



MANAGING URBAN LANDFILLS: EMPHASIS ON THE RIVERTON DUMP



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EXECUTIVE SUMMARY

Jamaica generates approximately 800,000 tons of residential waste annually. The proper management and disposal of this waste is the responsibility of the National Solid Waste Management Authority (NSWMA). However, the continued dumping of waste at this waste-shed with little or no sorting poses major health and environmental concerns. This policy brief was motivated by the need to increase awareness and understanding of the potential benefits of proper waste management and waste minimization practices. The routine occurrence of fire at the most active waste management site in Jamaica – the Riverton landfill – is also of major concern. These fires, resulting from spontaneous combustion and arson, serve to highlight the health and environmental risks associated with poor waste management practices.

Proper waste management techniques and waste minimizing strategies have become paramount due to population growth. However, identifying suitable waste-sheds has become increasingly difficult with the high demand for land space and the reluctance of communities to have “dump” sites within close proximity. In addition, the location of waste-sheds close to water streams is a dangerous practice as most streams and rivers are used as water sources in Jamaica. While the NSWMA battles with these decisions regarding waste-sheds, the authorities have focused on waste minimization and maximization of the use of current sites. Yet an assessment of national solid waste disposal shows that the management of waste-sheds has been inadequate and legislative measures as set out by the National Environmental Planning Agency (NEPA) are not being adhered to. Therefore, the need arises to transform these waste-sheds into best practice sites and the following recommendations are intended to achieve this objective:

SECURITY – Access to waste-sheds should be limited and monitored. Only authorized workers should have access to these sites and steps should be taken to ensure full compliance.

MANAGEMENT – Strategic waste management techniques and waste minimization strategies (composting and recycling) should be incorporated on a wider scale in the waste management framework. It is also the responsibility of management to ensure that these waste-sheds are operated within the ambits of the law so as to prevent any irregularities.

FIRE PREVENTION/REDUCTION MEASURES – The waste-shed should be covered with earth regularly as set out in the solid waste management legislation. Fire hydrants should also be located at strategic positions on site to better facilitate firefighting efforts. The possibility of incorporating an advance sprinkler system should also be investigated as part of a properly engineered landfill.

TRANSITION OF WASTE-SHEDS INTO AN ENGINEERED SANITARY LANDFILL – An engineered landfill approach is essential in maintaining compliance with NEPA’s environmental statutes. It allows for proper leachate control to ensure ground water bodies are not contaminated, effective methane (main GHG emission at landfills) control through flaring or gasification based waste-to-energy to provide on-site power and odour and dust control to minimize negative health impacts on residents in nearby communities. An engineered landfill also allows for more effective fire management.

PUBLIC-PRIVATE PARTNERSHIP – Waste-sheds should be divested through the use of Public-Private Partnerships. This would reduce government expenditure on landfills and potentially increase productive activities such as electricity generation to the national grid from incineration based waste-to-energy as has been alluded to in a 2010 study sponsored by the GOJ titled “Integrated Waste Management Strategy and Action Plan” and the 2010 energy from waste policy “National Energy-from-Waste Policy 2010-2030”

RELOCATION OF WASTE-SHEDS (MEDIUM TO LONG-TERM) – Waste-sheds should not be located in busy urban areas as harmful activities at landfills could see larger portions of the population being affected. As such, it is recommended that a search for suitable sites ensue and preparations made for the relocation of urban waste-sheds.

It is anticipated that with the incorporation of these recommendations into Jamaica’s waste management framework, the burden of waste management on the Government would be reduced as well as the cost associated with any irregularities. The country would also become less dependent on imported energy.



WHY JAMAICA NEEDS PROPER WASTE MANAGEMENT

The country generates approximately 800,000 tons of residential waste annually. From this estimate, 60 percent is disposed of at the Riverton waste-shed.¹ The cost of solid waste disposal, which includes collection and transfer and the general maintenance of the landfills, was estimated by National Solid Waste Management Authority (NSWMA) at JA\$10.3 billion, or approximately JA\$28 million daily.² From this budget, the annual operations at the Riverton waste-shed cost JA\$6.18 billion or nearly JA\$16.8 million daily.³

There are also environmental costs associated with the operation of the major landfill, as the Riverton waste-shed is located close to mangroves and the Duhaney River. This results in water pollution at these sites as well as in the Hunts Bay area. There is also heavy metal contamination from cadmium, manganese, lead and similar levels from pesticides.⁴ These water and air pollutants have significant negative implications for wild life and residents who are exposed. Ambient air quality monitoring revealed the presence of nitrogen dioxide, volatile organic compounds, and sulphur dioxide in high concentration in the surrounding areas. Similarly, PM10⁵ analysis within a 1 kilometre and 2 kilometre radius was reported to be of high risk and risky, respectively.

