# Sustainable Waste Management Systems and their application in Trinidad and Tobago

**Devin Hayward**
**Department of Civil Engineering and Applied Mechanics**
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# Abstract

The protection of public health is the basis behind any waste management system while its sophistication is dictated by environmental impact concerns and constraints on the ideal solution. Waste management systems can and should be designed from a sustainable basis. This thesis examines the theoretical basis of sustainable waste management systems and explores their application in Trinidad and Tobago. The transformation of Trinidad's existing waste management system into one which is sustainable begins with a thorough characterization of the existing formal and informal waste management sectors. Their linkages are identified and understood, leading to recommendations towards the alteration of the existing policy/legislation basis, system structure and operations to create a sustainable system. The resources and expertise are in place to complete such a transformation and the resulting system will benefit the nation; converting an antiquated policy of environmental neglect into that which will provide for the earth and future generations.

La protection de la santé publique constitue l'élément de base de tout système de gestion des déchets tandis que sa sophistication est dictée par un souci d'impacts environnementaux et des contraintes sur la solution idéale. Les systèmes de gestion des déchets peuvent et doivent être conçus dans une politique de développement soutenable. Cette thèse examine la base théorique des systèmes soutenables de gestion des déchets et explore ses applications à Trinidad et Tobago. La transformation du système de gestion des déchets existant à Trinidad en un système soutenable commence par une caractérisation complète des secteurs formels et informels de gestion des déchets existants. Leurs connexions sont identifiées et comprises, menant à des recommendations altérant la politique/legislation existante, la structure et les operations du système afin d'en créer un soutenable. Les resources et expertises sont en place pour accomplir une telle transformation et le résultat bénéficiera la nation; convertir une politique désuète négligeante de l'environnement de cette manière assurera un futur à la terre et aux générations à venir.

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# List of Acronyms

| | |
|---|---|
| CBO | Community Based Organization |
| CCP | Communal Collection Point |
| CDC | Centers for Disease Control and Prevention |
| CEPEP | Community-Based Environmental Protection and Enhancement Programme |
| CGL | Caribbean Glassworks Limited |
| $CH_4$ | Methane |
| $CO_2$ | Carbon Dioxide |
| CSO | Central Statistical Office of the MOPD |
| DSD | Duales System Deutschland AG |
| EC | Environmental Commission |
| EMA | Environmental Management Authority |
| EM Act | Environmental Management Act |
| EPP | Environmental Policy and Planning Division of MOPUE |
| EWI | Environment West Indies |
| GHG | Green House Gas |
| HDPE | High Density Polyethylene |
| $H_2O$ | Water |
| ISWM | Integrated Sustainable Waste Management |
| MC | Municipal Corporation |
| MMWBM | Metro Manila Council of the Women Balikatan Movement |
| MOF | Ministry of Finance |
| MOH | Ministry of Health |
| MOLG | Ministry of Local Government |
| MOPUE | Ministry of Public Utilities and the Environment |
| MOPD | Ministry of Planning and Development |
| MRF | Material Recovery Facility |
| NAG | Neighbourhood Action Group |
| NEP | National Environmental Policy |
| NGO | Non Governmental Organization |
| $NO_x$ | Nitrogen Oxides |
| PCB | Polychlorinated Biphenyls |
| PET | Polyethylene Terephthalate |
| POS | Port of Spain |
| POSCC | Port of Spain City Corporation |
| RC | Regional Corporation |
| RDF | Refuse Derived Fuel |
| RIM | Recycling in Motion |
| SWMCOL | Trinidad and Tobago Solid Waste Management Company |
| SOCOSEMA | Sociedad de Seleccionadores de Materiales |
| SIDS | Small Island Developing States |
| $SO_2$ | Sulphur Dioxide |
| TCL | Trinidad Cement Limited |
| TRTCL | Trinidad Recycling and Trading Company Limited |
| T&T | Republic of Trinidad and Tobago |
| UBVA | United Bottle Vendors Association |
| UN | United Nations |
| UPMCL | Unicell Paper Mills Caribbean Limited |
| UWI | The University of the West Indies |
| WHO | World Health Organization |

# Chapter 1: Introduction

Solid waste management is an important worldwide environmental and public health concern. In the developed world, sophisticated systems and techniques are put in place to collect, process, and dispose of wastes. It is difficult to site suitable landfill locations firstly because any proposed location must carry certain geographic and geologic characteristics to allow for the ultimate containment of disposed wastes. Secondly, the proposed site must also be approved by the local stakeholders; which is often no easy task. These kinds of difficulties have lead to a focus on reducing those wastes which require final disposal.

'Diversion' strategies in waste management systems are instituted to reduce those materials requiring ultimate disposal in a landfill through reuse, recycling and reallocation of waste materials. This is evidenced through the commonly accepted waste management hierarchy which defines reduction, reuse, recycling, and incineration with energy recovery as preferred over disposal in a sanitary landfill (Lardinois & Furedy, 1999). The waste management strategies are ordered in this manner to fulfill the intended minimization of detrimental effects on public health and the environment due to the waste stream. Although every country may value these strategies, their ability to adhere to them is defined by many factors. It is these factors, of which available financing is significant, which lead to the differing waste management philosophies and outcomes seen in the developed and developing world.

In the developing world the environmental problems of poor waste management can be readily witnessed. Open dumping is a common practice with landfills consisting simply of open fields designated as disposal sites. Environmental controls are rarely instituted, nor can they be afforded. Often municipal waste management budgets are not sufficient to complete the required waste management activities resulting in unsanitary conditions and public health concerns (van de Klundert & Anschütz, 2001).

Typically, the recycling activities of the developing world are carried out by informal waste management sectors. These sectors are driven by the market demand for recycled goods (Medina, 2000). Although this sector is helpful from an environmental sense, it also has problems associated with its operations. There are security and safety issues caused by salvager operations in landfills and urban areas. Salvaging activities may also conflict with the activities of the formal waste management sector and there are the added health and social concerns related to salvaging for both the workers and the general public.

This research project completes a characterization of the waste management sector in and around Port of Spain, Trinidad and examines its potential transformation into a sustainable waste management system. The research phase was completed in May – August 2004 and was based on the formal research questions listed below (the research methodology is presented in Chapter 3):

1. What are the waste management policies of Port of Spain and what relationship do they have to the informal waste management sector? Are the institutional linkages as the policies infer them to be?
2. Who are the various actors involved in both the formal and informal sectors and what are their roles within their respective sectors?
3. What are the mass and material flows of waste within these sectors?
4. How are the formal and informal waste management sectors linked? Are these linkages efficient or inefficient; favourable or unfavourable and how so?
5. How can the linkages between the informal and formal waste management sectors be improved?

Trinidad, and specifically Port of Spain, is an interesting case study as Trinidad and Tobago (T&T) is a country in the process of developing into a first world nation. The government has pledged to complete the process by 2020 (Vision 2020, 2005) and is currently working through the various planning and implementation stages (Pased *pers. comm.*). To truly reach first world standards, the transformation process must include a reform of the current solid waste management system. Waste management in Trinidad is typical of the low standards of the developing world. This is exemplified by the fact that none of the island's seven landfills utilizes a liner system while the country's largest landfill (the Beetham site) is situated in a local wetland (Warren *pers. comm.*). The waste

collection system is more modern and efficient but its operations could also be improved. The country's recycling activities are completed by the informal waste management sector. These activities operate parallel to the formal waste management system and succeed in the diversion of a significant volume of materials from the nation's landfills, but also create conflicts. Salvagers at the Beetham site rebel against the formal waste management entities operating the landfill and are the root of multiple security issues (Garraway *pers. comm.*). There is also concern for the adverse health effects to which salvagers are exposed.

It is proposed that a sustainable waste management structure will alleviate many of these problems and strengthen the overall waste management system. This report will explore the implementation of a sustainable waste management system in T&T. The discussion begins with an introduction to the theoretical basis of sustainable waste management systems (Chapter 2). The research methodology is presented (Chapter 3). The waste management situation in T&T is fully characterized (Chapter 4) to provide for an understanding of its foundations and operations. This knowledge is then combined with the theory to explore the transformation of the existing waste management system into one which carries a sustainable basis (Chapter 5). The conclusions summarize the findings which provide a strong basis for the reform of T&T's waste management system.

# Chapter 2: Literature Review and Background Material

The waste hierarchy ranks the various waste management components and strategies available in the implementation order for an ideal waste management system (Lardinois & Furedy, 1999) as follows,

1. Prevent the creation of waste in product design and packaging
2. Reduce the toxicity or negative impacts of the waste that is generated
3. Reuse in their current forms the materials recovered from the waste stream
4. Recycle, compost, or recover materials for use as direct or indirect inputs to new products
5. Recover energy by incineration, anaerobic digestion or similar processes
6. Dispose of waste in an environmentally sound manner, generally in sanitary landfills

Reduction, reuse, recycling, and incineration with energy recovery are preferred over disposal in a sanitary landfill. If all the steps were carried out, the resulting waste management system would be proactive and complete. The inherent energy in the wastes would be removed and utilized; the wastes would be minimized in mass and volume and biologically stabilized before final disposal. As the hierarchy represents the most desirable system, it does not consider constraints. The local constraints will dictate the final form of the waste management system. Budgets may not exist to support incineration or anaerobic digestion activities; public opposition may prevent the inclusion of such systems and the adoption of minimal waste package designs will entail significant political and stakeholder activities.

In the developed world today waste management is generally policy driven. Legislation demands sanitary landfill practices and mandates diversion activities and sustainable practices[1]. The numerous examples of sustainable legislation and policies shows the relative visibility of environmental issues in the developed world and their importance as part of the political agenda. This visibility is further expressed through the demand for sustainable products and those entities which have profited from incorporating sustainable

[1] See numerous waste management legislation throughout North America and Europe such as the Waste Diversion Act of Ontario (Ministry of the Environment, 2002)

practises into their business model (Hawken, 1999). It can be said that this environmental awareness drives and influences waste management policies, which in turn drive innovation and efficiency in the waste management sector (Blight & Mbande, 1996).

The situation in the South is different. The constraints placed on municipal governments often reduce their ability to provide proper waste management systems. Open dumping is a common practice, environmental controls are rarely instituted, nor can they be afforded, and lack of sanitation is a significant issue (Medina, 2000; van de Klundert & Anschütz, 2001). These waste management practices result in significant public health and environmental problems; however the latter are often superseded by basic survival concerns. As the constraints on the waste management systems of the South often preclude the government's involvement in recycling operations, the demand for recycled products is left to be satisfied by the private sector (Taylor, 1999). This is the basis for the vibrant informal recycling sectors which exist in many developing cities.

This chapter provides the theoretical background for the overall discussion, beginning with the basis of solid waste management practices; this includes the environmental health risks imposed by solid wastes and a section examining the elevated exposure to these risks experienced by salvagers and waste management workers. A short overview of current waste management technologies is given and then solid waste management practices in the developing world are reviewed. This provides the background for the current situation in Trinidad. A discussion on the integration of salvager collectives into sustainable waste management systems leads into some specific issues pertaining to sustainable waste management systems. The chapter closes with a general overview of Trinidad and Tobago.

## *2.1 The Basis for Solid Waste Management Practices*

Solid waste management practices were introduced to combat the negative human health effects associated with solid wastes. Increased urbanization[2] created sanitation issues as

[2] Over the period of 1880-1910 the number of urban centres in the United States increased from 939 to 2,262 and the number of cities with populations over 100,000 increased from 19-50 (Melosi, 2000).

urban citizens were not able to self-sufficiently process their wastes. Those living in rural areas were able to process wastes, through reuse or the feeding of organics to animals for example, and bury those which required final disposal. In urban areas, waste burial was not an immediate option and processing options were reduced. This created a problematic situation. Solid wastes were disposed of in the streets along with human and animal feces (cesspools and latrines were often overwhelmed by the waste volumes to be processed). The resulting unsanitary conditions lead to cholera and yellow fever epidemics, sometimes killing thousands. As waste management was beyond the individual means of the urban population, local governments took on the responsibility of providing for sanitation (Melosi, 2000).

Sanitary concerns initially focused on water sources, as once contaminated, they would cause a proliferation of disease and pestilence. Private entities began to provide sanitation services by constructing the required infrastructure, such as sewers and cesspools, and licensing their utilization. Early sewer systems would transport wastes from the city streets and dump them elsewhere for dilution. An example is the common practice of directing sewer outlets into nearby water bodies, such as the local harbour. Eventually the negative impacts of this practice were identified and forced the construction of treatment facilities at these outlets[3]. By 1880 the basic function and form of water and wastewater systems were well established while solid waste management systems were only beginning to form. Continued health epidemics proved the inability of the private sector to ensure sanitation, thus this duty was transferred to government. As part of this duty, local governments began providing for the collection and disposal of solid wastes (Melosi, 2000).

### 2.1.1 Environmental Heath Effects Imposed by Solid Wastes

The environmental pollutants related to solid wastes come in both liquid and gaseous form. Leachate is the product of soluble contaminants, contained in disposed solid wastes, entering clean water sources. A water source, such as rain water falling on a

[3] Some developed cities continue the practice of discharging their untreated sewage. For example Halifax, Nova Scotia continues to discharge raw sewage into the local harbour.

collection of solid wastes or groundwater intersecting such wastes, could be contaminated in such a manner. Leachate moves through the ground with the groundwater, polluting both soil and water particles with which it comes in contact. The bacterial decomposition of disposed wastes produces the common greenhouse gases (GHGs) carbon dioxide ($CO_2$) and methane ($CH_4$). Methane is also highly flammable and may explode where concentrations rise above 5-15% by volume (McBean et al, 1995) forming an additional safety hazard to its negative environmental effects.

Inadequate waste management practices lead to unsanitary conditions. Such conditions lead to the proliferation of pathogens, or infectious agents, which result in the risk of infection, disease and ultimately death, to the local population. Examples of such epidemics are numerous throughout history and are represented by outbreaks of typhoid fever, cholera, yellow fever and the black plague[4]. These epidemics have resulted in thousands of deaths in short periods of time and are the motivation for the sanitary practices of today, of which waste management practices form a component (Melosi, 2000). Unsanitary conditions caused by inadequate waste management will also lead to an increase in the animal, insect and rodent populations, which act as vectors for the spread of the aforementioned diseases (SWMCOL, 2000; McBean et al, 1995). Animal populations can be infected through the act of feeding on uncollected wastes. More recently, uncollected wastes have influenced the spread of West Nile virus and malaria, where uncollected wastes clog drains and absorb water which creates ideal breeding conditions for mosquitoes (Centers for Disease Control and Prevention, 2005).

### 2.1.2 Elevated Risks to Waste Management Sector Workers

In addition to the environmental health effects of wastes, there are the health and safety risks imposed on those working in and around the wastes themselves. These waste management workers may be part of the formal waste management sector working as either landfill employees or waste collection workers[5]. They may also fall under the

[4] Information on these diseases may be found on the websites of both the Centers for Disease Control (http://www.cdc.gov) and the World Health Organization (http://www.who.int/en)

[5] Those collecting wastes on a door to door basis for transport to a landfill

informal waste management sector as persons who sell materials they salvage from the waste stream. Of these three working classifications, salvagers are the most prone to these elevated risks for several reasons. First, they tend to work long hours and may even live for extended periods of time in landfills. This increases their exposure, and thus their risk. Secondly, salvagers may not have access to the appropriate clothing or safety equipment which will mitigate these risks. Formal waste management employees would typically have lower exposure levels then experienced by salvagers. Fewer hours spent among the wastes will reduce their exposure as will access to safety equipment and clothing. Among the formal waste sector workers, landfill employees and collection workers will have differing risk profiles. Table 2.1 categorizes the relative risk levels of waste management sector workers to these elevated risks.

Table 2.1 gives a qualitative assessment of some specific risks to which waste management workers are subject. These risks are above and beyond those risks to which the general public are traditionally exposed (as covered in section 2.2.1), except where collection or sanitation is lacking. The quantitative aspects of these risks are not covered sufficiently in the literature for mention here. The discussion will continue in section 2.4.3 with a case study of the salvaging activities at the On-Nooch landfill in Indonesia.

**Table 2.1: Relative Risk Level of Waste Management Workers to Specific Risks**

| Risk | Workers Subject to Risk | Relative Risk Level |
|---|---|---|
| Skin and blood infections from direct contact with waste | Collection Workers<br>Landfill Employees<br>Salvagers | Medium<br>Medium<br>Medium |
| Eye and respiratory illnesses due to air containing high pathogen contents, particulates, bio-aerosols and volatile organics | Collection Workers<br>Landfill Employees<br>Salvagers | Medium<br>Medium +<br>High |
| Zoonoses from bites by stray animals feeding on wastes | Collection Workers<br>Landfill Employees<br>Salvagers | Low<br>Medium<br>Medium + |
| Enteric infections from flies feeding on wastes | Collection Workers<br>Landfill Employees<br>Salvagers | Medium<br>Medium<br>Medium+ |
| Increase in adverse health effects from suspected increased toxic exposure | Collection Workers<br>Landfill Employees<br>Salvagers | Medium +<br>Medium<br>High |
| Parasitic and enteric infections from improper waste handling | Collection Workers<br>Landfill Employees<br>Salvagers | Medium +<br>Medium<br>High |
| **Health and Safety Effects** | | |
| Musculoskeletal disorders from heavy lifting and operating landfill equipment | Collection Workers<br>Landfill Employees<br>Salvagers | Medium +<br>Medium<br>Medium + |
| Puncture wounds | Collection Workers<br>Landfill Employees<br>Salvagers | Medium +<br>Medium<br>High |
| Injuries due to surface subsidence, underground fires and slides | Collection Workers<br>Landfill Employees<br>Salvagers | N/A<br>Medium<br>Medium+ |

*Risks are taken from SWMCOL (2000) while the relative risk levels are of the opinion of the author

## 2.2 Current Waste Management Technologies

Waste management practices have come to incorporate the concept of sustainability, in contrast to the founding "dump and forget" philosophies. Early waste management systems would simply transfer wastes from their highly visible and troublesome origins (e.g. urban households and city streets) to areas where it was perceived they could be forgotten. Water bodies, such as the local harbour or river, often served as final disposal sites for sewer outlets and solid wastes (see Section 2.2) as they provided free transport away from the population centres. Other systems utilized burial as a final disposal method. It was discovered later that these methods were inappropriate and the environment was not an endless sink for our wastes. Increasing constraints, including a

lack of land suitable for disposal sites, and environmental awareness has lead to the sophistication of waste management technologies. Current systems recognize the inherent energy in the disposed wastes and seek to maximize its recovery. Final disposal is seen as a last resort and measures are taken to reduce the environmental harm caused by disposed wastes. This section will provide a brief overview of the current technologies utilized in waste management systems to facilitate diversion and energy recovery along with those systems utilized currently in sanitary landfill design.

Waste reduction, reuse and recycling schemes form important components of many waste management systems. These strategies work to divert wastes from the need for final disposal. Diversion systems may include the utilization of waste management technologies in their operations. One area where current technology is often utilized is the processing of recyclables. A Material Recovery Facility (MRF) houses a classification system to process wastes for diversion purposes. A classification system may operate with human labour, mechanical power or a combination of the two. Mechanized systems classify materials based on their density, thermodynamic, electrostatic or optical properties. Technologies also exist which classify materials based on their size. The sophistication of these technologies has evolved such that they are capable of classifying an input waste stream into high quality individual material streams for diversion. Further information can be found in Scheirs (1998).

Aerobic (in the presence of oxygen) composting systems aim to divert the organic fraction of the general waste stream from final disposal. Here aerobic bacteria biodegrade organic wastes into organic complexes producing heat and gas with a high carbon dioxide ($CO_2$) content (30%) and low methane ($CH_4$) content (2-5%) (Sharma & Reddy, 2003; McBean et al, 1995). The bacteria require only oxygen, thus a common strategy is to organize the organic feedstock into windrows. Windrows are long and narrow piles which are easily accessed for turning. The action of turning the windrows aerates the organic piles and allows for aerobic conditions to be maintained. Turning operations may be automated with mechanical systems or completed by crews, typically with the assistance of heavy equipment. Front end processing of the organic feedstock improves

the final compost quality as contaminants may be removed. The resulting compost material may be utilized as a fertilizer, removing its need for final disposal.

