the context of African countries, the appropriateness of any technology is measured by the following requirements:

- low cost to meet the economical budget;
- simple technology, for an effective management and maintenance;
- cost-efficiency;

- low energy demand and possible energy recovery;
- integration of the informal sector, formalising and up-scaling the informal collection and recycling;
- opportunity for new businesses.

Many treatment technologies are available worldwide, generally classified into thermal, biological, and physical treatment technologies. However, only some of them are technically or economically viable in Africa in the short- or medium-term.

As already mentioned, the choice of the most suitable solutions is particularly influenced by the waste composition, and the main waste fraction in Africa is typically represented by the organic waste. The high generated quantity and the exclusion from the informal recycling due to its no-market value make of biowaste the most critical aspect. Food waste recycling regulations are generally absent or, if present, they are inefficiently implemented (Thi et al. 2015), also because separate collection is absent in most African countries.

The typical low calorific value and high moisture content of the waste in these contexts, jointly with the high investment costs and lack of proper skilled technician, make thermal treatments the least preferable option (Aleluia and Ferrão 2017, 2016). Among the physical methods, the processing of waste into refuse-derived fuel (RDF) is quite limited in DCs. Lohri et al. (2016) recognize char fuel production from biowaste as a promising option; however, the high investment cost reduces the accessibility of such technology. Among the others, biological treatment methods represent the least costly and most suitable approach when dealing with developing countries (Aleluia and Ferrão 2017). According to the generated product, they can be classified in processes producing fertilizer and soil amendment such as composting, protein-rich animal food in the case of Black Soldier Flies treatments (BSF), and energy carrier, associated to the anaerobic digestion (Lohri et al. 2017).

The reuse and recycling practices of valuable inorganic waste (such as glass, metal, paper, and plastics) are performed by the informal sector, occurring spontaneously when economically viable. However, better inclusion and formalization of the formal sector represent an important option for improving waste recovery. Several encouraging examples come from different developing countries, with the aggregation of waste pickers in cooperatives or micro-enterprises and achieving recycling rates up to 20-30% by weight (Gutberlet and Careno 2018; Wilson et al. 2009). The involvement of the informal sector represents a critical task at political, economic, and institutional levels in order to achieve social acceptance, political will, mobilisation of cooperatives, partnerships with private enterprises, management and technical skills, and legal protection measures (Ezeah et al. 2013).

According to Lavagnolo and Grossule (2018), in the design of a solid waste management system, sensitisation represents a fundamental tool in order to assure the success of the 3S strategy application. An education process needs to be carried out at different levels (from citizens to administrators) and throughout the entire framework of the Solid waste management system.

Case studies

Some projects implementing the 3S strategy have been designed in Sub-Saharan Africa by the Environmental Engineering research group of the University of Padua, to which the authors of this article belong:

1. a bottom up cultural project developed in Yaoundé, Cameroon, to raise awareness in environmental topics, particularly solid waste management, involving local people of different education and cultural levels;
2. a project of collection and valorisation of household waste in Agnibilékrou, Ivory Coast;
3. a quite complex technical project regarding the MSW collection and disposal in Bissau, Guinea Bissau.

1. The literary café in Yaoundé, Cameroun (2015)

Yaoundé counts more than 4,000,000 inhabitants (population growth of 7-10%). Nearly 80% of the urban population lives in informal settlements and 46% of the population has no access to improved water sources and uses latrines as wastewater devices. The daily production of municipal waste has been calculated in about 840 tonnes: less than 50% is collected, the rest is abandoned on the road or in water channels and often burned in the open air. No formal recycling is planned and only 5% of waste is informally recycled by private citizens. The awareness of the people as regards environmental and health issues should be urgently improved, although no educational material is available, particularly for the unschooled people.

Within this framework, a decision was reached to design a venue open to the public of all ages and levels of education, based on the model of the literary café, where they can find more or less detailed information (video, books, journals, etc.) relating to environmental issues; there they can connect to the internet to browse international related platforms, and seminars on specific topics can be organized to encourage debate and raise awareness. The literary café welcomes common people rather than intellectuals, invites local and visiting experts to promote dialogue, and hosts creative interactions, conversations, and training seminars (Lavagnolo and Failli 2018).

The literary café was initially financed by a series of different institutions, but after a start up phase, the organizers set up a business activity. The literary café opened at the end of 2015 and is managed by a local non-profit organization. Many activities have been carried out since then, such as awareness and information campaigns on environmental issues for all (seminars and training on municipal garbage, WEEE recycling, computer laboratory); the production and distribution of informative material (how to prevent health risks due to poor sanitation); education and training for women and young people in situations of vulnerability (especially in the form of campaigns against gender-based violence and the promotion of women in the business world).