The frequency of landfill fires at the Riverton waste-shed has increased and so too has the management cost and health related issues of residents located in close proximity to the landfill. One of the most recent massive fires at the Riverton waste-shed resulting from spontaneous combustion between February 6-13, 2012, was estimated at JA\$25 million to extinguish. The total cost of these fires, however, is far greater than extinguishing the blaze, as there are severe losses associated with healthcare, education and productivity. As such, the backlash of poor management of waste-sheds is a massive burden on tax-payers and residents of adjacent communities who are left battling emotional and physical discomforts such as respiratory problems, cardiac illnesses and disorientation.

The following sections will explore experiences of waste management internationally in an effort to inform the Jamaican context. In addition, Jamaica's problems with the management of solid waste are investigated and possible solutions presented. The paper culminates with the suggestion of policy guidelines that are intended to improve the current waste management system.

1 Solid Waste Management Authority (2013)

2 Planning Institute of Jamaica (2007).

3 Riverton waste-shed collects approximately 60 per cent of waste generated and as such 60 per cent of the management cost is attributed to that site.

4 NEPA (2010)

5 Particulate matter less than 10 microns.



GLOBAL WASTE MANAGEMENT PRACTICES ⁶

BARBADOS

Having only 432 square miles of land mass and a population amounting to approximately 272,000 Barbados has solid waste problems similar to those encountered in Jamaica. These problems include illegal disposal or dumping, inefficient land usage as well as landfill fires.⁷

Policies aimed at waste prevention and minimization includes the Government of Barbados' partnership with the Sustainable Barbados Recycling centre to operate a solid waste management centre. This partnership allowed for the recovery of recyclables which would have otherwise been disposed of at the landfills. The centre included a transfer station, composting facility and a chemical waste storage system. This recovery of recyclables diverts approximately 65 percent of the waste away from the landfill and into useful production (recyclables, compost, aggregates and mulch). Research continues into the recycling of tires into rubberised asphalt or as a fuel source. There is also some amount of monetary compensation attached to the recycling of white goods (these include refrigerators, washing machines and stoves) which reduces dumping of these types of goods.

A 'return on deposit' system is also an active waste reduction scheme in Barbados where payments are made to consumers

for the return of both plastic and non-plastic containers; this encourages the collection and return of these items which leads to the reduction in the amount of waste going to landfills.

However, one limitation to the measures of waste reduction and minimization in Barbados is the lack of funding. Therefore, almost all of these minimizing measures are privatised with little or no Government intervention.

JAPAN

Japan is ranked as the fourth largest exporter and importer and the third largest economy by nominal gross domestic product. The country has a large population of approximately 126 million people and only a small land mass of 377,955 square kilometres. As such, special precautions have to be taken in the management of solid waste.

A number of measures were implemented to ensure effective and efficient waste management practices in Japan.⁸ These include transfer stations where the waste is transferred from small or medium trucks to larger fuel efficient vehicles.⁹ This results in fuel consumption and CO2 emissions being reduced significantly.

6 For the purpose of this research, waste management in Barbados, Japan and Singapore were examined.

7 National Environmental summary of Barbados, 2010

8 Ministry of Environment, 2010

9 It should be noted however that these stations would be suitable only when the transfer distance exceeds 18km.

The Reduce, Reuse and Recycle (3Rs) policy initiated the collection of PET¹⁰ bottles, food trays and cans in separate containers for reuse as recycled resources in the manufacturing of new products. The home appliance recycling project also falls under this category of 3Rs policy. Producers of home appliances have extended producer responsibility (warranty) which binds them by law to properly dispose of household products at the end of their life cycles.

Biomass utilization technologies are used to extract methane from high moisture content and organic wastes for power generation. For instance, bio-digesters are used to process organic fertilizers and animal waste for power generation purposes. Cooking oil (meat fat) with low moisture content is also being recycled and processed into biodegradable fuel.