Other waste management technologies focus on energy recovery. Incineration and anaerobic digestion process wastes to recover energy and create a new final product. The incineration of wastes yields an inert ash residue which is up to 90% smaller by volume (70% by weight) then its origin material (Rhyner et al, 1995; Tillman et al, 1989). The heat produced during combustion may be recovered and converted into energy, typically through a steam turbine process. The major emissions of the combustion process are $CO_2$, water ($H_2O$), unburned particulate matter, sulphur dioxide ($SO_2$), nitrogen oxides (NOx) and to a lesser amount toxic substances such as polychlorinated biphenyls (PCBs), hydrochloric acid, dioxins, and heavy metals (Rhyner et al, 1995; Niessen, 1995). Many of these emissions are harmful to the environment and therefore require attention. The various types of incinerators produce different emissions but the final emission concentrations are largely dependent on the combustion conditions and the composition of the feedstock wastes. Fluidized bed incinerators utilize a bed of sand 'fluidized' by a high pressure injection of heated air from below. This creates highly turbulent conditions which efficiently transfer heat and optimize combustion. Combustion is further optimized through the recirculation of unburned materials into the combustion chamber. This creates lengthy residence times which are important for reducing the formation of harmful compounds such as dioxins. Limestone is commonly injected into the combustion chamber to reduce the formation of sulphur oxides and hydrochloric acid while combustion temperatures maintained at 815°C reduce the formation of NOx (Neissen, 1995; Rhyner et al, 1995; Tillman et al, 1989). Fluidized bed incinerators are used most extensively in Japan and less so in Europe and have begun to be utilized in U.S (Rhyner et al, 1995; Tillman et al, 1989).

Another waste to energy application is the utilization of Refuse Derived Fuels (RDF) in cement kilns. RDF is a fuel source developed from solid wastes. A waste stream is processed to accumulate materials which carry high heating values and meet the specific physical and chemical requirements applicable to the process in which they will be

utilized. For RDF to be utilized in cement kilns, desirable materials include plastics, tyres, used oil products, wood and paper wastes (Scheirs, 1998). The waste is processed, typically shredded to a size of 1-8mm, and fed into the kiln where combustion occurs and fuels to the ongoing process. The high temperatures in the kiln (1000°-2000°) and the long residence times (5-6s) result in complete combustion of the wastes (Scheirs, 1998; Wei-Mudden, 2004). The ash particles are incorporated into the cement composition thus ash disposal is typically not a problem. This is also true of the heavy metal contaminants in the wastes. RDF can replace the typical non-renewable coal fuel used in the cement production process by up to 40% and it has been shown that the air emissions produced using either fuel are similar and below regulation limits (Scheirs, 1998).

Anaerobic digestion systems allow for energy recovery from the organic fraction of the waste stream in the form of methane. Under anaerobic conditions (in the absence of oxygen) facultative anaerobic bacteria break down complex organic molecules into simpler molecules and organic acids. These acids are then consumed by methanogenic bacteria along with hydrogen to form $CH_4$ (45-57%) and $CO_2$ (40-48%) (Sharma & Reddy, 2003; McBean et al, 1995). The recovered methane is often burned and utilized to create steam which powers turbines for electricity production. Anaerobic digestion systems require a delicate chemical balance and thus typically utilize a front end processing system which removes unwanted materials from the organic feedstock.

Technology is also utilized in sanitary landfill systems to reduce the probability of environmental harm due to disposed wastes. Liner systems are constructed to enclose the disposal area and separate it from the surrounding environment. Leachate is captured and treated along with landfill emissions. A gas collection system allows the methane produced during bacterial decomposition to be captured and utilized. Landfills can be designed to maximize methane production by providing the ideal physical conditions. This involves monitoring field saturation levels, oxygen concentration and temperature. Captured leachate may be reintroduced into the landfill to increase moisture content and provide nutrients for bacterial decomposition. Such a design transforms the landfill into a bioreactor. Redundant containment systems may also be utilized to detect and account

for the failure of the primary liner system. These systems decrease the long term probability of environmental harm, which follows the notion of sustainability. Further information may be sought in solid waste management textbooks (Sharma & Reddy, 2003; McBean et al, 1995; Koerner & Daniel, 1997).

## 2.3 Solid Waste Management in the Developing World

In contrast to the developed world, environmental and waste management issues are not a priority in the developing world. Here the impoverished nature of many people's lives dictates that they must live from day to day. Their worry about their next meal or about adequately supporting their family eclipses environmental concern (Furedy, 1989). If waste collection is unavailable, disposal will occur by whatever means is convenient; possibly including burial of wastes locally, disposal in vacant lots, rivers, drains, or the streets (Medina, 2000). These are some of the characteristics which add to the already difficult conditions under which solid waste managers must work in the south.

Lack of funding combined with lack of infrastructure, undermanned and unqualified staff make for the problematic waste management practices of the South (van de Klundert & Anschütz, 2001). Collection systems must deal with the complicated collection aspects of low income neighbourhoods combined with the increasing waste generation rates of the expanding cities (Medina, 2000; Taylor, 1999). In general a lack of funds prevents the municipality from the ability to operate a collection system which can handle all these demands. Further problems emanate from the disposal side where governments utilize open dumps as the costs of a sanitary landfill cannot be justified. Again lack of funds prevents the proper staffing of the waste management authority both in terms of those qualified to design the system and ensure its operation and those who actually carry out the operation duties. From this perspective the outlook is not positive as the already significant pressures on the waste management systems of the South will only grow with increasing urban populations.

In the South poverty dictates a higher inherent value in materials. "One man's waste is another man's treasure". Families reuse clothing and feed organic wastes to chickens and

pigs out of necessity. Nothing is disposed of that can be utilized in some manner. Lack of formal recycling systems has lead to the formation of vibrant informal recycling sectors to satisfy the demand for secondary materials by the industrial sector. The substitution of secondary materials for their virgin counterparts remains good business in many instances. The informal sector utilizes the skill of material recovery from the waste stream, in which many are well versed from their daily lives, to feed the secondary material demand. The informal sectors of developing cities are well developed and in many cases recover a significant amount of material.

This section will provide an overview of the solid waste management practices and issues pertinent to the developing world. It begins with an introduction to the typical waste collection and disposal system issues in third world cities. The discussion then moves to the introduction of the informal waste management sector; its common organization, the actors which facilitate its daily operations, and the hazards to which these actors are subject. Also discussed are the relevant social issues related to those working in the informal sector, with the sub topic of women and children examined separately. With the negative aspects identified the positive aspects of salvager cooperatives and their incorporation into sustainable waste management systems are highlighted. The section culminates in the examination of sustainable waste management systems; their framework, waste system elements, stakeholders involved and their dissemination into a habitat level organization. Finally examples of successful intersectoral partnerships in existing waste management systems are presented.

### 2.3.1 Waste Collection and Disposal

Developing cities often spend 30-50% of their operational budgets on solid waste management although often only 50-80% of the total refuse generated is collected (Medina, 2000; Bartone & Bernstein, 1993). The rapid expansion of third world cities has produced additional wastes which already over capacity waste management systems cannot accept; upgrades are often not an option as the required funds and expertise are lacking (van de Klundert & Anschütz, 2001; Buenrostro & Bocco, 2003). The collection services that do occur are generally concentrated in middle to high income areas (Sicular,

1992). The rudimentary layout of squatter settlements, not overseen by official planning processes, present narrow winding unpaved streets which are not conducive to traditional waste collection methods and thus are rarely serviced (Medina, 2000; Pickford, 1984; Holmes, 1984). With no collection, citizens find alternative disposal methods such as burying or burning the wastes or disposal in vacant lots, vegetated areas, river and streams. A lack of sanitation infrastructure may also lead to human excreta entering the general waste stream. Illegal waste piles attract insects and rodents (disease vectors) and can contaminate surface and subsurface water sources (Bartone & Bernstein, 1993; Kungskulniti, 1990; Agunwamba, 2003).

Disposal systems also suffer from a lack of funds and expertise and these constraints lead to open dumping techniques. These are extremely harmful to the local environment as they lack the control systems of sanitary landfills in the North. The by-products of biological activities within the landfill[6], combined with leachate, contaminate the surrounding environments. Uncontained leachate carries landfill contaminants into the subsurface, polluting soil and water sources. Combined with this, $CO_2$ and $CH_4$ are both greenhouse gases while methane has the added safety risks of flammability and explosiveness in concentration. Failure to bury the wastes, as is done with daily cover in sanitary disposal systems, leads to the emissions of odours, dust, aerosol's and volatile organic compounds (VOCs). These compounds degrade the local air quality affecting those working around the wastes and any nearby residents. The constraints on the waste system often prevent the inclusion of special considerations for hazardous components thus industrial and hazardous wastes are assimilated into the general waste stream. This exposes those working around the wastes to dangerous substances such as pesticides, solvents or hospital bio-wastes. A lack of containment systems may also allow these substances to affect the surrounding environmental systems (Muttamara et al., 1996; Buenrostro & Bocco, 2003; Blight & Mbande, 1996; Kungskulniti, 1990).

Though many sophisticated waste management technologies exist in the developed world they cannot necessarily be directly transferred for use in the developing world. The waste

[6] $CO_2$ and $CH_4$

characteristics are very different in the North versus the South as waste composition is highly related to income and social status. Upper income residents tend to produce low density waste characterized by packaging components such as paper, plastic, cardboard and metals while poorer residents produce waste characterized by a higher density mix of organics, sand and inert materials (Sicular, 1992; Blight & Mbande, 1996). Organics have a high density and water content, both of which can increase in the rainy humid climates of many third world countries. Commonly wastes are stored in open containers and transported in open trucks which expose the wastes to the elements, thus a density increase is typically seen through the collection process (Sicular, 1992; Cointreau, 1984). The higher density wastes of the South do not require the compaction techniques utilized in landfills in the North and high moisture contents combined with the presence of inert material, such as soil and ash, renders the application of waste-to-energy facilities undesirable or infeasible (Sicular, 1992).

### 2.3.2 The Informal Recycling Sector

The existence of a vibrant informal recycling sector is common in many developing cities. Informal recycling activity is driven by the industrial market for recycled materials. The replacement of virgin materials with their recycled counterparts in various production processes generally results in lower costs and increased environmental performance.

There is a common hierarchy to informal waste management sectors throughout the South. The chain begins with salvagers, or waste pickers, who separate the recyclables from the mixed waste streams. These materials are then sold to middlemen, wholesalers, and junk dealers who further process the recyclables and sell them to industrial clients for a profit. The lower end of the informal hierarchy is commonly occupied by the impoverished. These individuals may utilize the waste stream to satisfy their basic needs: clothing, materials for shelter, tools, and sometimes food (Furedy, 1989; Taylor 1999). The collection and sale of recyclables provides a source of income while also contributing to the greater good of the city through reuse, and recycling. Figure 1 depicts a typical organizational structure of an informal recycling sector.

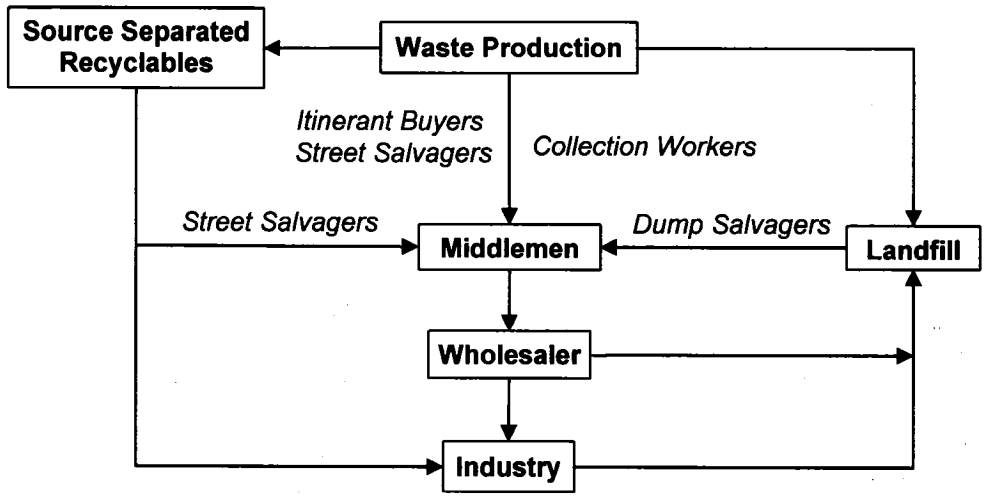


**Figure 2.1: Typical organization of the informal recycling sector**

Salvagers can be classified by their chosen method of recovering recyclables. Dump salvagers may reside on or in close proximity to a dump and rely heavily on its contents for themselves and their families survival; salvaging clothes, materials for their shelter, or even food scraps for consumption along with the materials they sell to the informal sector (Buenrostro & Bocco, 2003; Ojeda-Benitez et al., 2002). This type of existence is normally due to extreme poverty, although others who are not impoverished may also engage in salvaging activities as it provides them with a good living. These individuals salvage at the landfill as it has the greatest concentration of wastes (Medina, 1998; Kaseva & Gupta, 1996; van Beukering, 1994; Agunwamba, 2003; Medina, 2000). In some studies it has been found that dump scavengers have an income higher than that of the local average (Medina, 1998; Kungskulniti, 1990; Agunwamba, 2003).

Dump salvagers are subjected to monopsonistic market conditions; that is a market where only one buyer exists. The remote location of many dumps makes it difficult, if not undesirable, for salvagers to transport materials elsewhere. Thus the only outlet for sale exists through the local middleman. Middlemen transport materials purchased at the dump to markets where a higher price can be achieved. Often middlemen use the leverage provided by their monopsonistic position to lower purchasing prices and increase their profit margin (Medina, 2000; Vogler, 1984).

Salvagers may also purchase source separated recyclables from individual households. This practice exists in different forms throughout the world. In China, junk-buyers, also known as itinerant buyers, purchase source separated materials from households and businesses. These materials are then transported to redemption depots where they are sold for profit (Shichao, 2002; Furedy, 1990). In Cairo, Egypt wastes are collected by 'zabbaleen' who remove useful materials before disposal. In this system the zabbaleen do not purchase the materials but offer the service of collection to acquire the wastes. Recovered materials are sold while the organic fraction is fed to pigs (Medina, 2000; van de Klundert & Lardinois, 1995). The pig excrement is subjected to an aerobic composting process, along with separated organics, at the zabbaleen windrow composting facility. The result is highly valued compost which is sold to farmers in the surrounding area (Lardinois & van de Klundert, 1994).

Street salvagers collect waste from the communal waste bins, streets, canals, and back lots of third world cities. Source separated recyclables, intended for collection by formal recycling systems, are often recovered by street salvagers, resulting in a loss of income for the municipality (Goff, 1994). It is also observed that collection crews in the formal system complete salvaging activities on the side. Collection workers have been shown to double their income with this activity (Medina, 2000; Buenrostro & Bocco, 2003; Ojeda-Benitez et al., 2002; Agunwamba, 2003; Sicular, 1992; Furedy, 1990). Time-and-motion studies of collection crews in Bangkok, Thailand indicate as much as 40% of their loading time can be spent on salvaging activities. It is suggested that the incentive of extra earnings may increase the work rate such that the unproductive salvaging time is negated (Cointreau, 1984).

Middlemen and wholesalers link the supply to the demand. In addition to this, they process the materials (cleaning, sorting, bailing etc.) to better meet the end users requirements. This is the basis of their services and thus the justification for their profit margin. Middlemen, also labelled dealers, are those who purchase recyclables from individual salvagers and sell them to wholesalers. Wholesalers purchase material from many middlemen to ensure an adequate supply. A wholesaler may own warehouse space

and employ individuals to carry out its operations. Whereas a dealer purchases many different types of recyclables, a wholesaler generally specializes. Wholesalers may deal on a regional or national basis and generally require significant working capital and access to business infrastructure such as computers, phones, and faxes (van Beukering, 1994).

### 2.3.3 Environmental and Occupational Hazards for Salvagers

Section 2.2.1.2 discussed the elevated risks of working in and around wastes. A qualitative assessment of these risks was made to compare the relative risks of salvagers compared to landfill employees and waste collection workers. Here a case study of the salvager community operating out of the On-Nooch landfill in Bangkok, Thailand (Kungskulniti, 1990) is reviewed to demonstrate these elevated risks and exposures.

The On-Nooch site, an open dump, is the center of operations for an estimated 400 day-salvagers and 40 night-salvagers. It is one of three landfills which receive waste from the Bangkok area. The waste management system of Bangkok lacks a separate hazardous waste component, thus all wastes are treated equally and disposed in the city's landfills. This raises the exposure risks of waste management workers and salvagers to materials such as pesticides, solvents, fecal matter, biomedical wastes, other chemical wastes and other toxic industrial wastes.

Concern for exposure to these environmental hazards is not reflected in the salvagers clothing choices and activities on site. The majority of salvagers utilize headwear for protection from the sun along with some form of footwear. Other than this the clothing can range from loose fitting pants and a loose t-shirt to shorts and a bare upper body. These articles of clothing provide little to no protection from environmental exposures and may in some cases increase the risk to occupational hazards. Lack of safety rated footwear in the typical landfill environment would expose a person to any number of sharp objects. This observation can be extended to any other areas of bare skin. Loose clothing is prone to catching on jagged edges or moving parts. Loose clothing could become ensnared in the moving parts of heavy equipment operating on the landfill. This

could result in serious injury. Salvagers were also observed recovering food from the landfill for consumption. The option also existed to purchase food from the on-site vendors. It can be assumed that either of these food choices would only add to the overall negative exposure risks.

When questioned about health concerns, the majority of salvagers reported cuts and other injuries, along with headaches and internal problems, as a consequence of their work at the landfill. The use of Appine-Tab, a stimulating drug, was not uncommon. More than half of the salvagers reported working every day of the week while three quarters confirmed access to cleaning facilities and the ability to take two or more baths a day. Many of the salvagers lived in a settlement adjacent to the landfill. This heightens their exposure levels.

The ultimate health effects of these kinds of exposures are not positive. One study, quoted in Medina (2000), concluded that Mexico City dump salvagers have a life expectancy of 39 years as compared to the 67 years of the general population. Also mentioned in Medina (2000) is a study which showed an Egyptian salvager community to have an infant mortality rate of one in three. It is clear that the public health aspects of scavenging are a concern.

### 2.3.4 Social View of Scavenging

Welfare systems are rare in the developing world and the poor must find other avenues to obtain their basic needs. In urban areas it is particularly difficult to access the basic materials for survival (e.g. food and water). Natural water systems or wildlife stocks do not exist as common resources in urban settings. This excludes the option of hunting or gathering water as could be done in rural areas. The poor must look to other common resources, to which the urban waste stream is one, to obtain the materials essential for survival. Materials disposed by the more affluent members of society are commonly utilized for shelter, clothing, fuel, income through resale, and sometimes even food. To this end the urban waste stream is an extremely important resource to many of the poor in the developing world (Furedy, 1989).

Though there are various extremes of poverty levels within the scavenging community, not all salvagers rely on the waste stream for their basic needs. Many salvagers make above the average income and those higher up in the informal hierarchy obtain a significant profit margin (van Beukering, 1994; Medina, 1998; Vogler, 1984). They enjoy their jobs as they are entrepreneurial in nature and for many salvagers it is one of a very limited list of employment opportunities. Low education levels and age factors, be it too young or too old, prevent many from obtaining employment in the formal sector (Medina, 2000).

Salvagers traditionally are viewed at or near the bottom of the social hierarchy. This is due to a few key factors. Their poverty level does much to lower the social standing of salvagers in many eyes. Those that scavenge are then further reduced due to their willingness to live off of and actively engage in society's waste stream. Though salvagers find many useful materials in the waste stream, those of higher social status see only those living off that which they have disposed. The extreme end of this philosophy was observed in Colombia in 1992 when the bodies of 40 salvagers were found in Barranquilla on the site of a local university. The murders were part of a 'social cleansing' campaign by a paramilitary group. Their organs were removed and sold for transplants while the corpses were sold to the university medical faculty to be utilized in research (Medina, 2000).

Often a negative societal view towards salvaging is adopted by the local government. Medina (2000) describes the dominant view as one of repression. For example, laws are put in place to outlaw scavenging and hostile attitudes are extended towards salvagers. Salvagers are seen as inhuman and a source of embarrassment for the city. Attitudes of neglect and collusion also exist. Neglect is when the government chooses to ignore the existence of the salvaging community and offers no help to them (Medina, 2000). One would assume the hope is that the perceived problem of salvaging would disappear naturally under a policy of neglect.