2. Collection and valorisation of household waste in Agnibilékrou, Ivory Coast (2016)

Agnibilékrou, with a population of 69,174 inhabitants (2014), suffers severe problems related to the lack of an efficient solid waste management that leads to the littering of streets and canals, and to uncontrolled waste burning and burying. The limited financial and economic situation, together with the urgent need for actions aimed to health and environmental protection, make the 3S strategy a potential valuable first approach. The project has been implemented with the financial support of the Waldensian Evangelical Church and has the following objectives: environmental sensitization of the population; sanitization of the city by removing/controlling the informal deposits of waste; implementation of a reliable door to door collection for 30% of the population; design of a compost facility for the organic waste fraction management, assuming the future upgrade to a separate collection; definition of a business plan for the sale of compost on a base of the subsistence economy; design of an economic and environmental sustainable landfill.

The study was developed in collaboration with the local agricultural cooperative Coopayea, which provided an added value to the project. The cooperative represented not only the main beneficiary of the business of compost, but also, with the involvement of 3,000 women, the cooperative enhanced women's empowerment in society. The sensitisation campaign was developed by means of educational activities with children, local radio, and social events involving the community, in order to promote the active participation of the citizens. The sanitisation measure consisted in the overall removal of widespread waste, in order to provide an immediate demonstration of the improved quality of life by controlling waste disposal. The implementation of a door-to-door collection in five districts was simultaneously developed, serving 30% of the population. The aim was to design a robust and efficient waste collection system to be progressively extended to an increasing number of inhabitants and to be upgraded with the separate collection of the putrescible fraction.

3. Solid waste management in Bissau, Guinea Bissau (2015-16)

In Bissau, the capital city of Guinea-Bissau, in 2015 a new MSW management system was implemented with the collaborations of the Government, the municipality, the local companies, an Italian NGO, the University of Padua, and the citizens. Inside the ten-year plan, the project was based on 3S strategy. At that time Bissau produced around 300 tonnes of MSW per day (2015) and only 55% of MSW was collected (50% from the urban centre and 5% from peripheral areas), the rest was discharged along the roads, in the water channels or burned in open fires. The collected waste was disposed in the *Antula* open dumpsite, 10 km from the city centre, where many scavengers collected valuable materials, while cows and pigs looked for food. Scavengers were organized in specialized waste pickers groups: foreigners (from Nigeria or Senegal) collected metal scraps, while women plastic collected bottles and glass jars with a screw cap.

The distinctive feature of this project is that all the different steps put into action were discussed, shared, and implemented by the different stakeholders. The intervention, financed by the EU and the Guinea Bissau Government, was designed considering the local needs in terms of environmental and health protection (sanitisation), economic and social empowerment (subsistence economy), safe treatment/disposal of waste (sustainable landfill), education of the local administrators and the citizens (sensitisation). An educational campaign for cleaning the streets (waste collection) was organised in different neighbourhoods, with the aims to raise citizens' awareness and to collect data on waste quality and quantity (figure 4); a survey was planned to collect information about the *Antula* scavengers and the market of valuable materials, for a future safe involvement in the MSW management plan and their social inclusion; technical surveys for the siting of the new sustainable landfill were developed with the Guinea Bissau Interministerial Commission, the local authorities and the citizens and a specific Multi Criteria Analysis was designed on purpose.



Figure 4. Educational campaign to promote waste collection in the neighbourhoods of Bissau (2015-16).

Finally, the sustainable landfill was designed considering the potential environmental impact, the technical constraints (no skilled technicians, scarce availability of appropriate construction material, no stable energy supply, few paved roads) and following socio-economic criteria (religious sites in the surroundings, jobs opportunity, financing). A new and safer management of the waste at the *Antula* open dumpsite was also suggested, to face the period before the opening of the new landfill, and the final remediation.

Conclusions

Sustainable development needs wise and strong environmental policies to ensure long-term prosperity for all, particularly in Africa where natural resources are mainly exploited by international companies through foreign investments. One of the main environmental pressure is the huge amount of waste that will double in less than ten years, due to demographic and

economic growth, especially in the Sub-Saharan region. So far, there have been few examples of successful strategies and policies on solid waste management realised in Africa, which causes serious problems of environmental pollution, resources depletion, energy consumption, and social inequity. The implementation of the 3S strategy promoting sanitation, subsistence economy, and a simple but sustainable wasteland disposal, could be considered the first effective step towards the realisation of the more complex circular economy, whose application would need public infrastructures, a stable energy network, skilled technicians at different educational levels, a strong and successful industrial policy, and huge investments. Above all, education should be considered the most powerful driver for raising awareness among citizens, politicians, and administrators and should accordingly be the priority of Africa in the new century.

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