The landfills in Japan are categorized as controlled (the collection of non-harmful waste), inert (plastic, rubber debris, metal ceramic and bricks) and isolated (heavy metal and harmful wastes). These classifications also reduce the levels of harmful human exposure as well as cross-contaminations.

SINGAPORE

Regulation of solid waste in Singapore is also a challenge as the country occupies 716 square kilometres of land area with a population of over 5 million. Waste management is further strained by the fact that Singapore operates one of the world's busiest commercial hubs, the fourth largest financial centre and fifth busiest port.

The management framework ensures that prior to the collection of solid waste, recyclables are sorted and retrieved. The remaining waste is then collected and sent to one of the four state owned waste-to-energy plants based on the type of solid waste for incineration.¹¹ The waste must be accompanied by a way-bill to indicate the type and source of the waste. This process of landfill disposal reduces the amount of waste that would need to be disposed of.

In addition to established waste management regimes, waste-to-energy facilities have been improved and along with the tyres and wood waste resource recovery system diversified.¹² This diversification saw the exploration of several ways to reuse these products, resulting in as much as 83 percent of the scrap tires recovered and 64 percent of the wood waste generated being recycled.

An extension of the waste management projects in Singapore is the 3Rs (Reduce, Reuse and Recycle) projects; this prevents waste generation at the source and reduces the amount of waste going to the disposal sites.

Of equal importance in Singapore is the illegal dumping initiative. This allows for illegal dumping to be a serious offense and any such practice attracts a fine. Members of the public are educated about illegal dumping and are encouraged to report these activities; which can be done anonymously.

10 Polyethylene terephthalate-a thermoplastic polymer resin of the polyester family generally used in synthetic fibers.

11 Incineration reduces the volume of solid waste by approximately 90 per cent and produces steam that runs turbine generators to generate electricity.

12 National Environment Agency of Singapore, 2012/2013



JAMAICA'S WASTE MANAGEMENT SYSTEM: PROBLEMS AND PREDICAMENTS

Jamaica, a Small Island Developing State with land mass of 10,900 square kilometres and a population of 2.8 million people has battled with proper waste management for several decades. The management of solid waste in Jamaica is the sole responsibility of the National Solid Waste Management Authority (NSWMA) and is regulated by the National Environmental Planning Agency. Legislative measures relating to waste management include: the National Resource Conservation Authority Act (1991) with primary responsibility for the protection and management of the natural resources and the controlling of pollution; and the National Solid Waste Authority Act (2001) which serves to provide the necessary regulations and effective management of solid waste (safe guard public health, ensure waste is collected, sorted, transported, recycled, reused or disposed of in an environmentally sound manner). Solid waste is also governed under the Environmental Permit and License System with responsibility to ensure requirement standards and the Draft Air Quality regulations or air quality monitoring specifications are met.

The NSWMA unit currently operates and manages four main waste-sheds which are strategically located throughout the island. The most active of these is the Riverton waste-shed which occupies about 120 hectares of land and receives approximately 60 percent of the waste generated. Routine garbage collections throughout the island are done by small to medium sized trucks and are disposed of directly at the waste-sheds with little or no sorting prior to disposal. The garbage collection schedules see

the collection of residential waste occurring once per week whereas; main street or road-side pickups are conducted daily. Even with these measures in place, problems still arise; the most common of which are fires, hazardous material disposal as well unlimited access to the sites by unauthorized personnel. These are clear breeches of the environmental legislations.

Waste management efforts are also aided by waste minimization initiatives by private and public sector organizations. This has resulted in the reduction of the amount of waste to be disposed. The Reduce Reuse and Recycle initiative by the NSWMA has increased the awareness of the potential benefits of waste minimization, and as such, waste generated by households have seen reductions across most communities over the three year initiative (2010-2013).¹³ Similarly, the recycling efforts by the University of the West Indies, Mona saw the launch of the expansion phase of its plastic bottle and recovery for recycling project in March of 2010. This gave rise to the dissemination of clearly marked recycling bins throughout the campus and in ten (10) schools in the surrounding communities, to collect all plastic bottle containers.

Other plastic and glass bottle recycling projects are undertaken island-wide with Wisynco and Desnoes and Geddes being the main players. However, large scale recycling is limited. Therefore, there are still challenges in tackling Jamaica's waste management problems, resulting in the need to assess possible solutions.