Medina (2000) describes the policy of collusion in regards to the informal recycling sector through examples of the on goings in Mexico City. Here a cartel type situation has formed where the local bosses (caciques) control the salvaging community through force. Refuse collectors demand tips from households and small industry to collect their waste. Finally, lucrative collection routes through wealthy neighbourhoods are sold to the highest bidder. Government officials are paid to turn a blind eye and have been known to be involved in these activities.

### 2.3.5 Women and Children in the Informal Sector

Both women and children are at a disadvantage working in the informal sector. They generally cannot carry the weight of material that an adult male can and may be muscled out of the market for the lucrative recyclables. In Asia, it is reported in Furedy (1989) that the street and dump salvagers are predominately women and children. By contrast, middlemen and those that run the wholesale operations are overwhelmingly male. Women and children are paid less and receive smaller cash advances from the middlemen. The health risks of exposure to wastes are increased in the case of the children and their developing bodies (Singh, 1996). The same concern can also be extended to those women who are pregnant or may be in the future. There are also reports of women street cleaners who were subjected to sexual abuse in Latin America (Furedy, 1989).

### 2.3.6 Salvager Cooperatives

Many of the disadvantages experienced by salvagers may be mitigated through the formation of a salvager cooperative. Cooperatives organize members into a collective focused on the recovery and sale of recyclables, significantly increasing efficiency. Organized collection routes allow for extensive coverage of the city and the combined revenues are distributed amongst the collective. This transforms the traditional effort expended on conflict and competition towards the collective betterment of the group. The collective pool of recovered materials allows for the bypassing of middlemen and wholesalers and access to their premium selling prices. The volume requirements of industry can be met while quality requirements can be provided by processing activities

which are funded and completed by the collective. Stability is increased and the collective attitude removes the corruption, prejudice, and gender issues experienced by independent salvagers. Cooperatives may also offer benefits such as access to capital loans and health insurance (Medina, 2000). Below are some examples of successful cooperatives.

In Mexico, the Sociedad de Seleccionadores de Materiales (SOCOSEMA) formed in reaction to the announcement from the local middleman that only paper would be bought and at a lower price. Through the help of a college professor, a sympathetic Mayor, and the financial support of a local businessman, the cooperative was formed. The SOCOSEMA displaced the middleman and salvager incomes increased tenfold. In Colombia the non governmental organization (NGO) Fundación Social launched its National Recycling Program in 1991. The structure of the program includes national, regional and local associations and in 1996 spent US $700 000 on Colombian cooperatives through loans and grants. The most successful association under the program is the Cooperativa Recuperar. This cooperative has over a thousand members with 60% of them women. The salvager members earn approximately 1.5 times the minimum wage. The cooperative is associated with the Colombian medical system and members receive life and accident insurance. Members can also receive loans to continue their education. In 1998 Recuperar recovered 5000 tons of recyclables (Medina, 2000).

### 2.3.7 The Incorporation of Salvager Cooperatives into Sustainable Waste Management Systems

Salvager cooperatives are highly efficient waste management contractors which can offer their services at low cost. With this they are an attractive addition to any solid waste management system. To allow for an optimal incorporation of salvagers or a cooperative two key considerations should be made:

- Which role given to salvager cooperatives will most improve the waste management system from an environmental and operational standpoint?
- Which role will most improve the employment, social status, and occupational health exposure issues generally experienced by salvagers?

Consideration of these questions brings many conflicts to light. To maximize recycling efficiency, source separation must be increased. Recyclables separated at source avoid contamination and are readily available for input into the recycling sector. Such a system could be encouraged but it must be noted that such materials are generally highly contested in developing cities. Such a program might garner resistance from those who currently control such clean wastes. Resistance has also been documented from communities who contest the guaranteed access of salvagers to the recyclables produced in their neighbourhood. The fear is that salvagers bring criminal activity with them (Furedy, 1997).

Removal of recyclables from the waste stream, through source separation or increased formal recovery, will ultimately compromise the livelihood of the remaining salvagers. Even with formalization, informal salvaging will continue. Every salvager who is formalized will ultimately be replaced by one who is poorer as the act of salvaging remains a viable job for unskilled workers (Furedy, 1997). This does not render the formalization of salvagers futile, it only demands that waste management planners and social agencies work together to maximize the efficiency of the system and the welfare of the salvagers (Furedy, 1997).

This was done in Metro Manila where the Metro Manila Council of the Women Balikatan Movement (MMWBM) began a waste management program in 1983 in San Juan City. This program utilized "eco-aides" to retrieve source separated materials. The eco-aides were recruited by the local waste dealers involved in the project and are paid a fixed price for each material regardless of market fluctuation; the capital to purchase the recyclables is provided by the waste dealers. Collection carts were provided through the joint funding of the MMWBM and the waste dealers. The MMWBM organizes the routes and researched new markets for recyclables to encourage the participation of the middlemen. The eco-aides were generally recognized by the police and their harassment, which was formerly a problem, was avoided. The MMWBM has continued to argue for mandatory wet/dry separation and composting programs to the local municipalities (Furedy, 1993).

An example of such a system is given by the Waste Wise project in Bangalore, India. This was a small pilot project, launched in 1990 in an affluent Bangalore neighbourhood, which aimed to improve the working conditions of 10-16 year-old street children. Participating households separated their wastes into wet and dry baskets which were collected by the children. Also collected were the unsanitary wastes which were disposed of in the local street bins. This service prevented the participating households from having to transport their waste to these local bins. Organics were separated out and composted in a local park, whose land was made available by the Bangalore Corporation. The recyclables were sold to market though their potential amount was reduced as many households choose to sell the most valuable materials to itinerant buyers. The children were provided with training and the necessary collection materials and were paid around $14/month. They also received funds for tea and food. The program was funded by service fees paid by the participating households (Furedy, 1993).

## *2.4 Sustainable Waste Management Systems*

A sustainable waste management system strives to operate by integrating stakeholders in an efficient manner in the environmental, social and economic spheres. To allow for this the stakeholders, including the formal, informal and private sectors along with community based organizations (CBOs) and NGOs, are involved in design, creation, implementation, and operation of the system. The informal and private sectors provide waste management services at low operation costs while the formal government, in consultation with NGOs and CBOs, can provide the organization and management skills required to oversee the operational aspects (van de Klundert & Anschütz, 2001; Taylor, 1999).

### 2.4.1 Integrated Sustainable Waste Management

An integrated sustainable waste management (ISWM) system is a complex and interrelated grouping of elements. The organization of the system elements is defined by its stakeholders needs in the technical, environmental, economic, socio-cultural, policy/legal and institutional spheres. Analysis with the ISWM framework provides tools to municipal managers, decision-makers and members of city councils, in the developing

world, who are responsible for the development and operation of their respective waste management systems. With these tools a waste management system can be created or reformed to process wastes in an environmentally efficient manner considering economical and geographical constraints (Scheinburg, 2001a; Scheinburg, 2001b; Muller & Hoffman, 2001; Dulac, 2001).

The framework is built from four principles (van de Klundert & Anschütz, 2001):

- **Equity**: all citizens are entitled to an appropriate waste management system for environmental health reasons
- **Effectiveness**: the waste management model applied will lead to the safe removal of all waste.
- **Efficiency**: The management of all waste is done by maximizing the benefits, minimizing the costs and optimizing the use of resources, taking into account equity, effectiveness and sustainability
- **Sustainability**: the waste management system is appropriate to the local conditions and feasible from a technical, environmental, social, economic, financial, institutional and political perspective. It can maintain itself over time without exhausting the resources upon which it depends

The ISWM framework can be extended to a habitat level framework. The examination of the system at its various habitat levels (household, neighbourhood and city) will allow an intricate understanding of the system through the interactions of the stakeholders and the waste system elements at each level. Figure 2.2 attempts to capture this schematically.

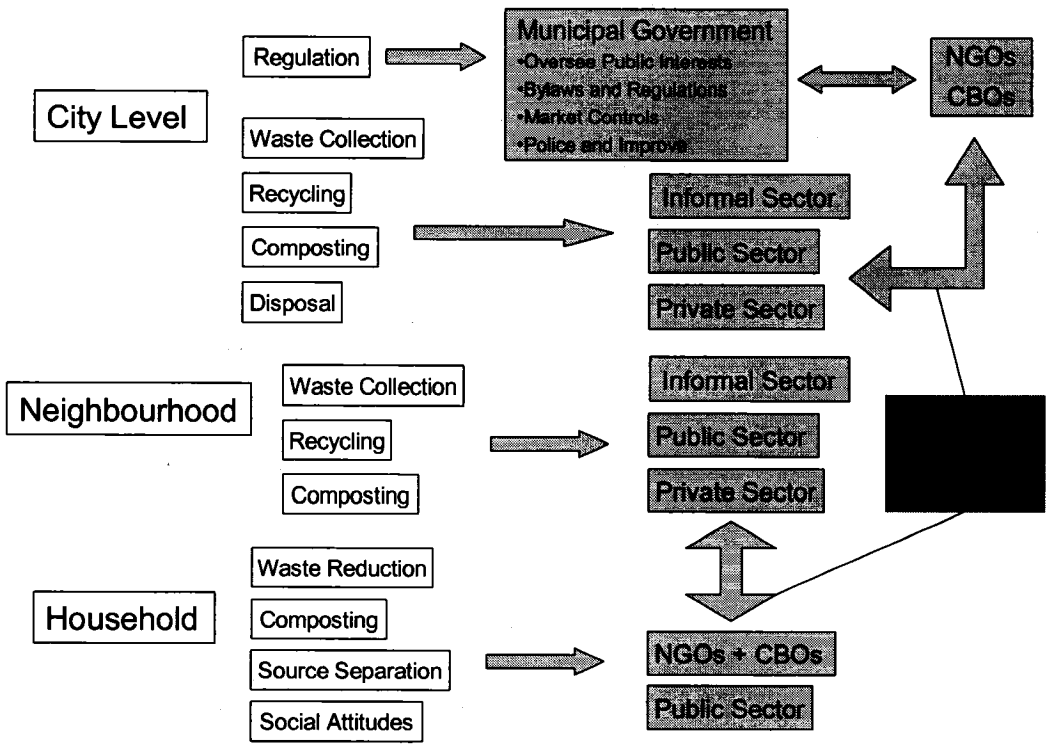


**Figure 2.2: Habitat level organization of sustainable waste management systems**

At each habitat level the interaction of the system elements with the various stakeholders may be observed. At the household level families can contribute physically to the system through waste reduction, source separation and composting activities. On a social level parents can help to instil these concepts in their children so future generations will understand their benefits and continue to operate and improve the system. NGO's, CBO's and the local government can work to institute programs which encourage these activities and educate society of their benefits. These ideas can then be spread to the neighbourhood level where neighbourhood collection, recycling and composting programs can be instituted. Here the informal, private and public sectors may be organized to operate the various elements of the system. At the city level, all the elements operate at a larger scale while the municipal government oversees the entire system. Bylaws and regulations are put in place to police the system to protect the public's interests. Market controls can also be utilized to promote certain beneficial activities and system improvements. Below are some examples of intersectoral partnerships which seek to optimize relationships such as those depicted in Figure 2.2.

### 2.4.2 Examples of Intersectoral Partnerships

In Surabaya, Indonesia private and community partnerships have been used extensively to overcome the lack of municipal funds available to operate the waste management system. 2500-3000 salvagers recover 10-20% of the recyclables before the wastes reach the city collection depots. At the landfills, roughly 10% of the recyclables remaining are diverted from the waste stream and avoid incineration. A salvager family averaged US$180-200 per month through the sale of recovered recyclables in 1992. In the streets 13 000 street sweepers are employed to maintain sanitation. The majority of these are employed by resident associations or salvager collectives with fees collected from residents. Approximately 10% are employed by the city (Taylor, 1999).

The municipal government of Surabaya encourages the formation of cooperatives and provides training to increase the productivity of the system and enhance the education of the public. This brings a positive outlook to the informal recycling sector. To the city of Surabaya the informal waste management sector is extremely important to the daily workings of the waste management system and as such society is respectful of their contributions. The business community is active in providing gift parcels of food and clothing to the informal waste workers during important Muslim holidays. The higher income residents have organized parties for the workers in the past (Taylor, 1999).

In Shanghai a collaboration which is essential to the waste management system exists between CBOs and the local government. A community based collection system requires residents to transport their wastes to communal collection points (CCPs). From here local government collects and transports the wastes to the final disposal sites, which are a three day round trip via barge. The CCPs are usually not more than 100m from each household and they serve approximately 100-300 households. Neighbourhood committees oversee the operation and maintenance of the CCPs. These costs are covered mostly by government funds with some additional input from household service charges. Mobile collection carts, provided by the neighbourhood committees, are utilized to transport wastes to the CCPs. Employees, commonly retired community members, push the carts from the households to the CCPs (Taylor, 1999).

## 2.5 General Overview of Trinidad and Tobago

Trinidad and Tobago is a two island republic with a population of approximately 1.3 million people. Of this population, 95% reside on the larger island of Trinidad which houses the capital of Port of Spain (POS) (Central Statistical Office [CSO], 2003a). T&T is a culturally diverse nation, including large African and mixed ethnic populations, although the majority of the population (40%) is of East Indian descent (CSO, 2003a). The urban population has been increasing over the years and it is estimated that 70% of the population reside in urban areas. The population of Port of Spain increased 6.5% between 1990 and 2000 to a population of just over 49,000 (CSO, 2003a). The industrialized economy is lead by its oil and natural gas production and also features well developed heavy industries including iron and steel, methanol and nitrogenous fertilizers and petroleum products (Tourism and Industrial Development Company of Trinidad and Tobago, 2005). Trinidad's economy also includes a financial services sector centered in POS . The tourism market is also important, peaking during the annual Carnival festival. Trinidad and Tobago's GDP is estimated at US 9.2 billion dollars (CSO, 2003a).

T&T is currently in a state of development. It is a country rich in oil and natural gas at a time when these commodities are at a premium. A walk down the streets of POS illuminates decaying infrastructure, and homeless individuals begging for change intermixed with the vibrant commercial activity in the downtown core. Specific to solid waste management, T&T's waste management system has improved significantly over the last few decades although it continues to be an area of concern (Warren *pers. comm.*). The illiteracy rate is small at 2% of the population, over 15yrs of age, and 90% of the population have access to an improved water source (World Bank Group, 2005).

There is concern with regards to the formation of squatter settlements and drug related crime. Trinidad is used as a transfer point in international drug trafficking mostly due to its location. Squatter settlements are located all over the island and are continually springing up. Many attribute this social degradation to the rising crime rate (Cooper *pers. comm.*). Numerous conversations on the topic of crime, combined with frequent crime related media headlines, gave evidence to the culture of fear on the island. Further to this,

during the field research phase, the business members of San Fernando[7] staged a protest against rising crime rates by closing their shops for a day. Possibly in relation to this protest, the government was attempting to reform the existing crime legislation near to the end of the field research phase.

### 2.5.1 Small Island Developing States

Environmental concerns are further amplified on small island developing states (SIDS) where environmental, social, and economic resources are stretched. There is a separate initiative to the global environmental agenda which explores the problems and solutions relevant to SIDS. These are specifically relevant to the Caribbean which is composed of SIDS.

The reduced land mass and fragile ecosystems of the island nation of T&T are of specific importance to the topic of waste management. Landfills can be environmentally costly and require land to be committed long term to the task of waste containment. Lack of due diligence with respect to wastes could lead to significant environmental damage. The population of T&T cannot afford such damage to the limited resources and fragile ecosystems of their island. Often promoted as an eco-tourism destination, T&T's ecosystems require special consideration as they may quickly disappear under adverse conditions. The nature of SIDS only heightens the importance of solid waste management and increases its complexity. These factors lead to waste management being adopted as one of 14 priority environmental issues during the UN Global Conference on the Sustainable Development of SIDS[8] in 1994. From these proceedings the following statement emerged:

> *"The shortage of land areas and resources available for safe disposal, population growth and the increase in imports of polluting and hazardous substances combine to make pollution prevention and the management of wastes critical issues for SIDS. Wastes in those States tend to be highly visible, but due to their limited capacity to monitor the waste stream, the true extent of the problem*

[7] The second largest city in T&T located in the south west portion of the main island.
[8] The Global Conference on the Sustainable Development of Small Island Developing States, held in Bridgetown, Barbados in 1994, was the first follow-up meeting to the United Nations Conference on Environment and Development which was held in Rio de Janeiro, Brazil, in 1992.

*remains poorly understood. For SIDS, the disposal of wastes is a serious constraint to sustainable development."* (as cited in Wei-Muddeen, 2005)

### 2.5.2 Trinidad and Tobago's Vision 2020

The Government of T&T has instituted a multi-disciplinary planning process to aid the development process of Trinidad such that it will be regarded as a First World nation by the year 2020. The Vision 2020 process presents a formal vision of a nation in which (Vision 2020, 2005):

- *"Every citizen has equal opportunities to achieve his fullest potential*
- *All citizens enjoy a high quality of life, where quality healthcare is available to all and where safe, peaceful, environmentally-friendly communities are maintained*
- *All citizens are assured of a sound, relevant education system tailored to meet the human resource needs of a modern, progressive, technologically advancing nation*
- *Optimum use is made of all the resources of the nation*
- *The family as the foundation of society contributes to its growth, development and stability*
- *There is respect for the rule of law and human rights and the promotion of the principles of democracy*
- *The diversity and creativity of all its people are valued and nurtured"*

The Vision 2020 planning process is an important development process which will provide building block policies for many sectors. A sustainable vision is presented which calls for "environmentally–friendly communities" and the optimum use of the nations resources. These outcomes are also important towards the implementation of a sustainable waste management system and therefore the Vision 2020 process should be duly considered in conjunction with the sustainable waste management planning process.

# Chapter 3: Methods

The field data collection followed a qualitative research methodology and was carried out in Trinidad from May to August 2004. A literature review was completed prior to the field research phase which gave an understanding of the waste management situation in other developing areas. This knowledge was utilized to construct the preliminary research methodology which formed the basis for the data collection activities. During the field research phase, the appropriate data was collected to allow for the characterization of both the formal and informal waste management sectors based in Port of Spain. Semi structured interviews formed a key component of the data collection as important figures in both sectors were interviewed to gain an understanding of their structure and operations. A dynamic methodology was developed to allow for its refinement in the field as the unknowns became accessible. This chapter will outline the research methodology utilized for data collection.

## *3.1 Scope Definition*

The project is a pilot study with the goal of characterizing both the formal and informal waste management networks in Port of Spain and specifically that relating to the Beetham Landfill. The research was initiated at the Beetham site and exploration of factors affecting this site expanded the project to regional and national scales in specific areas. For example, the mass flow analysis of the informal sector included the examination of national import and export statistics along with national waste characterization data. In other areas the scope remained at its original boundaries. For example with the examination of the salvager contingent remained confined to those operating out of the Beetham landfill. This framework is applicable to a dynamic pilot study but it is important to provide a critique of the approach to allow for future work to continue and improve on the observations reported here.

## 3.2 Field Study Methodology

A qualitative research process is described in Babbie (2001) as attempting to make sense of an ongoing process which cannot be predicted in advance. A general qualitative methodology is shown below (adapted from Babbie, 2001):

1. Make initial observations
2. From these, develop tentative general conclusions
3. From these conclusions determine further observations to be made
4. Make these observations
5. Refine conclusions and continue process

This process defines the approach used during the field research data collection phase. Initial observations stemmed from the literature review and allowed for the development of the preliminary research methodology. This primary framework and knowledge base provided the starting point for the data collection phase. Further observations then developed out of the data collection activities and lead to refinements of both the methodology and the knowledge base. The cycle continued throughout the research phase to further refine the characterization data of both the formal and informal sectors.

The basis of the research methodology is used to answer the formal research questions below:

1. What are the waste management policies of Port of Spain and what relationship do they have to the informal waste management sector? Are the institutional linkages as the policies infer them to be?
2. Who are the various actors involved in both the formal and informal sectors and what are their roles within their respective sectors?
3. What are the mass and material flows of waste within these sectors?
4. How are the formal and informal waste management sectors linked? Are these linkages efficient or inefficient; favourable or unfavourable and how so?
5. How can the linkages between the informal and formal waste management sectors be improved?