13 NSWMA, 2013

SOLUTIONS TO JAMAICA'S WASTE MANAGEMENT WOES

Initiatives by both private and public bodies are inadequate, though their efforts are commendable. Failed efforts by the Government also point to the need to possibly divest the landfills by way of Public-Private Partnerships.¹⁴ This would unearth investment opportunities whether locally or through foreign direct investments. Through these partnerships, it is expected that productivity will increase and fiscal deficit exposure reduced while at the same time providing public services and infrastructural projects.¹⁵

The transformation of the Riverton waste-shed into a best practice site requires effective execution of policy in five major areas: tighter security regulations; proper waste minimization techniques (recycling and composting); regular covering of the waste-shed (fire prevention and reduction measures); implementation of a sanitary landfill as set out in the legislation governing waste management; and the relocation of waste-sheds to less populated areas.¹⁶ These best practices would ensure more efficient uses of dump sites, and a safer environment.

SECURITY

With approximately 120 hectares of unfenced land space it can be very difficult to monitor traffic at the Riverton Landfill. Trucks as well as residents have unlimited access to the waste-shed with limited security presence at check points. This not only poses a threat to individuals interfacing with the toxic waste but to the country, as individuals who come in contact with contaminated waste may spread diseases.¹⁷ Limiting access to such sites could also reduce the number of deaths and/or injuries during the operation of heavy equipment, since scavengers routinely try to recover what they can either for general reuse or for the scrap metal trade. With this said tighter security measures could ensure that contamination as well as injury or death is avoided. This effort should be accompanied by the wearing of protective gears by all persons entering the waste-shed to eliminate possible exposure to harmful contents.

WASTE MINIMIZATION

Characteristic studies conducted by the National Environment and Planning Agency reveal that 82 percent of the waste generated in Jamaica is organic; that is, the waste is either recyclable or compostable. This represents a volume of approximately 1 million tons.¹⁸ Over 62 percent of the organic waste generated is made up of household waste, market waste, cuttings and horse waste making it perfect for composting.

Recycling would be a viable option to undertake since plastic and paper products account for 21 percent of the total waste generated. Waste processing on a formal scale in Jamaica is limited except for glass and plastic bottle recycling.¹⁹

The collection of waste paper, PET plastic bottles and scrap metal used mainly for export purposes could potentially become a viable business in Jamaica, as similar models exist in Japan and Singapore. These recyclables are manufactured into new products such as ceramic tiles.

Another potentially viable business is the expansion of the current 'return on deposit' system. Similar to that of Barbados, the manufacturer of glass and plastic bottles have a return on deposit system in place which rewards the returns of these products with cash. Although this practice is on-going in Jamaica, only the glass bottles are returned. With the inclusion of plastic bottles, very little of these recyclable products will end up at waste-sheds since individuals would have an incentive to return these form of waste at designated collection points.

Composting is not new to the Riverton waste-shed. The NSWMA composting project was officially launched in 2009. The commercial component was initiated earlier that year at the annual Denbigh Agricultural show. There is also a thriving overseas market including that of The Bahamas for the compost. The finished products are also available locally through the distributing company Agro-Grace.²⁰

Composting as well as recycling would significantly reduce the amount of waste that would need to be disposed of, limiting the amount of greenhouse gas emissions and leachates entering water streams, making our environment cleaner and safer for future generations.

With approximately 1-2 fires annually at the Riverton waste-shed and an estimated cost of up to \$120 million to extinguish, the covering of the landfill regularly would reduce the amount spent on returning economic activities back to normalcy. It should be noted, however, that covering the landfill will not prevent fires altogether but would significantly reduce the frequent occurrences and in the event of fires it could be confined to a smaller area of the landfill. Limiting access to the waste-shed could also reduce fires set by arsonists leaving the chances of any potential fires down to spontaneous combustion.

14 A public-private partnership is a government service or private business venture which is funded and operated through a partnership of government and one or more private sector companies.

15 Development Bank of Jamaica, 2012

16 NSWMA, 2013

17 NSWMA, 2013

18 NEPA, 2013

19 Ministry of Energy and Mining, 2010

20 Jamaica Observer, 2011

It is also recommended that the waste-shed is cut up into tipping phases so as to prevent the use of the entire dump at any one time. Potential benefits of this implementation include unused land space in the event of fires, since not all the phases would be in active use. The covering of the dump site should be on-going on the sections that are not in use as this will aid in blocking the ignition of fires. The use of security personnel at the entrance of each tipping phase rather than only at the point of entry to the dump sites could also aid in limiting fires on these sites.

SANITARY LANDFILLS

Another solution is for a section of the waste-shed to be dedicated to the creation of a sanitary landfill. A sanitary landfill is a site where waste is isolated from the environment until it is safe; that is, until the waste is completely degraded biologically, chemically and physically. A sanitary landfill has four main requirements before it can be considered as such:

- *Leachates collection and treatment system; whether full or partial hydro-geological isolation.*
- *Local geological and hydro-geological investigation system where a waste disposal plan as well as a final restoration plan is in place.*
- *Permanent control which allows for trained landfill supervisors and staff to be available on site for its regular operation and maintenance*
- *Planned waste emplacement and covering, that is, the waste should be spread in layers and compacted.*

This type of technology will allow for the sorting of the waste entering the landfill, capturing of landfill gases, bio-gas production as well as the collection of leachates that could otherwise enter the water streams. With a sanitary landfill in place, the waste will be sorted according to types and characteristics; recyclable and compostable materials separated and the non-toxic material incinerated.²¹

A sanitary landfill could also result in the regularization of the pickers or sorters that frequent the dump in search of waste.²² They could be properly monitored and any form of contamination could be prevented. This could also see the number and frequency of physical injuries and deaths on the sites reduced.

The incineration of non-toxic municipal solid waste is considered an efficient method of waste disposal due to the potential for thermal energy and also its environmentally friendly nature.²³

This could reduce the amount of waste that needs to be disposed of by over 85 percent. This process of incineration is one of the most active waste management techniques used in Singapore to reduce the amount of waste that is needed to be disposed of. The economically viable analysis of waste to energy at the Riverton waste-shed showed that the municipal waste from this site can

be incinerated and the heat recovered. The high levels of plastic, wood, garden waste, textiles and food disposal, could give rise to electricity output of 255 Giga Watt-hours (GWh) per annum to the national grid from an installed capacity of approximately 35 Mega Watts (MWe).

PUBLIC-PRIVATE PARTNERSHIPS

Public-Private Partnerships could give rise to an estimated US\$143 million in foreign direct investment for an incineration based 35 MWe plant consuming around 1,800 tons of municipal waste per day. The expected annual benefits would also be significant including increases in productivity as well as reducing the levels of water and air pollution (See Table 1).

Table 1: Economic viability for a 1,800 ton per day incineration process

CATEGORY	WASTE QUANTITY, ESTIMATED REVENUES & COST
ANNUAL WASTE TO BE INCINERATED (TONS PER YEAR)	657,000
ANNUAL OPERATING COST	US\$6.2 MILLION
ANNUAL ENERGY SALES TO THE GRID (@US 12.05 C/KWH)	US\$3,065 MILLION
EBITDA	US\$3,059 MILLION
INDIRECT BENEFITS	> 241,000 TCO ₂ /YEAR (GHG EQUIVALENT) > 623,000 BOE AVOIDED PER ANNUM > 200 JOBS CREATED (INSTALLATION, O&M)
VALUE OF OIL IMPORT REDUCTIONS (@ US\$60/BBL)	US\$37.4 MILLION/ANNUM
VALUE OF CO ₂ EMISSION TRADE (@ US\$ 10/TCO ₂)	US\$2.4 MILLION/ANNUM
OVERALL DIRECT & INDIRECT BENEFITS (ANNUAL)	US\$39.8 MILLION

Source: Ministry of energy and mining (2010)

21 Incineration reduces waste volumes by as much as 90 per cent.

22 The pickers would be stationary and have the proper uniform and equipment.

23 Ministry of Energy and Mining, 2010

CONCLUSION AND POLICY RECOMMENDATIONS

Proper waste management techniques and effective waste minimization strategies, as set out in the respective legislations governing solid waste disposal and management, have not been adhered to. Recycling and composting activities are not done on a large scale, and as such the optimal benefits are not garnered from these activities. Moreover, the Government has failed to successfully implement policies and execute the requisite legislative frameworks necessary to operate a landfill or waste-shed according to best practices. The need therefore arises for the strengthening of existing waste management practices through policy changes and punitive measures for outright disregard for legislation. There is also need to look beyond the Government to the exploration of a Public-Private Partnership model for the divestment of landfills to local or international interests. This will assist in garnering the resources required to adequately manage a national waste disposal system.