These questions broadly define the targeted information for the data collection. It is also important to define the expected route for acquiring such information. These steps are then applied to specific areas of interest and refined appropriately as information is gathered. For this study, semi-formal interviews were used as a primary technique for

data collection. Semi-formal interviews allowed for flexibility to be incorporated into the interview process. This is essential to the qualitative process to allow for unforeseen circumstances to be embraced and assimilated rather than ignored. Before each interview the target information is defined, along with the corresponding questions to elicit this information, but it is understood that this is only a preliminary base for the interview. The interviewer must be prepared to move with the conversation, essentially refining the preliminary plan on the fly, to gather unforeseen information. This information will then be assimilated into the project framework and may or may not result in its refinement.

The specific nature of many of the interviews did not allow for a general template to be developed with the methodology. A question sheet pertaining to the informal sector interviews with salvagers was developed (see Appendix A) but when it came time for these interviews, these questions could not be applied directly. The interviews were completed at the Beetham landfill with those salvagers who were willing to participate. As many were working, and also leery of the situation, there was not time to apply a specific set of questions, nor was it appropriate. Rather, a conversational atmosphere was attempted and questions formed as they naturally arose from the conversation. A thorough understanding of the information desired was important towards assuring it was gathered, but additional key pieces of information arose through continued conversation. This was the basis of the informal interview framework and it was both necessary and effective.

## *3.3 Field Study Research Activities*

This section will outline some of the specifics of the research activities completed during the data collection phase beginning with Table 3.1 below. This table lists the various individuals interviewed during the data collection phase. They are organized according to their affiliation in T&T's waste management situation. This information is also presented in Appendix A in chronological order to give some idea of how the overall characterization came together.

**Table 3.1: Individuals Interviewed during Research Phase**

| Name | Position |
|---|---|
| **Formal Sector Related Interview Subjects** | |
| Richard Warren | Operations Manager , SWMCOL |
| Glen Goddard | Manager, EMA |
| Honourable Penelope Beckeles | Minister of Public Utilities and Environment |
| David Pased | Ecologist, MOPUE |
| Deborah Thomas | Director, MOPD |
| Winford David | City Clerk, POSCC |
| Akash Hanooman | Environmental Engineering Specialist, MOPUE |
| Alban Scott | Manager, SWMCOL |
| Jameel Mohammed | Technology Officer, MOLG |
| Shari Juarwan | Information Officer, SWMCOL |
| **Informal Sector Related Interview Subjects** | |
| Aldwyn Clark | Director, Ace Recycling Limited |
| Mr Jai Paul | Caribbean ISPAT |
| Sharon Jagroob | T&T Recycling Company |
| David McGaw | Board of Directors, Carib Glassworks Ltd; Senior Lecturer, Chemical Engineering, UWI |
| Errol Ramlakhan | Senior Purchasing Officer, Carib Glassworks Limited |
| Angelus Pilgrim | Senior Lecturer, Chemical Engineering, UWI |
| André Garraway | Beetham Landfill Manager, SWMCOL |
| Michael Veighwig | Health & Safety Officer, Beetham Landfill, SWMCOL |
| Mr Medsing | Project Engineer, Unicell Paper Mills Caribbean Limited |
| Anthony Manswell | Director, Recycling in Motion |
| Various Salvagers | Beetham Landfill |

Trinidad's waste management policies form the basis for the structure of the formal waste management sector and its operations. These were therefore the starting point for the formal sector research activities. A top down approach was followed to bring first a broad level understanding of the sector, then identification and examination of the specifics. Dr. Vincent Cooper, the research liaison in Trinidad, provided an initial overview and introduction to the waste management situation while also providing an initial introduction to a few key formal sector contacts. Interviews were scheduled with senior level officials at the Environmental Management Authority (EMA), the Trinidad and Tobago Solid Waste Management Company Limited (SWMCOL) and the Ministry of Public Utilities and the Environment (MOPUE). These are the major organizations involved in the formal waste management system in Trinidad. These discussions provided a strong base for the remainder of the research activities giving additional

contacts, information and generally answering many of the initial broad level queries. From here the specific details were identified and it was decided how to go about obtaining them.

With the initial formal sector contacts, research activities moved into the informal sector. A top down approach was again utilized beginning with discussions involving the end user recycling companies. Of importance to the research activities within the informal sector were quantitative estimates of its mass flows. Also important was identifying the linkages between the formal and informal sectors as well as the overall structure within the informal sector. In this sense the top down approach allowed for a natural uncovering of the hierarchy as it expands from the end users providing the demand to those who seek to satisfy the demand.

# Chapter 4: Characterization of Trinidad's Existing Waste Management Sector

This chapter will characterize Trinidad's existing waste management sector through the presentation of the material gathered during the field research phase. The characterization data applies to the first three formal research questions (see Chapter 3) and part of question four. Chapter 5 will speak towards the remaining research questions.

The characterization is separated into that pertaining to the formal and informal sectors. The formal sector characterization begins by presenting its operations and structure along side the descriptions of its various entities. After this, the content turns to a review of the solid waste policy and legislation which provide the legal framework for the formal sector. Finally the specifics of the various aspects of the formal system are covered.

The informal sector characterization similarly begins with a discussion of its organization and structure while also examining those entities which carry out its operations. From here the specifics of the various recovery sectors are discussed and the chapter closes with discussion of the related material flows.

## *4.1 Trinidad's Formal Waste Management Sector*

The formal waste management sector is defined as the components of the waste management system which are under the control of the government. In Trinidad this broadly includes waste management policy, planning, implementation and operation. This section will introduce the various entities which allow for the operation and long term planning of the formal waste management system. Also covered are the solid waste legislations and policies which define its legal framework and structure. The discussion rounds out with the operation details of the existing system.

### 4.1.1 The Organization of Waste Management Responsibilities within the Government

In Trinidad, the Ministry of Public Utilities and the Environment (MOPUE) and the Ministry of Local Government (MOLG) carry the major responsibilities for waste management. The MOPUE directs the policy and planning activities while the MOLG covers operations. Three ancillary ministries, the Ministry of Planning and Development (MOPD), the Ministry of Health (MOH) and the Ministry of Finance (MOF) contribute their comments where applicable on land use planning and assessment, public health and tenders/contracts respectively. Figure 4.1 depicts the formal sector hierarchy.

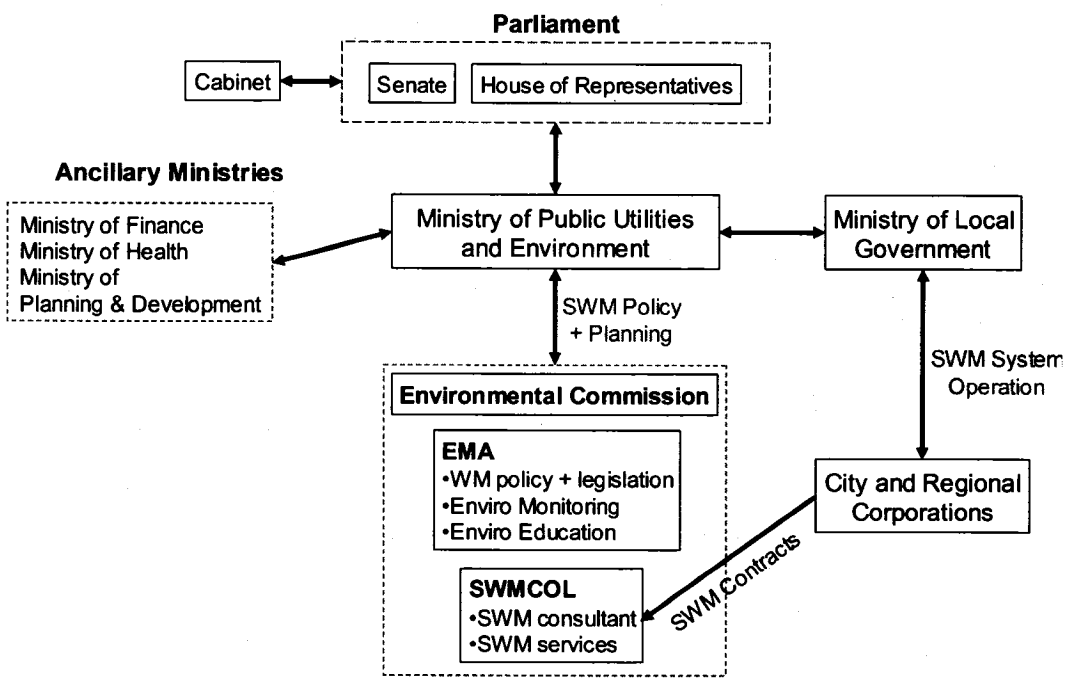


**Figure 4.1: Organization of the formal solid waste management sector**

The upper level of government is composed of cabinet and parliament. Trinidad's current governmental heads are President, George Maxwell Richards, and Prime Minister, Patrick Manning. Executive power lies with the Prime Minister and his appointed cabinet. Cabinet shapes national policy directives, laws and bills which are passed to parliament for debate and approval. Parliament is composed of the senate (upper house) and the House of Representatives (lower house). The senate members are appointed by the

President with input from both the Prime Minister and opposition. The House of Representatives is composed entirely of elected officials (Parliament of the Republic of Trinidad and Tobago, 2005; Pased *pers. comm.*).

The ministries carry out the directives set forth by both cabinet and parliament and allow for the daily operations of government. As discussed above, the MOPUE and the MOLG are the ministries responsible for the majority of the solid waste management related duties. The MOPUE oversees three important formal sector entities; the statutory bodies of the EMA and the Environmental Commission (EC) along with the private enterprise SWMCOL. The MOLG oversees the operations of the City, Borough and Regional Corporations.

#### 4.1.1.1 The Ministry of Public Utilities and the Environment

The official responsibilities assigned to the MOPUE are listed below (Government of the Republic of Trinidad and Tobago [GORTT], 2005):

- Public Utilities
- Water
- Electricity
- Electrical Inspectorate
- Postal Services
- Environmental Management
- Forestry, National Parks and Wildlife
- Horticulture
- Botanic Gardens
- Meteorological Services
- Pollution Control
- Solid Waste and Hazardous Substances
- Water Resources Management

Due to its responsibility for solid waste and hazardous substances, the MOPUE provides the overall waste management policy and planning for the country through its Environmental Policy and Planning Division (EPP). The ministry also develops the legislation which places these policies into practice. Finally the MOPUE oversees the operations of the EMA, EC and SWMCOL.

### 4.1.1.2 Ministry of Local Government

The Municipal Corporations Act enables the Corporations in the Municipality to handle the disposal of garbage from public and private property and to develop and maintain sanitary landfills as required (GORTT, 1990) . This translates to the MOLG overseeing the operation of the current solid waste management system; this includes all collection, disposal, and sanitation duties throughout Trinidad. In Tobago, these duties are passed to the Tobago General Assembly (SWMCOL, 2000).

Solid waste collection duties are discharged to the city and regional corporations through the MOLG. Each corporation is then responsible for the operation of the waste management system within their jurisdiction and receives a budget from the MOLG to complete these duties (Pased *pers. comm.*). In practice, commercial and industrial entities pay private contractors to collect and dispose of their wastes, though officially this responsibility is directed to the MOLG (SWMCOL, 2000b). There are fourteen City, Borough and Regional Corporations, also labelled as Municipal Corporations (MCs), overseen by the MOLG and their jurisdictions cover the island of Trinidad (Garraway, 2003).

The waste management duties in Port of Spain fall to the Port of Spain City Corporation (POSCC). Within the POSCC the Transport and Cleansing Department is responsible for the collection duties. The sanitation department of the Civil Works Division contributes by sweeping the streets and keeping the drains clean (David et al., 2003). A common trend within the MCs is the sub-contracting of all or a portion of their collection duties to private contractors. This practice occurs in POS where a lack of equipment and manpower prevents the POSCC from completing the entirety of their collection duties. Thus they contract the downtown collection routes to SWMCOL while they complete the collection routes in East POS (Warren *pers. comm.*).

It is important to note that the Municipal Corporations Act mandates that the powers of the corporation are exercised by its Council (Part II No. (1)), this places the final decision

power pertaining to the solid waste management system in each area in its councillor's hands. For example, within POS there are 12 districts, thus changes to the solid waste management system in each district must be approved by those districts councillor's (David et al., 2003).

### 4.1.1.3 Trinidad and Tobago Solid Waste Management Company

SWMCOL is a private corporation wholly owned by the government (similar to a crown corporation). Its creation in 1980 carried the mandate to manage, handle, collect, treat and dispose of all wastes, including sewage and septic wastes, through their own operations or through the provision of technical and managerial assistance to local authorities, statutory bodies or other public or private companies. SWMCOL was also directed to develop and operate the disposal sites on the island (SWMCOL, 2000). Over time, many of these duties were relinquished and passed to other authorities such that SWMCOL now operates as a private solid waste management contractor/consultant would. Currently SWMCOL carries the contract for the management of Trinidad's Beetham, Guanapo, and Forres Park landfills (this contract is administered through the MOLG) (Warren *pers. comm.*). As mentioned previously, SWMCOL also carries the contract for the downtown POS waste collection route.

On the consultation side, SWMCOL acts as the government's expert consultant on all solid waste matters. SWMCOL also frequently consults on waste management issues for both the EMA and the MOPUE. Government funding is provided to SWMCOL through the MOPUE and additional income is garnered from private waste management contracts. The private service thrust began in 1986 when SWMCOL was called upon to reduce its financial dependency on the Government (SWMCOL, 1998).

SWMCOL is central to the waste management lobby in Trinidad and has been at the forefront of the development of the waste management sector, formulating numerous proposals, spearheading environmental education activities and leading the way with recycling initiatives. A recent proposal for a transfer station based waste management system, submitted with Marshal Macklin Monaghan, was rejected but demonstrates

SWMCOL's drive to improve the sector (Warren *pers. comm.*). In 1991 SWMCOL began its first recycling programme collecting wastepaper and completing its classification into various grades for sale on the global market (SWMCOL, 1998). This programme remains the focal point of SWMCOL's recycling activities although attempts with other materials have been made (see Section 4.2.3.).

SWMCOL also works to educate the public in waste management and environmental matters. An example of this was their National Clean-Up Week activities (May 30 – June 5, 2004). SWMCOL encouraged the source separation of glass, plastic, and paper materials for curb side pickup during this week along with organising various community clean-up activities. A radio ad campaign was launched and discussions regarding waste management, recycling, and other environmental issues were held on local talk radio stations. SWMCOL also promotes clean-up days throughout the year where bulky wastes are collected for disposal and has plans to implement recycling programmes in the local schools. Used citrus drums, colour coded for various recyclables, will be installed to act as collection containers and encourage recycling activities. It is hoped that through the education of the younger generation the environmental awareness of the nation will improve (Warren *pers. comm.*).

SWMCOL also operates the Community-Based Environmental Protection and Enhancement Programme (CEPEP). CEPEP's mission is to "provide environmental improvement works through sustainable community efforts[9]" and is the vehicle for many local beach and community clean-ups and beautifying efforts. CEPEP provides entrepreneurial training to local contractors. These contractors then assemble crews and provide environmental works for the program. CEPEP provides employment for those who might otherwise lack such an opportunity while promoting environmental awareness and conservation at a community level.

### 4.1.1.4 The Environmental Management Authority

[9] SWMCOL CEPEP information pamphlet

The EMA was created in June 1995 through the Environmental Management Act (EM Act). Within the revised EM Act the general functions of the EMA are listed as (GORTT, 2000b):

- *"Make recommendations for a National Environmental Policy*
- *Develop and implement policies and programmes for the effective management and wise use of the environment, consistent with the objective of the EM Act*
- *Co-ordinate environmental management functions performed by persons in Trinidad and Tobago*
- *Make recommendations for the rationalization of all governmental entities performing environmental functions*
- *Promote educational and public awareness programmes on the environment*
- *Develop and establish national environmental standards and criteria*
- *Monitor compliance with the standards criteria and programmes relating to the environment*
- *Take all appropriate action for the prevention and control of pollution and conservation of the environment*
- *Establish and co-ordinate institutional linkages locally, regionally and internationally*
- *Perform such other functions as are prescribed*
- *Undertake anything incidental or conducive to the performance of any of the forgoing functions"*

With regard to solid waste management, the EMA handles the drafting of legislation and policy direction, in consultation with SWMCOL and the MOPUE, and the environmental monitoring of landfills (Goddard *pers. comm.*). It is also the mandate of the EMA to educate the public on environmental matters, although in the case of solid waste management SWMCOL usually completes these duties with consultation from the EMA (Goddard *pers. comm.*). Operation funds originate from the Environmental Trust Fund and legal actions are sought with the EC (SWMCOL, 2000).

### 4.1.1.5 The Environmental Commission

The Environmental Commission is a superior court of record which deals with the legal considerations of the EM Act (GORTT, 2000b). Its creation was called for within the EM Act and thus was created with the EMA. The jurisdiction of the EC, as defined in the EM Act, refers mainly to appeals towards actions of the EMA. The EC also acts as the court of law where the EMA would seek those actions beyond its own jurisdiction.

#### 4.1.1.6 Ancillary Ministries

Three main ancillary ministries, who play a smaller role in the formal waste management sector, are the Ministry of Planning and Development (MOPD), the Ministry of Health (MOH) and the Ministry of Finance (MOF). The MOPD is responsible for land use planning and environmental assessments (GORTT, 2005; Thomas *pers. comm.*). For example, during the development of a new landfill, the MOPD would be involved in selecting an appropriate site along with overseeing the projects environmental assessment. Among the many mandates assigned to the MOH, those related to solid waste management include public health, insect vector and epidemiology (GORTT, 2005). These arise from the environmental safety risks of solid waste management. The MOF is responsible for tenders and contracts, which are required for solid waste management (GORTT, 2005). Waste collection contracts with private contractors provide a specific example.

### 4.1.2 Solid Waste Legislation, Policy and Planning

The solid waste legislation and related policy and planning documents produced by the government of Trinidad & Tobago establish the legal framework for the formal waste management sector. This framework directs the operation and organization of the formal sector. This section will provide an overview of the solid waste legislation and related policy and planning documents in the order of their creation. This will provide an understanding of the evolution of the legal framework while also highlighting its impact on the current system. It is noted that the National Environmental Policy and Environmental Management Act were reviewed directly while the remaining document reviews were obtained from a secondary source (SWMCOL, 2000).

### 4.1.2.1 Public Health Rules and Regulations, Revised Ordinances (1950)

These regulations provide the earliest legislative delegation of sanitation duties (delegated to the MCs) (SWMCOL, 2000). Here "scavenging[10] and cleansing" duties are assigned to the local authorities who are also enacted to provide appropriate public drains (GORTT, 1995). They are also directed to maintain these drains, an action typically carried out through street sweeping, and direct maintenance activities, such as removing materials from catch basins which clog flow. These activities are meant to maintain a certain level of sanitation for the benefit of public health. During this time all public health concerns were assigned to the MOH, in other words the MOH was constitutionally responsible for waste management (SWMCOL, 2000). These ordinances directed some waste management duties towards the MOLG.

### 4.1.2.2 Litter Act Chapter 30:52 (1973)

The Litter Act aims to discourage littering in public places and premises by specifically defining the act as a chargeable offence and defining a punishment (GORTT, 1973). A $1000 fine, or six months imprisonment, is levied to those individuals found guilty of littering while a $2000 fine is applied to guilty corporate bodies. The act of littering is defined as depositing waste in any public area, other than those approved for waste, without reasonable excuse for doing so. Litter Wardens are enacted to exercise the duties of the act. A Litter Warden may be appointed by any public authority to enforce the provisions of the litter act in any public place under the jurisdiction of that authority. Litter Wardens may also issue clean up orders to the owners of premises they deem as unsightly or seriously detrimental to the amenities of the neighbourhood due to litter.

With this act the MCs were able to appoint Litter Wardens to enforce the Litter Act in their jurisdictions. This allowed for a promotion of sanitary activities and assisted MCs in the completion of their mandate under the Public Health Rules. The definition of littering in the act is problematic as the provision for a "reasonable excuse" provides an ambiguous subjective angle to the enforcement of the act.