• More specifically, the following recommendations have arisen out of the preceding discussion on waste management:

• Access to waste-sheds should be limited to authorized personnel. This will immediately reduce the frequent occurrence of physical injuries and/or deaths on the sites. Potential contaminations and possible exposure to harmful contents while on the landfills would also be reduced.

• Management on-site should be ramped up and careful planning executed. The day-to-day activities on the dump should be carefully monitored so that any irregular activities can be picked up early and measures taken to correct them. Regular monitoring could also serve to advise the management team of any illegal activities that can be taken care of before it escalates.

• As set out in legislation, the dump site should be covered with earth regularly so as to reduce the occurrences of fires. Although covering with earth will not prevent fires they can be reduced considerably. Also, landfills could be separated into tipping phases so that in the event of a fire, it will be confined to a particular section of the dump. Phasing would also result in no more than a few phases been used at any given time so the other phases could be in readiness for dumping.

• The process of transforming the waste-shed into a sanitary landfill would be beneficial to the economy since, it will reduce the amount of waste that would need to be disposed. The organic materials could be sorted and used for either compost or be recycled. The non-toxic material would be used for waste-to-energy through incineration (preferred by the GOJ), or gasification using bio-gas (methane predominantly). Certain waste streams such as tires can also be converted to biodiesel fuel through pyrolysis to fuel the trucks used for garbage collection. Bottom and fly ash left over from incineration plants could be disposed of at the landfills.

• Public-Private Partnership remains a potentially viable option available to the government to assist in the management of solid waste. It is expected to promote efficiency and productivity in the waste management system as well as reducing the deficit gap. As such, the call for Public-Private Partnerships should be taken seriously.

• In the medium to long term, suitable sites should also be sought for the relocation of landfills in urban areas to isolated locations, were security and health concerns can be minimized. Waste-sheds should not be located in busy urban areas as harmful activities at landfills could see larger portions of the population being affected

REFERENCES

Development Bank of Jamaica. (2012). Shaping new partnership for National development. Retrieved from http://dbankjm.com/files/public-private-partnership/ppp_policy.pdf

Ministry of Energy and Mining. (2010). National Energy-from-waste Policy 2010-2030. Retrieved from http://www.pcj.com/dnn/Portals/0/Documents/national%20energy%20from%20waste_policy.pdf

Ministry of Environment (2013). Solid waste management and recycling technology of Japan- towards a sustainable society. Retrieved from <https://www.env.go.jp/en/recycle/smcs/attach/swmrt.pdf>

National Environmental Agency, Singapore. (2012/2013). Waste Management. Retrieved from <http://www.nea.gov.sg/energy-waste/waste-management>

National Environmental Agency. (2013). Sustaining our environment. Retrieved from <http://www.nea.gov.sg/data/html/ar2013/index.html>

National Environment Agency. (2013). Solid waste management infrastructure Retrieved from <http://www.nea.gov.sg/energy-waste/waste-management/solid-waste-management-infrastructure>

National Environment Planning Agency. (2010). State of the Environment Report. Retrieved From <http://www.nepa.gov.jm/publications/SOE/2010/state-of-The-environment-report-2010-Jamaica.pdf>

National Environment Planning Agency. (2012). Report on ambient air quality monitoring conducted in the KMA. Retrieved from http://www.nepa.gov.jm/air-quality/Report-on-Ambient-Air-Q-Monitoring_Riverton-Disposal-Site.pdf

National Solid Waste Management (2013). Waste characterization and per capita generation report. Retrieved from <http://www.nswma.gov.jm/WASTEGENERATIONANDCOMPOSITIONSURVEYREPORT2013.pdf>

National Solid Waste Management. (2009). Combined Waste characterization and per capita generation report. Retrieved from <http://www.nswma.gov.jm/WasteCharacterisationReport2009NEPMSPMWPM.pdf>

Planning Institute of Jamaica. (2007). Management of hazardous and solid waste in Jamaica. Retrieved from http://pioj.gov.jm/portals/0/sustainable_development/management_of_wastes.pdf

United Nations Environmental Programme. (2010). National Environmental summary-Barbados 2010. Retrieved from http://www.pnuma.org/PNUMA_ORPALC.pdf



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