[10] In this context scavenging is taken to mean waste collection and removal

### 4.1.2.3 Solid Waste Management Master Plan of 1980

In 1979 the government commissioned a consulting firm to complete a comprehensive survey of the existing solid waste management conditions and practices of the country. This survey was the Solid Waste Management Study of 1979 and was utilized to form a Solid Waste Management Master Plan to direct the future of this sector (Ministry of Health, 1980). This acknowledged the importance of solid waste management in the eyes of the government. It is evident that the document had an influence on the current organization of the formal waste management sector. A review of the institutional framework lead to the suggestion for the formation of an autonomous, state owned, public utility corporation to administer solid waste management duties. The original intent was to have the corporation administer both the collection and disposal responsibilities but it was the desire of government officials that collection duties remain in the hands of local government. This recommendation was directly implemented with the formation of SWMCOL. Further, following the recommendations of the master plan, the waste management policy/planning and legislation duties were "retained under the ministry to which the solid waste corporation would report" (the MOPUE). Operational recommendations included major redevelopments at the Beetham and Guanapo landfill sites along with the construction of a new facility at Tarouba, which became the Forres Park site, to serve southern Trinidad. The master plan also called for the formation of a material recovery facility site at the Beetham landfill.

### 4.1.2.4 Municipal Corporations Act (1990)

The Municipal Corporations Act (GORTT, 1990) allows for MCs to provide collection and disposal services for private and public property. The act also allows for the corporations to develop and maintain sanitary landfills where required (Part XII – Miscellaneous Functions). Although the municipal corporations are allowed to enact these services they are not required to do so. In practice, the act has been interpreted such that the MCs do in fact carry out the collection and disposal duties with funds provided by the MOLG.

### 4.1.2.5 The House Refuse, Rural Districts, Private Disposal By-Laws (1995)

The House Refuse Bylaws (GORTT, 1995) allow for the disposal of "house refuse" in rural settings by burial and burning. The act defines house refuse to be dust, waste paper, broken glass etc., kitchen refuse, yard and garden waste, disused tyres, and the waste products of any trade or manufactory. As with the litter act, this by-law defines appropriate and inappropriate actions in the waste management system (i.e. it is appropriate to bury or burn house refuse in rural areas while these same actions are inappropriate in urban settings).

### 4.1.2.6 Environmental Management Act (2000)

The EM Act was originally introduced in 1995 and has since been repealed and re-enacted in 2000. Its objectives are stated as (GORTT, 2000b):

- "*To promote and encourage among all persons a better understanding and appreciation of the environment*
- *To encourage the integration of environmental concerns into private and public decisions*
- *To ensure the establishment of an integrated environmental management system in which the Authority, in consultation with other persons, determines priorities and facilitates co-ordination among governmental entities to effectively harmonize activities designed to protect, enhance and conserve the environment*
- *To develop and effectively implement written laws, policies and other programmes for and in relation to:*
    - *the conservation and wise use of the environment to provide adequately for meeting the needs of present and future generations and enhancing the quality of life*
    - *the Government's commitment to achieve economic growth in accordance with sound environmental practices*
    - *the Government's international obligations*
- *To enhance the legal, regulatory and institutional framework for environmental management*"

The act established the EMA[11] and defined its organization, function and mandate while providing for its operation through the Environmental Trust Fund. The act established the EC as a superior court of record with jurisdiction to hear environmental matters and

[11] Referred to as the Authority in the objectives

called for the drafting of both the National Environmental Policy (outlined below) and the Environmental Code. The Environmental Code is described as a comprehensive evaluation of the existing environmental laws and programmes with recommendations for their overall consolidation, rationalization and modernization. During the development of the Environmental Code, the EMA is directed to incorporate, where appropriate, economic tools such as product charges, adjustment of subsidies, establishment of tax differentiation or tax incentives to encourage beneficial environmental activities and create pricing which adequately reflects environmental costs.

### 4.1.2.7 National Environmental Policy (1998)

The National Environmental Policy (NEP) document of 1998 (GORTT, 1998) provides the overall policy framework for environmental management in T&T. The NEP evolved out of the EM Act (section 18) where the EMA was directed to develop a national environmental policy document. The goal of the policy is stated as:

> *"The conservation and wise use of the environment of Trinidad and Tobago to provide adequately for meeting the needs of present and future generations and enhancing the quality of life"*

To this end the policy outlines basic principles which aim to create an awareness of the environment and foster a feeling of care and respect amongst the population towards its conservation and preservation. The goal is one of sustainability where the nation does not exceed the carrying capacity of the environment in which it resides.

The first policy outlined is the Polluter Pays Principle. This could be considered a founding ideal of the overall policy where those responsible for the pollution will bear the costs of its prevention and mitigation. This mirrors the environmental management philosophy seen in the developed world. Further to this, the NEP outlines a move towards cleaner technology rather than end of pipe pollution control for industrial processes. This advocates developing closed loop systems where both the inputs and outputs of industrial processes are minimized. In such systems, energy use is optimised and wherever possible wastes are recycled back into the system while hazardous materials are substituted by those which carry lower environmental risk. The NEP also addresses

hazardous substances and hazardous waste. It directs the EMA to develop hazardous waste handling and disposal guidelines and shifts the responsibility of hazardous substance safety to the manufacturer such that the manufacturer is responsible for ensuring adequate safety, toxicity and eco-toxicity tests are complete before substances are placed on the market. Specific to waste management, the NEP outlines the following policies (GORTT, 1998):

- *"Encourage the prevention or reduction of waste production and its harmfulness, particularly through the development of clean technologies, techniques for the final disposal of dangerous substances in waste destined for recovery, and the development and marketing of products designed to have minimal environmental impact by nature of their manufacture, use or final disposal.*
- *Encourage the recovery of waste, including recycling, reuse or reclamation, and the use of waste as a source of energy;*
- *Ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment, and in particular without risk to air, soil and plants and animals, without causing a nuisance through noise or odours, and without adversely affecting the landscape;*
- *Prohibit the abandonment, dumping or uncontrolled disposal of waste;*
- *Establish an integrated and adequate network of waste disposal installations"*

### 4.1.2.8 Proposed Beverage Containers Act (2000)

The proposed Beverage Container Deposit Legislation (GORTT, 2000a) aims to enact the larger policy objectives of the environmental management system defined in the NEP and EM Act. A walk down any major street in POS will display litter, in the form of Polyethylene Terephthalate (PET) beverage containers, collecting in the drains. This bill aims to encourage their recycling thus diverting their litter from the streets and their appearance in landfills. A bottle deposit enacts the "Polluter Pays" principle as only those who fail to return the bottle for recycling will end up paying the deposit. The act is to be administered by the EMA who is enabled to do what they need to both improve the system and provide for its operation. The deposit charges proposed are based on the volume of the container; below 0.5L the deposit is $0.10 and above 0.5L $0.20.

### 4.1.2.9 Impact of the Various Legislations

It can be seen through a chronological examination of the waste management legislation that the focus has broadened more recently. Documents such as the NEP and the EM Act operate holistically as compared to the specific delegation of duties seen in the Public Health Ordinances and Litter Act. A holistic viewpoint is beneficial when considering sustainability, but there is also a need for specific policy direction.

The legislative documents can be classified according to their impact on the formal solid waste management system. Analysis indicates one group which impacts on a broad policy level, while another contains those legislations which directly affect the operations of the solid waste management system. Table 4.1 presents the documents, in summarized form, under these classifications.

It can be seen that the older documents such as the Public Health Rules and the Litter Act were very specific in their designation of duties whereas more recent legislation (NEP and EM Act) address the topic of environmental management; solid waste management is then only one aspect of this. There is a need for an update of both the constitutional/legislative definitions of the waste management system and a waste management policy document should be drafted to guide future activities (see Chapter 5).

**Table 4.1: Summary of Environmental and Solid Waste Legislation**

| Legislation | Important Points |
|---|---|
| **Legislations Affecting Broad Level Policy Objectives** | |
| Environmental Management Act (2000) | • Promote environmental awareness and integration of environmental concerns into private/public decisions<br>• Establish an integrated environmental system<br>• Develop environmental laws, policies & programmes<br>• Enhance legal, regulatory, and institutional framework for environmental management<br>• Also established the EMA and EC and delegated the development of the NEP and Environmental Code to the EMA |
| National Environmental Policy (1998) | • Polluter pays principle<br>• Cleaner technology rather than pollution control<br>• Reduce, reuse, and recycle wastes combined with energy recovery<br>• Proper disposal without endangering human health |
| Proposed Beverage Containers Act (2001) | • Outlines a deposit-refund system to encourage the recycling of beverage containers |
| **Legislations Affecting SWM System Operation** | |
| Public Health Rules and Regulations, Revised Ordinances, 1950 | • Defines rules to insure proper sanitation<br>• The responsibility for removal of household refuse is placed on the local authorities |
| Litter Act Chapter 30:52 of 1973 | • Outlaws littering in public spaces<br>• Individuals guilty liable to $1000 fine or six months imprisonment<br>• Corporate bodies liable to $2000 fine |
| The SWM Master Plan of 1980 | • Contained recommendations for the improvement of the solid waste management system as it existed in 1980<br>• Not legislation though it has affected both the operations and the policy/planning of the system since 1980 |
| Municipal Corporations Act, 1990 | • The Corporations in the Municipalities are enabled to provide for collection/disposal of private/public waste along with disposal sites |
| The House Refuse (Rural Districts) (Private Disposal) Bye-Laws, 1995 | • Allows for the burial or burning of wastes as a disposal method for private dwellings, places of business and institutions in rural districts |

* compiled from SWMCOL (2000), the Environmental Management Act (GORTT, 2000b) and the National Environmental Policy (GORTT, 1998)

### 4.1.3 Trinidad's Solid Waste Management System

Trinidad's solid waste management system is somewhere between a typical developed world system and that which might be found in the developing world. The collection system has developed into a robust system which utilizes modern equipment and

practices. In contrast, the disposal system is significantly damaging to the environment and not able to appropriately service the nation's demands. This section will provide an overview of the operation of Trinidad's formal waste management system along with a characterization of the general waste stream it services. Budgetary allocations, along with a review of the community involvement aspects, are also reviewed. The section closes with a discussion of future policy directions.

### 4.1.3.1 Collection

The administration and operation of the solid waste collection system in T&T is similar to that seen in the developed world. The collection system is administered by the MCs at a local level, as decreed in the Municipal Corporations Act (GORTT, 1990). The majority of the collection responsibilities are tendered out, while a small number of routes may be completed in house by the MCs. The MCs are also responsible for street sweeping and cleansing duties. In Port of Spain the waste management duties fall to the POSCC. Within the POSCC, the Transport and Cleansing Department is responsible for the collection duties while the sanitation department of the Civil Works Division sweep the streets and clean the street drains. The POSCC contracts out the downtown collection duties to SWMCOL while completing the East POS collection in house.

The collection system is effective and fulfils the waste collection requirements of the nation, taking advantage of private contractor expertise and investment in advanced waste collection equipment (Garraway, 2003). Currently waste management contractors are not subject to formal licensing and certification (Warren *pers. comm.*). This can cause regulatory problems as there is no formal means of insuring a private entity's ability to meet its contracted obligations. As the MCs are delegating the execution of their mandate to private contractors, there should be some mechanism in place to insure the delivery of this essential service. Accreditation would allow for some baseline level of service required by the government for the right to compete for collection contracts. This would exert some level of control over privately contracted parties thus increasing the reliability of the system.

The private contractors holding collection contracts have invested significant capital into their operations and equipment. A typical crew consists of a rear-loading compaction truck combined with three labourers, one driving and two loading. Collection coverage is quoted at 100% (Garraway, 2003), however this is deceiving. The problem of indiscriminate dumping remains visible, especially within rural and lower income urban areas. Low income urban areas often contain illegal housing developments (not subjected to MOP approval). As such, roadways appear which are narrow and steep, and in some cases unpaved. This makes passage difficult for collection vehicles in normal conditions while in wet weather, completion of collection duties may be impossible. Residents who do not have access to collection services will find alternate disposal options. These often include the dumping of wastes in convenient areas, such as main roads or empty lots. East POS, located in the hills of the Northern Range, has these problematic collection characteristics.

Although indiscriminate dumping is visible and collection problems do exist, T&T's collection system is robust and able to assimilate problem areas. This is illustrated by the following example in a residential area. Waste was commonly dumped adjacent to the main road directly opposite to what is assumed to be a squatter settlement. This was a collection of houses located in an area above the main road with a steep access road joining them. It is assumed that this collection of houses was not serviced by collection trucks as the residents disposed of their wastes along the main road, expecting that collection would then have to collect them. In practice, these wastes were not collected regularly and with time developed strong odours in addition to the appearance of flies, vermin and stray dogs. Eventually the growing pile would be cleared by collection workers utilizing a flat bed truck and shovels/pitchforks (this is in contrast to regular collection where bagged waste is transferred to a compaction truck). These activities were noted approximately three times over a two month period. After this period, disposal bins were placed in the trouble spot. Following this, the bins were utilized and emptied regularly by a separate crew with a special vehicle while the regular crew continued normal service. Other such problem areas in East POS have been replaced with concrete enclosures (David et al., 2003) to allow residents a location to place their

wastes rather than contributing to indiscriminate dumping and the associated public health risks.

### 4.1.3.2 Disposal

In Trinidad, the responsibility for final disposal is delegated to the MOLG on a regional level and in certain specialized local situations the appropriate MC will oversee final disposal. There are three major regional landfills in Trinidad which fall to the MOLG; these are the Forres Park Landfill in the south, the Guanapo site in north central Trinidad and the Beetham site in the northwest (see Appendix B). SWMCOL currently administers the management of the sites through a contract with the MOLG. There are also smaller local landfills, such as that found in Toco, which are managed by the local MC (Warren *pers. comm.*). The Beetham landfill (focal point of this project) is the largest on the island, servicing the northwest region, including Port of Spain. It is estimated Beetham receives approximately 510 tonnes/day of general waste versus the 277 tonnes delivered per day to the Guanapo site in the south (SWMCOL, 1995). There is a significant salvager presence at the three regional landfills which form the basis for the informal recycling sector (Warren *pers. comm.*).

Within T&T there are no engineered sanitary landfills (Garraway, 2003). A lack of environmental control systems allows for the migration of leachate and landfill gases from the nations landfills into the islands fragile ecosystem. In the case of the Beetham site, it is obvious that environmental considerations were not prominent during the planning stages as the landfill is situated within a local wetland. The environmental hazards of solid wastes have been discussed (see Section 2.1) and T&T's current disposal system does little to mitigate these. As such it is problematic.

The research completed at the Beetham site identified it as the personification of many of these negative impacts. The largest landfill in the nation disposes of wastes directly within a wetland, and contains no control systems to contain its negative by-products. In close proximity is the Beetham Estates (a low income settlement) which is subject to unquantified effects due to the landfill. Methane fires have been a problem in the past

and the resulting emissions may be directed towards the Beetham estates, depending on the prevailing winds (Garraway, 2003). Ground water contamination may also affect this community, but this has not been investigated nor documented.

The site receives all manner of solid wastes, including fecal waste disposed in a stabilization pond on site. A lack of a dedicated hazardous waste site may also direct these wastes to Beetham. Mechanisms exist to administer the various hazardous wastes streams (e.g. hospital wastes are incinerated on site) although they may not be entirely effective; the appearance of syringes and other blood-contaminated waste in Beetham's tipping area suggests this weakness (SWMCOL, 2000). Modified open dumping techniques are utilized. Incoming wastes are offloaded and spread by heavy equipment[12]. The application of cover is sporadic and therefore the bug and animal infestation is significant. There has been no appreciation of its design elevations thus the landfill has surpassed its design capacity and continues operations (Garraway, 2003).

Further complicating the situation is the presence of a salvaging contingent. These individuals work amongst the wastes and are exposed to elevated health risks (see Section 2.1.2). The informal nature of their occupation tends to cause additional problems. They are often at odds with the site security, for which they have little respect (Warren *pers. comm.*). Illegal activities, such as robbery and general harassment of incoming drivers, along with violence among the salvagers are not uncommon (Garraway *pers. comm.*). All of this suggests some needed improvements within the final disposal system.

### 4.1.3.3 Waste Characterization

Improvements to the solid waste management system require information on character and quantity of the wastes. Two waste characterization studies provide the data for this analysis. The first study was completed by SWMCOL in 1995 at the Beetham, Forres Park, and Guanapo Landfill sites (SWMCOL, 1995). This exercise was completed over the period of a week documenting statistics such as the number and type of vehicles

[12] During this process the waste is also compacted by the heavy equipment simply by its mass moving over the loose wastes

arriving along with their waste contents and collection area. The major waste categories were household, commercial, industrial, white goods, construction, yard and garden and institutional. Samples of the household wastes were taken to produce a detailed characterization while the same was not repeated for commercial and industrial wastes. Here only an approximate analysis was completed by taking note of the components of waste in the trucks entering the landfill. This study was built upon in 1999 with a visual assessment survey. This survey documented the number of vehicles entering the site and their sizes to produce an average waste volume estimate entering the site. An uncompacted waste density of 400kg/m$^3$ was assumed to convert volume estimates into weights (SWMCOL, 2000). The results are presented in tabular form in Appendix B.

The characterization presents an approximate picture of the incoming waste stream to the Beetham landfill. 19% of incoming wastes originated from San Juan/Barataria, which is one of the most densely populated of the service areas, while the next largest source (14%) originated from Port of Spain (containing a significant commercial and industrial composition). Thus the incoming wastes to the Beetham site may be taken to represent a significant portion of the population (including residential, commercial and industrial sources). Table 4.2 summarizes the total tonnage estimates, taken from the 1995 characterization, of potential recyclables in the Beetham landfill waste stream.

**Table 4.2: Potential Recyclables at Beetham (SWMCOL, 1995)**

| Waste Type | Estimated % of Total Waste Stream | 1995 Tonnes |
|---|---|---|
| Yard Waste | 30 | 56940 |
| Paper | 19 | 35405 |
| Foodstuff | 11 | 21462 |
| Plastic | 10 | 18761 |
| Metal | 5 | 9746 |
| Glass | 4 | 8395 |
| Textiles | 3 | 5840 |
| Rubber/Leather | 2 | 4380 |
| Wood | 2 | 2847 |

Of note, an estimated 60,000 tonnes of organics were disposed in the Beetham landfill in 1995. This compromises 30% of the total waste stream and does not consider the foodstuff component, which also constitutes a significant organic portion. Therefore the

organic fraction is the most significant; mirroring that which is often observed in other developing countries (Dulac, 2001). Paper and plastic also form a significant fraction while metals, glass and textiles appear in smaller numbers. All these materials may be targeted for recycling and therefore suggest an aggressive recycling strategy has the potential to significantly reduce the final disposal requirement at the Beetham landfill.

### 4.1.3.4 Socio-Demographic Waste Characterization

The "disposal culture" of T&T is a much discussed topic in the context of recycling on the island. It is often suggested as the reason why future recycling projects will not work (Warren *pers. comm.*; Goddard *pers. comm.*). Empirical studies have shown a correlation between the environmental awareness of the population and the success of recycling programs (Van Beukering & Bowman, 2001; Berglund & Söderholm, 2003) thus it is clear that such an increase will improve the chances of success with such programs in Trinidad. It is unclear whether an increase above a certain threshold will be a requirement, in other words the "disposal culture" must be overcome before recycling can be implemented, but it can be concluded that increasing the environmental awareness/education of the public will be beneficial and should form an important part in future waste management plans and activities. One strategy is to complete the education activities in tandem with implementation and increasing success by strategically appealing to certain socio-demographic characteristics of the target population. This section examines some of these waste characterization statistics.

The character of wastes differs depending on socio-demographic variables. The results of a socio-demographic waste characterization (contained in Table 4.3) completed in Trinidad demonstrate this (Headley, 2003). The study completed a waste characterization at source based on socio-demographic traits. The wastes of six communities in Diego Martin were characterized according to their income and dwelling traits. Further data was assembled from a questionnaire which was completed by residents of the area.

**Table 4.3: Socio-Demographic Waste Characterization by Weight (Headley, 2003)**

| | Low Income | | Middle Income | | High Income | |
|---|---|---|---|---|---|---|
| | Single | Multi | Single | Multi | Single | Multi |
| Organics | 33% | 32% | 31% | **43%** | **27%** | 28% |
| Paper | **16%** | 18% | **30%** | 21% | 23% | 24% |
| Plastics | 19% | **24%** | **12%** | 20% | 16% | 22% |
| Diapers | **18%** | 8% | 12% | **1%** | 7% | 6% |
| Glass | 7% | 11% | **6%** | 9% | **11%** | 8% |
| Metals | **3%** | 4% | 5% | 5% | **8%** | 3% |
| Other | 5% | 3% | 4% | **1%** | 8% | **9%** |

The dark numbers highlight the highest values while the lighter numbers highlight the lowest values

It is intriguing to consider the design of a recovery system which strategically incorporates these kinds of data. For example, consideration of the data contained in Table 4.3 suggests focusing plastic recovery efforts on low income areas and paper recovery efforts on mid to high income areas. Would such a program have greater success than one which caters equally to all citizens? The data shows a greater concentration of plastics in the lower income wastes, as compared to the middle and upper income classifications, but this does not mean that the overall mass of plastics is larger. A larger mass of upper income wastes could of course result in a greater amount of plastics as compared to a smaller mass of low income wastes, and in either case the appearance of these materials speaks nothing to their recovery; this of course will depend on the method of recovery. For example, a salvager should have greater success recovering plastics if they exist in larger portions in the wastes. On the other hand, a participation based recovery system has an additional dimension. Here lack of participation equates to nothing recovered but a high participation rate for wastes containing insignificant recoverable materials also equates to nothing recovered.

Thus willingness to participate forms an important variable. The survey portion of the research displayed an apprehension from low income communities to purchase recycled products. (Headley, 2003). They were also less willing than the higher income communities to participate in source separation activities. A suggestion of compensation for these activities generally did not increase the will to participate, in all income brackets. A positive correlation between education levels and willingness to participate was observed. These results seem to suggest that recycling programs may not have success in Diego Martin. If these results were mirrored elsewhere, it may be beneficial to

proceed with environmental education to increase awareness before the implementation of recycling programs.

In any case, attempting to quantify and predict the public's willingness to participate will always be difficult. Unfortunately this is an important element in waste management programs and socio-demographic data should assist with the habitat level planning. These types of statistics allow for comprehensive waste management planning on a community level, which may be useful in Trinidad's case. Thus continued compilation of socio-demographic statistics in Trinidad should continue to contribute to future comprehensive waste management planning.

### 4.1.3.5 Budget Allocations

Government expenditures on waste management can be broken down into collection, disposal and policy/planning. The budget expenditure data presented here adds to the formal sector characterization.

The budget expenditures for collection services include the contract expenditures for contracted collection services along with the costs incurred by the MCs to complete collection duties in-house. Street sweeping and sanitation costs are also included; these are typically incurred by the MCs. The total budget allocated for collection services in the 2001 budget was US$14,345,368 ($US13,597,868 Trinidad and US$747,500 for Tobago). This represented 2-5% of the total municipal budget for that year (Garraway, 2003). A summary of the various costs applicable to the individual regional corporations are contained in Table 4.4.

**Table 4.4: 2001 Government Waste Management Expenditures (Garraway, 2003)**

| Regional Corporation | % of annual budget for SWM with respect to municipal total budget | Cost per tonne (US$) |
|---|---|---|
| Tunapuna/Piarco | 4.06 | 15.5 |
| Couva/Tabaquite/Talparo | 2.40 | 23.4 |
| Diego Martin | 2.40 | 58.7 |
| San Juan/Laventille | **4.73** | 17.2 |
| Borough of Chaguanas | 3.29 | 13.8 |
| City of San Fernando | 1.09 | 17.8 |
| Penal/Debe | 2.3 | 22.2 |
| Princes Town | 1.61 | 40.4 |
| Sangre Grande | 2.39 | 47.6 |
| Siparia | 1.98 | **8** |
| Tobago | N/A | 10.6 |
| Borough of Arima | **0.64** | 12.9 |
| Borough of Point Fortin | 1.21 | 24.8 |
| City of Port of Spain | 0.67 | 11.3 |
| Mayaro/Rio Claro | 1.64 | **71.0** |

It can be seen that in San Juan/Laventille solid waste management carries the largest influence relative to the total municipal budget at 4.73% while in the Borough of Arima waste management accounts for only 0.64% of the total municipal budget; which is similar to that of Port of Spain. Relatively low unit costs are also experienced in both Arima and POS (12.9 and 11.3 $/tonne respectively). This may be a result of an elevated collection efficiency afforded by the dense urban environment of these areas along with their relative proximity to a disposal site (Beetham for POS and Guanapo for Arima). The opposite is true for Diego Martin, which is further from Beetham than Port of Spain and has a density typical of suburban areas, and may be reflected in its relatively high cost per tonne of US$59. Garraway (2003) offers some additional explanations for cost variations:

- *"Level of accuracy and consistency in data collection parameters*
- *Travel time costs for contractors given the distance between collection routes and the disposal site. This could be applied in the case of Mayaro/Rio Claro, Princes Town and Sangre Grande where official disposal sites are located some distance from the final point on the collection route.*
- *Higher maintenance costs associated with additional distance travelled*
- *Difference in system and equipment types (mechanized systems as opposed to non-mechanized collection vehicles, inclusion of bulk bin systems on collection routes, level of special services offered as part of contract obligations)."*

Disposal costs include the total cost of construction, maintenance, operation and ultimate closure of a landfill. All of these costs are based on the size and sophistication of the landfill (in both cases higher values will result in higher costs). In 2002 US$2.5 million was allocated to SWMCOL for the operation of Guanapo, Forres Park and Beetham landfill sites (Garraway, 2003). It is expected this value will be increased to $3-4 million in near future to better represent the actual costs of the operation (Scott *pers. comm.*). Tipping fees are not collected at any of the landfills thus there is no cost recovery for disposal operations. This may be prudent as tipping fees may only increase the incidence of indiscriminate dumping.

Some examples of budget expenditures in the area of solid waste management policy/planning are presented here. Since the inception of the EMA, the major waste related focus has been in the area of hazardous waste. Other waste management initiatives include the Beverage Container Study along with Anti-Litter Education and Litter Act Enforcement. The EMA's priorty spending has been in the area of air and water related issues over its existence (Goddard *pers. comm.)*. Table 4.5 below presents the approximate budgets for the EMA's waste management related initiatives.

**Table 4.5: EMA Waste Management Expenditures (Goddard *pers. comm.*)**

| Year | Initiative | Amount (US$) |
|---|---|---|
| 1999-2000 | Lead Site Clean-up | 1,500,000 |
| 1999 | Beverage Container Study | 50,000 |
| Ongoing | Litter Act Enforcement | 250,000/yr |
| 2004 | Blood Lead Study | 250,000 |
| 2004 | Lead Site Clean-up | 400,000 |
| 2004 | Anti-Litter Education | 400,000 |

The estimated total for this area of expenditures, including air and water related expenditures, is around US$4m/yr, placing waste management expenditures at around 30% of the EMA's total budget (Goddard *pers. comm.*). The directives from the MOPUE have lead the EMA away from waste management such that it is not a big budget item (Goddard *pers. comm.*). In 2004 the EMA was given a specific budget for anti-litter education. This may display the government's intent to increase the EMA's waste management activities in the future.

### 4.1.3.6 Community Involvement

Parts of both SWMCOL and EMA's education initiatives have been geared towards community involvement exercises. This is important for environmental education as an empowered community will care for their way of life and that of their families and neighbours. Those who care for their community should support environmental equity philosophies and care for both the current and future environmental health. The basic principles outlined in the NEP call for the respect and care of communities along with their empowerment to care for their own environment. The document states that local communities, environmental NGOs and CBOs provide the easiest channels for the creation of sustainable societies. If citizens care about their communities and feel they have the power to enact change to protect them, it raises the probability that such change will occur.

SWMCOL's community building activities began with their Charlie program. This program introduced Neighbourhood Action Groups (NAGs) to encourage the conversion of litter ridden "Charlie" spots into beautiful areas. The program's slogan was "NAG Charlie Away" and contests were held to promote the cleaning of communities (SWMCOL, 1998). From here SWMCOL has continued to promote community clean up days where individuals are encouraged to come out and participate in the cleanup. Festivities are often organized afterward to further the community building exercise. Here SWMCOL is instilling an environmental community ethic and encouraging environmental preservation and improvement through community actions. NGOs are also involved in this drive. Organizations such as the Rotary Club and the Lions Club encourage these activities and support many of the events. Local banks may also contribute funds to the clean up cause.

SWMCOL also spearheads the Community-Based Environmental Protection and Enhancement Programme (CEPEP). Their mission is to "provide environmental improvement works through sustainable community efforts[13]". CEPEP is a government

[13] CEPEP promotional pamphlet distributed by SWMCOL.

program which contracts out environmental works to a number of micro enterprises formed by local entrepreneurs. The CEPEP program also provides the appropriate business training to operate these micro enterprises. The environmental works of the CEPEP program include cleaning activities in the local drains, parks, cemeteries and fields. Crews are often seen trimming overgrowth and grass in these locations throughout the island. The cuttings are then piled for pickup by the waste authorities. There have been negative incidents where the CEPEP crews removed important vegetation, an example is that of vegetation providing flood control, and critics of the program point to their untrained nature and the potential for environmental harm rather than good (Cooper *pers. comm.*). Other works of the CEPEP programme include beautifying efforts and landscaping projects throughout the island. Blue coveralls, with the CEPEP logo, form the program's uniform and it has been quoted that this uniform empowers its members. Many are proud to be part of the program where they receive a wage while also contributing positively to society (Warren *pers. comm.*). Micro enterprise leaders gain further benefits through the business experience and hopefully turn a profit.

### 4.1.3.7 Solid Waste Management Future Policy Directions

Currently the EMA and the MOPUE have been working on a proposed hazardous waste management plan combined with the related landfill guidelines. These documents will update the nation's policy on hazardous waste and establish a formal system to address its movement, use and disposal (Goddard *pers. comm.*). Another important policy project has been the proposed Beverage Container legislation (see Section 4.1.2.8) which has gone through various incarnations (Pased *pers. comm.*). A lobby against this legislation is lead by the major soft drink manufactures who feel the added cost to their products will reduce sales (McGaw *pers. comm.*). Both these pieces of legislation appear to be on track to be formally approved by cabinet and parliament in 2005 (Pased *pers. comm.*).

The government has also begun work towards the development of a new waste management system. The government is in the preliminary stage of accepting consultant proposals towards the development and implementation of a new system (Pased *pers. comm.*; Hanooman *pers. comm.*). The MOPUE has had various proposals for

consideration in the past; including the joint SWMCOL/Marshall Macklin Monaghan proposal in 2000 outlining a national sanitary landfill and transfer station based system (SWMCOL & MMM, 1999). Currently a major project is underway lead by Environment West Indies (EWI) out of Martinique. The study, labelled EuroColumbus, is examining a consolidated regional recycling and waste management strategy for the Martinique, Barbados and Trinidad. The main consultants are Burgeap from France. The project completed its data collection phase in early 2004. EWI are also lobbying to the EPP to become the consultant for the future solid waste management system development. It is the intention of the EPP to continue to gather and assimilate the necessary data as they move towards the eventual development of this system (Pased *pers. comm.*; Hanooman *pers. comm.*).

## *4.2 Trinidad's Informal Waste Management Sector*

The informal waste management sector is driven by market forces. A market begins with demand, which in this case is provided by industries seeking secondary raw materials for their manufacturing processes. To meet this demand recycling markets have formed around the world. In the developed world, formal recycling systems recover these materials while in the developing world, a lack of formal recovery systems has lead to the formation of informal systems to satisfy demand. Such an informal system exists in Trinidad and is characterized here.

The general waste stream can be considered an accessible common resource as it is formed by discarded materials, of which by definition ownership has been relinquished. These discarded materials may still prove useful to others thus they are often subjected to salvaging activities. Salvaging may be completed by the poor searching for materials to aid in their survival while others recover secondary materials specifically to service the industrial demand; thus accessing the business opportunity provided.

In T&T the majority of the recovery activities occur in Trinidad. Only glass and ferrous metals are utilized domestically, therefore most of the recovered materials are shipped abroad for sale and utilization. The informal waste management sector in Trinidad is

increasing and there are significant recovery opportunities (see section 4.1.3.3). This section will characterize the informal waste management sector in Trinidad beginning with the classification of the informal entities involved in its operations (Figure 4.2 below gives a schematic representation). A review of the current recycling operations is provided and the characterization ends with an overview of the materials flows within the informal sector.

The materials driving the informal sector originate from post consumer or post industrial sources (see Figure 4.2). Wastes classified under the post consumer label include domestic wastes such as food/drink containers, organics or food wastes discarded from homes or in public waste receptacles. Also included are non hazardous wastes from commercial operations. Post industrial wastes include all non-hazardous wastes originating from industrial operations; an example is waste plastics from plastic production processes. Of interest to the informal sector are those materials which are recyclable and for which there exists a demand.

Once generated, wastes may be source separated and recycled, either internally or externally through a wholesaler, or disposed thus entering the general waste stream. Source separated post consumer wastes may be collected through informal systems, such as wholesalers collecting paper or glass, or they may also be salvaged by street salvagers. Entrance into either of these streams will cause the materials to bypass the landfill. Wholesalers may also have agreements with industrial organizations for the collection of their post industrial, source separated wastes.

Wastes which are not diverted from the general waste stream proceed to the landfill. During the transportation phase, collection crews, public or private, may recover materials for sale to landfill buyers upon arrival at the landfill. Wastes are transferred from collection trucks to the landfill in the tipping area. Here salvagers sort through the wastes in hopes of recovering secondary materials which carry a demand. Those materials recovered are sold to landfill buyers, who in turn sell to wholesalers.

Wholesalers may then distribute the materials for domestic recycling, or ship them abroad for sale on foreign recycling markets.

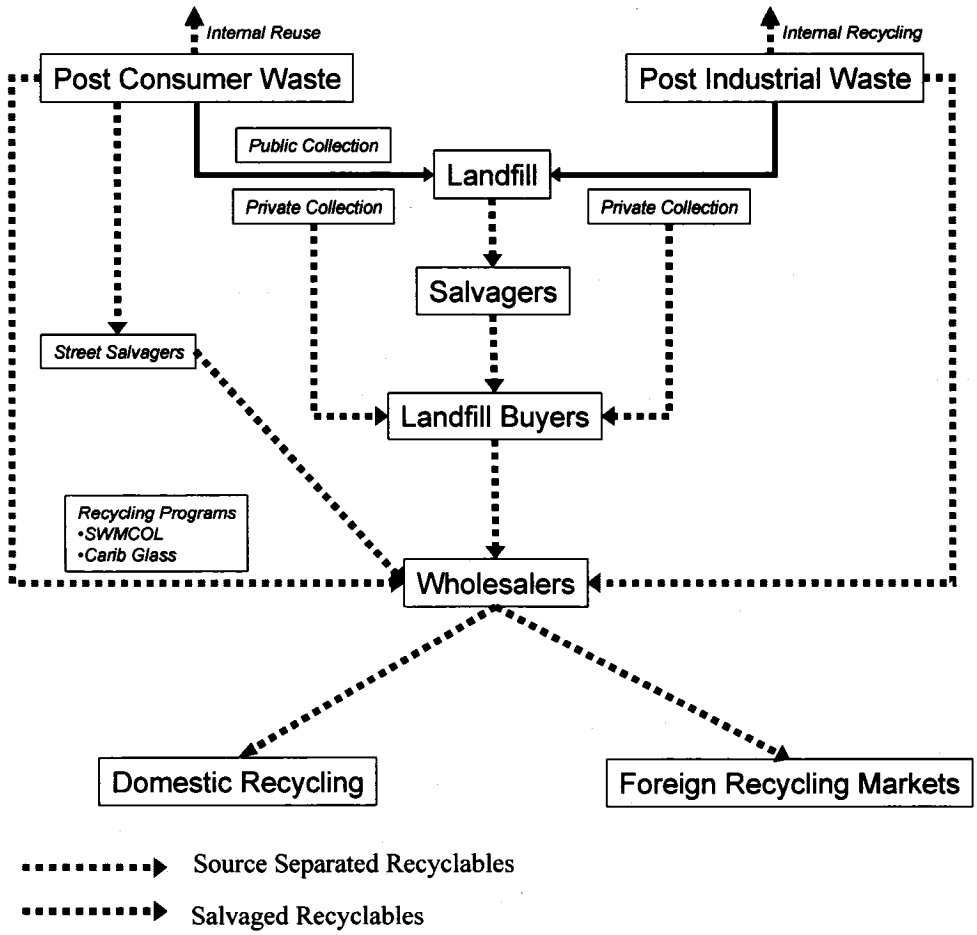


**Figure 4.2: Organization of the informal waste management sector**

## 4.2.1 Classification of the Informal Waste Management Entities

The entities which form the informal sector in Trinidad can be organized into three categories; these are salvagers, landfill buyers, and wholesalers. This section will define these classifications and describe their activities.

### 4.2.1.1 Salvagers

Salvaging activities form a significant basis for the operations of the informal sector in Trinidad. Salvagers recover recyclable materials from the general waste stream for sale on the informal market. The majority of salvaging activities occur at the nation's landfill sites, the focus here being the Beetham site. The Beetham landfill is the largest in T&T

accepting wastes from northwest section of the island (including POS, San Juan and Tunapuna). Section 4.1.3.3 displays the estimated recyclable content entering Beetham which fuel its salvaging activities. Salvaging generally begins in the tipping area where salvagers sort through the freshly deposited wastes and recover any recyclables they come upon. The major materials targeted include ferrous and non-ferrous metals, plastics, paper and board products, and glass. Smaller niche items include propane tanks and textiles. It is estimated that over 75 salvagers center their operations at the Beetham site.

Salvager operations are defined according to availability, accessibility, and the contents of the accessed wastes. Lucrative loads may arrive at any time but the salvager must be available to access their contents. Unavailability may include distance from the tipping area (e.g. selling to buyers), temporary inactivity (e.g. a break for lunch), or absence. The competitive nature of the salvager also affects recovery rates. Aggressive individuals will have increased accessibility. For example, a group of salvagers work from the entrance of the landfill such that they have first access to the arriving trucks. They board the trucks as they enter and access their wastes, increasing their probability of recovering valuable recyclables. The same concept applies at the tipping area. Physical traits may also contribute to accessibility. Larger individuals can carry greater amounts and may also utilize their stature to intimidate competitors. The final factor is the content of the wastes accessed. Different loads contain varying amounts of recyclables at differing qualities. For these reasons, individual recovery rates and earnings vary widely.

Salvaging activities also occur outside the landfill, although these are thought to account for a small percentage of the overall activity. Salvaging activities can be observed in the streets of Port of Spain where street salvagers sort through public garbage receptacles, litter located in parks and drains or anywhere else they might acquire valuable recyclables. Waste collection workers also salvage. These workers collect recyclables, primarily glass bottles and other loose and easily recovered materials, encountered during their collection duties and place them in bags hung off the back of the compaction trucks. Upon arrival at the landfill, these materials are sold to landfill buyers. The capital received provides a secondary source of income.

#### *4.2.1.1.1 Field Health Observation of Salvaging*

The health concerns for salvagers are numerous. Due to the entrepreneurial nature of their employment, these concerns are left for salvager consideration and often are not addressed. The lack of an external health and safety plan leaves salvagers exposed to the occupational hazards and health risks associated with their activities (see Section 2.1). The associated risks may be separated into environmental health and occupational safety risks. This section will provide an overview of the health risks observed for the salvagers at the Beetham site.

Hazardous waste exposure presents a serious health risk to salvagers at the Beetham site. Although there is specific consideration for these wastes within Trinidad, some do enter the general waste stream. One example is hospital wastes, for which a protocol outlining their on-site collection and incineration exists, yet syringes and other blood contaminated wastes appear in tipping areas (SWMCOL, 2000). Exposure to such wastes is highly unsanitary and could lead to serious negative health effects.

Additional environmental health risks stem from salvaging activities. The handling and processing of wastes, central to salvaging activities, presents many possible exposures. Failure to utilize gloves, often practiced by salvagers, combined with the lack of wash facilities, dictates that any exposure will not be mitigated. The exposure risks are enhanced by the long work hours of many salvagers. They consume disposed foodstuffs found in the wastes and cook meals over fires on site. Further exposures arise through common processing activities such as the burning of plastic wire coatings to access the copper core. This activity garners higher copper prices; however it also exposes the salvager to harmful dioxins (Goddard *pers. comm.*). Other possible exposures include the lead in batteries or the Freon in air conditioning units. Combined with this is exposure to the terrible local air quality, which is filled with particulates amongst other things. Although the specific health effects of these combined exposures have not been examined, it is clear that they cannot be positive.

The occupational safety risks on the Beetham site are also numerous and a lack of proper equipment and safety procedures amongst the salvagers increases the probability of injury. A typical salvager uniform includes a t-shirt, shorts and footwear (some wear work boots while others wear running shoes). This clothing does little to protect the salvager from sharp or blunt objects and often whatever protection that is offered is negated by the practice of working without a shirt. A lack of safety equipment increases the risk of injury in the tipping area where trucks and heavy equipment are constantly in motion. The activities of the salvagers indicate they have little concern for these occupational risks. They were observed jumping on and off trucks in motion, often independent of the driver's awareness or approval. Their movements about the tipping area do not respect those of the heavy equipment moving and compacting wastes or trucks positioning to dump wastes. In the past this has resulted in accidents where salvagers have been pinched between trucks, injured by their moving parts, or run over. One salvager reported that some who have been hurt were taken to hospital while others died and were left amongst the wastes. The salvagers are aware of the dangers though they appear to have little concern for them.

#### 4.2.1.2 Landfill Buyers

Landfill buyers are next in the informal hierarchy. These buyers act as the middlemen between salvagers and wholesalers. Their activities are based at the landfill where they purchase materials directly from the salvagers, providing the demand which fuels the landfill micro market. Purchased materials are stockpiled on-site until an appropriate volume, or load, is amassed. At this point the buyer will contact a wholesaler for a pickup. Buyers provide wholesalers with the volumes they desire preventing the need for wholesalers to access the salvagers on a micro level. Buyers may also complete some level of processing, such as sorting, to improve the product they sell to wholesalers. The monetary reward for their services is gained by including profit in the price given to wholesalers. Landfill buyers operate on this profit margin which although small on a per unit basis, grows worthwhile over the typical volumes exchanged between buyers and wholesalers.

The size and market share of the various buyers at the Beetham site varies. The low level buyers may utilise some employees, but generally work alone or with a partner. Employees might consist of salvagers associated with that buyer, supplying him/her with secondary materials, or providing labour through the transportation or processing of materials. For example, a buyer may hire a salvager to sort coloured and clear glass bottles and package them in bags for sale to wholesalers. Medium level buyers differ from low level buyers in that they purchase in larger amounts and may also have a greater number of employees. High level buyers, of which there are two at the Beetham site, have the largest influence in terms of materials purchased and employees. Both have close business relationships with various wholesalers, complete the largest amount of processing and have access to the most lucrative recyclables. It is recognized that the high level buyers control certain markets; discussions with smaller buyers illuminated the territorial lines in the glass market. The choice not to enter the glass market may also have arisen through small level buyers doubting their ability to compete with larger buyers in the lucrative markets. Each of the buyers maintains an area near the current tipping site[14] where storage, sorting, and packaging of materials occurs. One of the high level buyers maintains a large area adjacent to the tipping site while the other has entered into a lease with SWMCOL for the use of a designated area. The site is fenced in and contains a covered area where the buyer's employees complete processing activities. The site also contains a shed and is serviced by utilities. Each of the major buyers employs 5-10 people.

### 4.2.1.3 Wholesalers

Wholesalers operate outside the landfill and provide the link to international markets. Carib Glassworks Limited (CGL) and Caribbean ISPAT are wholesalers who provide the domestic demand for glass and ferrous metals respectively. Wholesalers generally have warehouse space where purchased materials are stored and processed. In addition to landfill buyers, which in one case accounted for an estimated 40% of a wholesaler's total material input (Jagroob *pers. comm.*), materials are purchased from industrial and

[14] The tipping area may be moved due to weather conditions. For example, when rain causes the current area to become soggy and unstable incoming trucks will be directed to a drier section of the landfill (Garraway *pers. comm.*).

commercial clients. Wholesalers tend to specialize in one recovery sector. Glass and metal materials are common focal points but certain wholesalers are aware of the emerging paper and plastic sectors and are considering entering these markets. The wholesalers in Trinidad vary in size and can employ in the range of 20 people. These employees complete processing activities such as sorting, bailing, and loading operations. Much of the recovered product is then shipped off the island for sale on international markets.

### 4.2.3 Current Recycling Operations in Trinidad

Currently the end users of recovered recyclables in Trinidad are few in number. This dictates that the majority of the materials recovered by this sector are shipped to international markets. The major recovered materials are glass, plastics, paper and metals with glass and metals being the only two utilized on the island (Clark *pers. comm.*; Jagroob *pers. comm.*). The domestic demand for glass and metals makes these markets the most stable of all (McGaw *pers. comm.*; Pilgrim *pers. comm.*). The other markets must adjust to the ebb and flow of international recycling markets, and in the case of plastics, have collapsed because of unfavourable market conditions (Warren *pers. comm.*). This section will characterize the operations of the major recovery sectors which form the informal waste management sector in Trinidad.

#### 4.2.3.1 Glass

The glass recycling sector is the most established in Trinidad lead by Carib Glassworks Limited (CGL), the bottle production arm of the Carib Brewery and its larger group of companies. CGL began producing bottles for the brewery in the late 1950's and has since expanded its operations to include several beverage bottles (e.g. soft drink and liquor bottles) and glass containers for the food and pharmaceutical industries. The glass production process requires cullet (glass pieces) mixed typically with 40-50% raw silica. The cullet must be of the appropriate final production colour. The overwhelming majority of CGL's production is comprised of clear bottles while amber production is sometimes included; green bottle production is confined to special orders. The cullet quota may be filled with domestically recovered materials but in their absence cullet is

imported. Therefore to reduce production costs, CGL began a glass recycling program in 1982 which marked the introduction of domestic demand for secondary glass materials. CGL remains the largest purchaser of recovered glass but does have competition in the local bottled nut industry. These companies utilize recovered glass bottles to package their product of nuts and candies which are sold throughout T&T (McGaw *pers. comm.*).

CGL's recycling activities moves their operations towards a closed loop system. Intact brewery bottles are collected, cleaned, sanitized and refilled with product for resale. To enter the reuse loop recovered bottles must satisfy specific quality criteria, all others are passed to the glassworks for recycling. On average, the brewery bottles are reused ten times before entering the recycling loop (McGaw *pers. comm.*). A deposit is levied on all brewery products to encourage their return and systems are in place to facilitate their return. Recovered bottles are collected at bars, hotels and restaurants and exchanged for new shipments while local supermarkets honour the deposit on bottles returned by their customers. CGL also provides glass recovery bins in specific malls and public spaces to allow for the voluntary return of glass wastes (Ramlakhan *pers. comm.*). CGL maintains an education/lobby division which handles the promotion of glass recycling activities and will provide expertise and assistance towards the formation of recycling programs at schools, business, and other institutions (McGaw *pers. comm.*). CGL is a proponent of the beverage container deposit legislation as such a system is expected to enhance the glass recovery rate and move CGL's production closer to the desired closed loop (McGaw *pers. comm.*).

The other arm of the recovery operations centers on salvaged glass materials. The current configuration of this system developed out of the United Bottle Vendors Association (UBVA), which was formed between CGL, SWMCOL, and the salvagers at the Beetham site in the late 1980's. Discussions between the stakeholders determined the optimal configuration of the association and set its operations in motion. SWMCOL provided a site with the required infrastructure, consisting of a shed combined with a lighted covered area for processing and storage. SWMCOL also facilitated access to wastes known to carry high contents of glass. CGL provided business training for the salvagers and trucks

to transport the recovered materials to the glassworks. It is estimated that this arrangement increased the recovery rate to 20% from its previous value of 5%. Eventually the collective dissolved and the current configuration was formed (SWMCOL, 1998; Warren *pers. comm.*; Clark *pers. comm.*; Ramlakhan *pers. comm.*).

The current configuration of the salvaged glass recovery system centers on an agreement between private contractors and CGL. Vehicles are leased to participating contractors to allow for the purchase and transportation of recovered glass materials to the glassworks. Both the lease and fuel costs are covered by the contractors while CGL maintains and insures the vehicles. CGL indicates to the contractors their requirements in terms of glass (e.g. tonnages of clear, amber and green) and sets the purchase price. The contractors then buy glass based on this directive and set their prices to ensure an appropriate profit margin, which may in some cases include a transportation fee levied to salvagers. The incentive for the contractors is to collect as much glass as possible to increase their profits. The glass is sold on a per tonne basis to CGL whereas the glass is purchased per bag from the salvagers. The rate for a bag of glass at the Beetham landfill during the field research phase was TT$5/bag. The standard bag was a burlap bag recycled from the food industry (citrus fruits etc). The conversion factor is estimated at 40 bags for one tonne of glass. Utilising this conversion rate, combined with the TT$5/bag selling price, it follows that salvaged glass is purchased at approximately TT$200/tonne. CGL in turn purchases the material from their contractors for TT$350/tonne. This places the transfer price between the landfill buyers and the CGL contractors between TT$200-350/tonne. This price will be defined by both the contractors and landfill buyer's profit margins. Currently CGL is working with five contractors. Two are responsible for the Beetham site, one each for the Guanapo and Forres Park site, and another for collecting materials from all other sources (e.g. collection bins, commercial or institutional recycling programs) (Ramlakhan *pers. comm.*).

Glass is typically delivered in whole form (unbroken bottles) and it is assumed this is due to its efficiency. Carrying broken glass would be difficult and dangerous for salvagers. It is also beneficial to sort whole glass materials versus broken pieces. The glass is

classified by colour into groups of clear, amber and green materials. Clear glass materials carry the highest demand, due to the clear bottle production requirements, with amber and green following behind (CGL has not purchased green or amber materials for the past few years due to production requirements). Discussions with a glass factory in the Dominican Republic may lead to CGL supplying them with coloured glass. If this agreement comes to fruition, CGL will begin buying coloured glass and shipping an estimated 50 tonnes per month to the Dominican Republic. On average CGL requires 400-500 tonnes of clear cullet per month. When coloured glass is under production it is estimated 50-100 tonnes per month is utilized (Ramlakhan *pers. comm.*).

The only other domestic demand for secondary glass materials originates from the bottled nut industry. Here companies buy salvaged bottles, typically liquor bottles, which are sanitized and filled with nuts and candies (McGaw *pers. comm.*). This product is then made available in supermarkets and often through street vendors. As the bottles are for direct reuse, they must be in good condition and cannot contain chips or blemishes. The bottled nut industry pays premium for such bottles (Ramlakhan *pers. comm.*) and therefore forms a priority demand for salvagers. This is a concern for CGL as the lost cullet may necessitate the import of materials to meet production quotas (McGaw *pers. comm.*). There is also the concern that these bottles are not properly sanitized before reuse as these industries are small grassroots organizations which may not be subject to any sort of inspection process (McGaw *pers. comm.*; Ramlakhan *pers. comm.*).

### 4.2.3.2 Plastics

Discarded plastic bottles are a major problem in Trinidad. A walk down any major street will show gutters and drains filled with discarded bottles. Bottles are strewn in the streets and parks and can also be spotted in rivers, streams and on the beaches. The general public is frustrated by this litter problem and a common complaint is the government's lack of action towards it. Both SWMCOL and the EMA cooperate to publish anti-litter advertising and organize clean-up campaigns in attempts to educate the public and alleviate the problem (see Section 4.1.3.6) but currently it continues. The recovery of plastic materials began in 1993 with the introduction of SWMCOL's plastics recycling

programme (SWMCOL, 1998). The programme encouraged the salvaging of PET bottles from the Forres Park and Beetham landfill sites which were then compacted and shipped abroad for sale. The programme became financially unviable with the fall of market prices and was subsequently cancelled (SWMCOL, 1998). Other attempts by local business have also failed under similar circumstances (Warren *pers. comm.*).

Currently recovered plastics are not utilized domestically and are therefore shipped abroad for sale on international recycling markets (Clark *pers. comm.*; Manswell *pers. comm.*). Research revealed the plastic recovery sector consisted of two main entities in Trinidad, one focusing on post industrial wastes and the other on post consumer wastes. Recycling in Motion's (RIM) operations center on the collection and sale of post industrial plastic wastes (Manswell *pers. comm.*). Post industrial plastic wastes are purchased from industrial clients. These wastes may be collected in a source separated form from such clients providing RIM with high quality uncontaminated input. In contrast, post consumer wastes, especially those salvaged from the general waste stream, will often contain contamination and require cleaning, increasing costs and often making the effort unprofitable (Manswell *pers. comm.*). Recovered plastics may also be sold in contaminated form for a lower price, but for their operations RIM chose to stay with uncontaminated post-industrial wastes. It is estimated they shipped approximately 21 tonnes of recovered plastics in 2003 (Manswell *pers. comm.*).

PlasticCo forms the other entity in the plastic recovery sector. PlasticCo had just begun operations at the commencement of the data collection period and was focused on collecting post consumer salvaged wastes from the landfills (Clark *pers. comm.*). The demand for these wastes was introduced with the completion of a plastics recycling plant in Guadalupe which was designed with extensive cleaning facilities to allow for the mechanical processing of salvaged post consumer plastics. PlasticCo was formed by the plants investors and local Trinidad investors to provide the plant with input materials including both post consumer and post industrial wastes (Clark *pers. comm.*). With the demand provided by PlasticCo, plastic salvaging activities resumed at the Beetham landfill.

Initially a pessimistic attitude towards the salvaging of plastics was prevalent at the Beetham site. The salvagers were cautious of entering the sector due to its prior failures and many felt their time was better spent salvaging the traditional materials such as glass. Adding to this negative attitude was the additional processing requirements of separating recovered wastes into PET and High Density Polyethylene (HDPE) along with removing any caps (Salvager *pers. comm.*).

From this initial start, the evolution of the sector at the Beetham site was interesting. The PlasitcCo demand presented an entrepreneurial opportunity for salvagers who could place themselves in a position to satisfy it. This was an opportunity for salvagers to establish themselves as buyers and move up the informal hierarchy. One ambitious salvager took advantage of the opportunity and became a buyer of plastics. Initial salvaging operations consisted of him collecting and storing wastes in an open area adjacent to the tipping area. At this time he was unsure how to tackle the processing component, pondering the temporary employment of another salvager for these duties while he continued to salvage. A visit to the landfill in the later stages of July 2004, showed the progression of the sector. The major landfill buyer had entered the sector and begun purchasing plastics and competing with the original salvager. At this time PlasticCo was providing both parties with $20m^3$ bins to fill with salvaged plastics for transportation to the PlasticCo warehouse.

The market for plastics on the Beetham site is similar to the glass market in that pricing is based on a standard volume bag. Here the conversion factor is approximately 5.5kg (12lbs) of plastic per bag (Clark *pers. comm.*). In July 2004, the price for a bag of unprocessed plastics was TT$2 (Salvager *pers. comm.*). This price could be received from the major landfill buyer or PlasticCo themselves (if an appropriate volume was obtained). The major landfill buyer had taken to purchasing unprocessed bags of plastics from salvagers and completing the processing internally with employees (processing activities included removing any caps and classifying the materials into PET and HDPE). With processing, the materials were sold to PlasticCo for TT$3/bag (Salvager *pers. comm.*). The individual salvager had chosen to simply collect large volumes of plastics

and sell them directly to PlasticCo for TT$2/bag unprocessed. In May, PlasticCo began purchasing plastics at TT$4/bag but quickly adjusted the prices to TT$2/bag (Salvager *pers. comm.*). PlasticCo states the price was adjusted as its original level was not economical (Clark *pers. comm.*).

PlasticCo was averaging an estimated 2.5 tonnes/wk of plastic in late July 2004 (Clark *pers. comm.*). They hope to significantly increase this rate to justify the construction of a recycling facility in Trinidad (Clark *pers. comm.*). It is estimated that approximately 10,000 tonnes of plastics would have to be recovered each year to justify such a plant (Clark *pers. comm.*). This equates to approximately 210 tonnes per week, which would require over an 8000% increase in the weekly recovered tonnages. Estimates of the waste plastics available for recovery do provide for this to occur. It is estimated that 5200 tonnes of PET beverage bottles are produced yearly in Trinidad (Pilgrim *pers. comm.*) while waste characterization data estimates over 14,000 tonnes of Trinidad's waste stream is PET and HDPE wastes (SWMCOL, 2000) . It remains to be seen whether the plastics recovery rate can be increased to the required level.

### 4.2.3.3 Paper

The paper recycling sector is well developed in Trinidad. SWMCOL began to explore the recycling of paper in 1989 (SWMCOL, 1998). A domestic market for recycled paper does not exist in T&T as all paper materials are imported. Therefore exploratory investigations were required to develop relationships with end users abroad who were interested in T&T's recovered paper materials. Once arrangements were in place, the first shipment of recovered paper left T&T in 1993 (SWMCOL, 1998). The initial major export market was Venezuela, but numerous defaults on payment led SWMCOL to terminate their business arrangements with the country (SWMCOL, 1998). Alternative markets were identified although similar problems arose and consequently the program has gone through its ups and downs (Warren *pers. comm.*).

Currently Ace Recycling is the major paper wholesaler in Trinidad (Warren *pers. comm.*). This company was founded by a former SWMCOL employee who left to form a private

recycling company. Ace Recycling now purchases the entirety of materials recovered through SWMCOL's recycling program (Warren *pers. comm.*). In addition to the SWMCOL inputs, Ace also purchases source separated paper from commercial clients and salvaged material from landfills. They also offer a shredding service for the disposal of confidential documents. It is estimated that Ace Recycling ships approximately 450 tonnes of recycled paper to international markets per month (Clark *pers. comm.*).

Recovered paper materials are sold according to their various forms including cardboard, tissue, coloured paper, white print, and pure white paper. The pure white variety fetches the highest price while the value for newsprint is generally small (Clark *pers. comm.*). The paper recovered from commercial and industrial clients may come in separated or mixed form (Clark *pers. comm.*; Warren *pers. comm.*). Ace Recycling operates a warehouse space where the recovered paper is sorted and bailed for shipment. The company employs approximately 50 people, on shifts, to complete the processing activities (Clark *pers. comm.*). Due to the unstable nature of the international secondary paper market SWMCOL have ceased the practice of purchasing recovered paper from their clients. Instead SWMCOL offers only the free collection of these wastes, thus removing the burden of disposal from the institution (Warren *pers. comm.*).

The salvaged component of the paper market is relatively minor (Clark *pers. comm.*). At the Beetham site paper is only salvaged by small to medium level buyers as the profits do not entice the activity of the upper level buyers. Salvaged material is separated into its various grades by the buyers and some minor processing is completed, such as the removal of dividers or the bindings on magazines and books (Salvager *pers. comm.*). The processed materials are then sold to Ace Recycling, who will collect the materials once a suitable mass is accumulated. Some examples of the prices received for the various grades are contained below (Warren *pers. comm.*; Salvagers *pers. comm.*).

**Table 4.6: Price Estimates for Various Recovered Paper Grades**

| Material | Market Price ($US) | Salvaged Material Price at Beetham ($TT) |
|---|---|---|
| Cardboard | 40-65 | |
| Tissue | 150-200 | |
| Coloured Paper | 200-240 | 300 |
| White Print | 210-295 | 450 |
| White | 250-310 | |

During the field research phase Unicell Paper Mills Caribbean Limited (UPMCL) was in the process of completing the design for the construction of a tissue production plant in the Arima industrial area (the schedule at that time called for the plant to be online for March 2005). The plant is to produce tissue paper, bathroom tissue, kitchen towels, facial tissues, napkins/serviettes and industrial towels in various grades. The 35,000 tonne/yr plant is designed to be fully flexible to accept either virgin pulp or waste paper inputs. It is estimated that the plant will utilize 200-400 tonnes/month of high quality post consumer waste paper for its initial production process. The plant is capable of accepting up to 40% recycled content so this number may grow in the future. The plant's primary market will be the West Indies and its contiguous areas, although additional materials may be exported for sale through the existing markets of UPMCL's parent company, the Sharma Group (Medsing *pers. comm.*).

The UPMCL plant should boost paper recycling operations in Trinidad. With its ability to accept significant volumes of waste paper inputs the plant will provide a stable local market for recovered paper materials. Assuming the waste paper is purchased at market value, the profitability of the sector will immediately rise as the shipping costs will drop significantly. UPMCL has plans to invest in the local recovery sector to improve its yield and quality. Sharma companies have similarly done so with their other plants with success (Medsing *pers. comm.*). Like CGL, it is beneficial for UPMCL to utilize secondary materials in their production process, thus their interest in the local recovery operations.

### 4.2.3.4 Metals

The demand for recycled metals is driven by both the local and international markets. Locally the Caribbean ISPAT steel mill purchases and recycles scrap steel and ferrous materials (Jai-Paul *pers. comm.*). All non-ferrous metals are currently shipped out to international markets (Jagroob *pers. comm.*). Wholesalers will sell their materials where they can receive the highest profit, thus dictating the percentage of material sold to ISPAT versus international markets.

ISPAT purchases materials based on their grade. The grades assigned A, B, and C, dictate the purchase price which typically differs by approximately $50TT amongst grades. In June 2004, the purchase price for grade A steel scrap was approximately $700TT/tonne. ISPAT purchases on average 1200 tonnes/month of recovered materials. Their target is 2500 tonnes/month but this figure has not yet been met. The purchase price is somewhat negotiable between the seller and ISPAT, but is also tied to international markets. Those who wish to become vendors must register as such with ISPAT and transport any materials for sale to the plant, located in the Point Lisa's Industrial Complex. Here it is weighed, assessed and the purchase is completed. ISPAT requires that the metal is cut into 3x2ft rectangles and is free of oil and grease. Gas tanks and other contaminated materials are not accepted. Vendors will often bring their own weigh slips to compare to the weight measured at the plant. The scrap steel is melted down and billets are produced for sale (Jai-Paul *pers. comm.*).

Another major metal wholesaler is the Trinidad Recycling and Trading Company Limited (TRTCL). This wholesaler concentrates on recovered non-ferrous metals but does also purchase ferrous materials. It is estimated that approximately 40% of their business is supplied by salvaged metals, purchased mostly from the Beetham site (Jagroob *pers. comm.*). The major non-ferrous metals involved in the informal sector are copper and aluminium. Copper is often recovered from discarded wires which can be sold in clean or unclean condition (Salvagers *pers. comm.*). The clean condition requires exposing the copper interior by removing the outer coating, a process which usually involves burning

the insulation material away (Garraway *pers. comm.*). The wires may also be sold in an unclean condition for a lesser price. Wholesalers claim they discourage the act of burning wires though there is little evidence of this. Aluminium cans and "pure" aluminium are sold separately. "Pure" aluminium may include various scrap automobile parts or certain food containers (e.g. some canned meats) (Salvagers *pers. comm.*).

The recycling of metals is an established sector on the island. The recovery rate has been increasing over time as more discarded metals appear at the landfills (Jagroob *pers. comm.*). There is concern over the specific problem of derelict cars. ISPAT is selective about what material it will accept and they will not accept disposed vehicle chassis. This leaves the problem of their disposal (Scott *pers. comm.*). Discussions with the EPP suggested that this problem will be addressed in future waste management system plans (Hanooman *pers. comm.*).

### 4.2.4 Material Flows in the Informal Sector

This section will quantify the major secondary material flows of Trinidad's informal sector to add to the characterization of the informal sector and its operations. Data was required to assess both the materials recycled domestically and those sold on international markets. The import/export statistics, published yearly by the Central Statistics Office (Central Statistics Office [CSO], 2003b), provided an estimate for those materials recycled internationally while the domestically recovered materials were estimated from the data set gathered through the interviews completed. Both the international and domestic recovered material flows are addressed consecutively in sections 4.2.4.1 and 4.2.4.2. These recovered material estimates are then compared to the waste characterization derived available materials estimates to produce recovery rate estimates.

#### 4.2.4.1 Internationally Recycled Material Flows

Table 4.7 presents the mass flows of the various secondary materials exported from T&T in 2003 (CSO, 2003b). This data was compiled manually from the yearly export statistics published by the CSO. These numbers give an indication of the mass flows occurring in the informal solid waste management sector and specifically allow for an estimate of the

recovered mass of secondary materials which are recycled internationally. The utilization of this data assumes the materials are recovered within Trinidad and entirely exported for sale in international recycling markets. In other words the export statistics entirely represent those materials recycled internationally.

**Table 4.7: 2003 Exported Secondary Materials (CSO, 2003b)**

| Item | Total Exported Tonnes | Major Export Country |
|---|---|---|
| Unsorted Paper | 6150 | El Salvador |
| Waste Alloy Steel | 2610 | India |
| Unbleached Kraft Paper | 2380 | Italy |
| Aluminium | 1820 | U.S.A |
| Plastics | 840 | Israel |
| Copper | 170 | U.S.A |
| Paper and Paperboard | 150 | Pakistan |
| Textiles | 20 | Barbados |
| Lead Waste and Scrap | 10 | U.S.A |

Only paper and plastic materials are entirely exported for recycling in Trinidad. Recovered metals may be recycled domestically with ISPAT or exported to international markets while recovered glass materials are recycled domestically. These mass flows therefore do not appear in the export statistic data set. Table 4.7 shows that waste paper (including the unsorted paper, unbleached kraft paper and paper and paperboard categories) formed the largest exported secondary material in 2003 with over 8600 tonnes exported. Paper materials are recycled aggressively through Ace Recycling and SWMCOL's paper recycling programs (see section 4.2.3.3). The paper recycling effort can be compared to that of the glass recovery sector in its sophistication and activity, thus its appearance as the largest of the exported materials is not unexpected.

Ferrous and non ferrous metals form the second largest export material. Like waste paper, these materials are also aggressively collected by metal wholesalers, such as ISPAT and TRTCL, along with a variety of smaller scrap metal dealers. This sector differs from the paper recovery sector in that its ferrous materials carry a domestic demand and may be sold domestically to ISPAT or on international recycling markets. The chosen avenue for sale is most likely dictated by the profit margin which may be obtained. If greater value comes to the seller through international markets, then it is

expected that those with access to these markets would sell there (these are the materials represented in Table 4.7). Non-ferrous materials are not recycled domestically therefore it can be assumed that the mass displayed in Table 4.7 quantifies the materials recovered in 2003.

The domestic demand for recovered ferrous materials is provided by ISPAT. The attempt to quantify ISPAT's share of the ferrous metal mass flow created some confusion. Ferrous secondary materials purchased by ISPAT are melted down in their facilities to produce ingots[15] and billets[16]. These materials may be utilized internally or sold externally, either within Trinidad or abroad. This is where the confusion arises as the data was not available to disseminate the mass flows exiting ISPAT. For example, focusing on billets sold to international clients, it is unclear whether the mass of recovered steel appears in the export statistics as a secondary material or as a primary product. These kinds of uncertainties are translated to the recovered ferrous metal estimates.

Plastics comprise the smallest portion of the exported secondary materials. The plastic recovery sector is not as developed as others. It has collapsed during past operations and has only recently restarted operations (see section 4.2.3.2 for background); this is the explanation for its low export standing. The masses presented in Table 4.7 are assumed to represent only those post-industrial plastics exported by Recycling in Motion in 2003, as PlasticCo was not operating at this time.

### 4.2.4.2 Domestically Recycled Material Flows

This section presents mass flow data obtained through the informal sector interviews. Visual assessment and observation at the Beetham site also produced some engineering estimates which were combined with the obtained informal estimates, along with engineering judgement, to compile Table 4.8 below. This table presents the average monthly mass flow estimates of an individual unit of the various informal entities. These

[15] A mass of metal melted and recast, typically into the form of a bar or block.
[16] A mass of metal melted and recast as a sheet.

estimates will be compared to the statistics in Table 4.7, where applicable, to examine their correlation. The discussion will be organized into the major recyclables as above.

**Table 4.8: Estimated Informal Sector Mass Flows**

| Informal Entity | Material Type | Mass Flow Tonnes/Month | Material Source |
|---|---|---|---|
| Landfill Buyer (Small) | Ferrous Metal | 1-3 | Salvagers |
| | Paper | 5-12 | Salvagers |
| | | | |
| Landfill Buyer (Mid) | Paper | 5-12 | Salvagers |
| | Plastics | 6-8 | Salvagers |
| | Ferrous Metal | 2-5 | Salvagers |
| | Copper | 2-5 | Salvagers |
| | Glass | 11-15 | Salvagers |
| | | | |
| Landfill Buyer (Large) | Ferrous Metal | 4-10 | Salvagers |
| | Aluminium Pure | 3-5 | Salvagers |
| | Aluminium Cans | 3-5 | Salvagers |
| | Copper | 2-4 | Salvagers |
| | Glass | 20-24 | Salvagers |
| | Plastic | 4-8 | Salvagers |
| | | | |
| Wholesalers | Paper | 20 | Landfill Buyers |
| | | 60 | SWMCOL |
| | | 360 | Commercial Clients |
| | Plastics | 2 | Post Industrial |
| | | 8-12 | Post Consumer |
| | | | |
| Domestic Recycler | ISPAT | 1200 | Wholesalers |
| | CGL | 400-500 | Landfill Buyers |
| | | 500 | Regional Collection |

The data is presented as a generalization of the typical monthly operation of the various entities involved in the informal sector. With the landfill buyers this generalization is not so easily applied. The classification applied here is broad in nature as in reality the salvager operations at the Beetham site are not necessarily so structured. Day to day activities are dynamic in nature and salvagers and buyers alike will adjust appropriately; buying and salvaging paper one day but maybe quickly changing focus to ferrous materials for a significant period of time after that (Salvagers *pers. comm.*). Thus the characterizations of the landfill buyers (presented in Table 4.8) do give an indication of the Beetham landfill operations, but should not be taken as routine. During the research

phase two large buyers existed with 5-10 medium level buyers and approximately 4-8 low level buyers.

Table 4.8 provides the only mass flow estimate for recovered glass materials as they are recycled domestically and therefore do not appear in the export statistics. This sector should represent the largest of the informally recovered materials in Trinidad as it is the most developed (see section 4.2.3.1 for background). Glass was the original focus of informal sector due to the domestic demand provided by CGL. It remains the main focus of the salvagers as the demand is stable. This was demonstrated during the research period when the Carib companies' encountered a labour strike. Production was ceased in both the brewery and the glassworks, removing the major demand for recovered glass materials. The labour dispute lasted for approximately 2.5 months yet the salvaging and buying of glass continued at the Beetham landfill; although there was an expected slowing of activity. The continued activity with the removal of demand points to the stability of the glass recovery market; the salvagers and landfill buyers were confident that demand would return when the labour strike ended thus they continued operations (Salvagers *pers. comm.*). It is also noted that the secondary demand for high quality recovered glass bottles for the bottled nut industry remained intact during the labour strike, providing another reason for the continued activity of the sector (Salvagers *pers. comm.*).

Table 4.8 lists a monthly input value of 400-500 tonnes of clear glass material (Ramlakhan *pers. comm.*). As clear glass products are the major output of the glassworks, a clear glass demand always exists while the plant is in operation. Green and amber products are produced less frequently thus demand generally exists only when products requiring these colours are under production; although CGL will store a collection of these materials for future operations. During coloured production runs, it is estimated approximately 50-100 tonnes of amber and green materials are required per month (Ramlakhan *pers. comm.*). Both of these estimates apply only to materials purchased from landfill buyers. A further 500 tonnes is estimated to originate from CGL's regional recycling operations (see section 4.2.3.1). As CGL represents the major

domestic demand for secondary glass materials, these numbers are assumed to represent the majority of the mass flow for glass materials. A secondary demand does exist in the bottled nut industry but no quantification of this mass flow was obtained.

Though an overall figure is not available, it is expected that the waste glass mass flows are the largest of the informal sector. If it is assumed 450 tonnes is collected on average from the salvagers, combined with an estimated 500 tonnes from regional recycling activities, this gives an estimated mass flow of 950 tonnes of recovered glass on a monthly basis. This would equate to over 11,000 tonnes over a year (if production continued throughout the year). This is much larger than 8600 tonnes of waste paper materials exported in 2003, noting that this estimate does not include the mass flows of the bottled nut industry. Coloured glass mass flows are also not considered here as they are not constant. This may change in the future if CGL enters their discussed agreement with an outside glass factory (see section 4.2.3.1). Such an agreement would create a regular demand for recovered coloured glass materials.

The examination of the mass flows for metal materials is somewhat ambiguous. This is demonstrated through a comparison of the values contained in Tables 4.7 and 4.8. The 1,200 tonne monthly input estimate obtained from ISPAT (Jai-Paul *pers. comm.*) equates to a 14,400 tonne yearly value. This is much larger than the listed 2,600 tonnes (Table 4.7) of waste steel exported in 2003. This discrepancy is likely related to the uncertainties related to the metal mass flows discussed in Section 4.2.4.1. As recovered metals carry both a domestic and international demand, their mass flows may transfer through multiple routes and it is unclear how these materials would then appear in the export statistics. Thus the assumption is made that the export material values represent the ferrous metal component from those wholesalers choosing to sell their materials on the international market. The estimates from Table 4.8 then represent the domestically recovered mass flows; those transferred to ISPAT. The total recovered tonnage would then include both the 14,440 tonne (Table 4.8) and 2600 tonne (Table 4.7) values. This gives a final recovered ferrous metal tonnage estimate of 17,000 tonnes.

The plastic mass flows originate from either post-industrial or post-consumer sources (see section 4.2.3.2 for background). Recycling in Motion estimated they shipped twelve 40ft containers of post-industrial plastics in 2003 (Manswell *pers. comm.*), or approximately 20 tonnes. This value is much below that which is listed in Table 4.7. It was assumed that the 840 tonne value in Table 4.7 was due to Recycling in Motions operations, but this assumption is obviously flawed. It seems that other entities must also be engaging in the recycling of post-industrial wastes. The unaccounted export tonnage could emanate from source separated wastes collected internally in production processes and shipped abroad. This will require further examination.

The collection of post-consumer wastes restarted in May 2004 by PlasticCo. By the end of the research period, PlasticCo's operations continued to focus on post-consumer plastic wastes salvaged at the Beetham landfill. Discussions with the two principal plastic buyers on site yielded monthly recovery estimates in the range of 4-8 tonnes (Salvagers *pers. comm.*). This gives a total of 8-12 tonnes per month of post consumer plastics transferred to PlasticCo from the Beetham site. PlasicCo aims to increase their recovery rate through post-industrial sources and increased capture of post-consumer wastes in schools, private organizations and public spaces (Clark *pers. comm.*).

An examination of the paper mass flows also illuminates some discrepancies. The combined monthly mass flow estimate obtained from Ace Recycling amounts to 440 tonnes per month (360 Commercial, 60 SWMCOL, 20 salvagers) (Clark *pers. comm.*). The average monthly estimate utilizing the export data statistics amounts to 720 tonnes. This estimate is more 60% higher than Ace Recycling's estimate and could point to errors in that estimate. In this case it seems appropriate to utilize the export values as an estimate of the recovered mass of paper. Recovered paper materials are entirely exported thus the export statistics become a reliable source here and it can be assumed that they accurately capture the mass of these exported materials.

Table 4.8 also gives an indication of the mass flows which pass through the various buyers on the Beetham site. A survey of these flows show the major difference between

the different level landfill buyers is the type and amount of materials collected. Mid level buyers may compete with high level buyers in regards to metal materials while also concentrating on alternate materials such as paper and plastics. The high level buyers collect significantly larger masses of glass then all other levels. This alludes to the discussed importance of glass materials to the salvagers. In the landfill micro market glass materials do form the most important sector while at the upper wholesaler levels it appears metals (ferrous and non-ferrous) form the largest recovered value (and estimated 17,000 tonnes compared to the 11,000 tonnes estimated for glass materials). These are the results of this analysis although known errors do exist as discussed with each materials individual section.

### 4.2.4.3 Estimated Recovery Rates

This section will formulate and present estimates for the recovery rates for the major recyclables in Trinidad. Here the utilization rate is not considered separately from the recovery rate as the two are closely tied in Trinidad. Due to the market basis of the informal sector, materials are recovered to satisfy an existing demand. In other words, inherent in the recovery operation is an expected utilization of the material; thus the utilization rate is not important. The focus is instead on the recovery rates of the various recyclables to provide an indication of the efficiency of the recovery operations. This will prove important for any future planning or design exercises (Chapter 5). The recovery rate can be defined as the percentage of material recovered from an available pool of the material; specific to waste management it is the amount of material diverted from the disposal stream. Thus the disposal stream must be characterized and compared to the material recovery amounts to allow for the calculation of recovery rates.

To disseminate the waste disposal stream, the waste characterization data of section 4.1.3.3 (Table 4.2) is available. This forms the only estimate, in most cases, for the pool of available materials for recovery. This data source specifically estimates the amount of material entering the Beetham Landfill. Ideally, the available material estimate would contain the mass of all wastes produced, material specific, nationally. This would include, for example, wastes produced and recycled internally in industrial processes and

would produce a complete estimate of the material specific wastes produced. Unfortunately, such a characterization was beyond the scope of this project and thus was not collected. The available material basis is then provided by the estimate of the recyclables entering the Beetham landfill (presented in Table 4.2). This data can be upgraded to better represent a national estimate by considering the national waste characterization data presented in Appendix B. This data allows for an estimate of the recyclables available in Trinidad's residential waste stream. This is the most representative estimate available but it is noted that the estimates of the recyclables available in the commercial and industrial waste streams are not included.

The estimated material recovery values are then obtained from consideration of the domestic and international recyclable material flows. Recovered plastic and paper material are entirely recycled internationally thus their recovery estimates are derived from the international material flows. As discussed in section 4.2.4.2 the paper export statistics form the best source for the recovered paper estimate. The value given in Table 4.9 below considers the combined unsorted paper, unbleached kraft paper and paper and paperboard tonnages given in the export statistics. The recovered plastic material estimate combines the 840 tonne export value with an additional estimated 120 tonne contribution from PlasticCo's operations. For the recovered metal estimate, both the international and domestic material flows must be considered. As discussed in section 4.2.4.2, it is assumed that the reported export values represent those ferrous and non-ferrous metals which wholesalers sold on international markets. To complete the metal recovery estimate there needs to be consideration of the domestic recycled materials at ISPAT. This contribution is given in Table 4.8 and is combined with the international ferrous and non-ferrous material flows to give the recovered material value displayed in Table 4.9. Finally glass is recycled domestically; therefore it recovered material estimate was established from Table 4.8 with an estimated 450 tonne monthly contribution from the salvagers and 500 tonnes/month from the regional collection system. This amounts to the 11400 tonnes displayed in Table 4.9.

**Table 4.9: Estimated Recovery Rates**

| Material | Available Material (tonnes) | Recovered Material (tonnes) | Recovery Rate |
|---|---|---|---|
| Paper | 35400 | 8700 | 25% |
| Glass | 14100 | 11400 | 81% |
| Metals | 17700 | 19000 | 107% |
| Plastics | 31800 | 1000 | 3% |
| **Total** | **99000** | **40100** | **41%** |

The resulting recovery rates give some interesting results and raise some questions of error. Immediately visible is the 107% recovery rate attributed to metals. This result is theoretically impossible as one cannot recover a higher amount of materials than is available, and points to error in the calculation. The discussion now turns to the accuracy of these results, beginning with those errors which are common to each result. Each result is then addressed individually.

As the available material estimates were derived from the national waste characterization data, two main sources are common to each result. The initial error source stems from the scope of the characterization data. The characterization estimates the composition of the waste streams entering the islands landfills and by nature neglects certain recoverable material streams. Take for example a participant company in SWMCOL's paper recycling program. The company internally collects waste paper for pickup by SWMCOL. These source separated materials appear in the recovered material estimates but are omitted from the available material estimate as they never enter the landfill, and thus never become part of the characterization. This introduces error into the recovery rate calculation. The second source of error stems from the inability to assess the industrial and commercial components of the national waste stream. The study provided only the industrial and commercial mass components for the entire waste stream. This does not allow for the addition of the paper and cardboard components in the commercial waste stream to be added to the available material estimate. This could amount to 7-10% error in some cases[17]. It should also be noted that the recovered material estimates must also contain an error component, but it is suspected that this is smaller than that described for the available material estimate.

[17] For example, the combined commercial and industrial waste paper and cardboard streams accounted for 10%, by weight, of the total Beetham landfill waste stream (SWMCOL, 1995).

The 107% metal recovery rate result confirms error in this term; this result is not theoretically possible. With the errors inherent in the available material estimate, it seems probable that the cause of this result is an underestimated available material value. There may also be error in the recovered material estimate (this uncertainty was examined in both sections 4.2.4.2 and 4.2.4.3). It also seems clear that the underestimation is due to source separation activities in this sector. Although the investigation of the various smaller level scrap metal dealers was not undertaken during the research phase, their existence was noted and points to source separation occurring. This could lead to the error in the result as discussed above and is should be accounted for in any future work.

The glass recovery rate is most likely overestimated due to an underestimated available material term. The existence of CGL's recovery program dictates that many of the recovered materials are not accounted for in the characterization data, thus the available material term is incomplete. In this case the 500 tonne/month material input from CGL's regional collection system (included in the recovered material estimate) is unaccounted for in the characterization data and thus the available material estimate. This contributes 43% error to the estimate assuming no other errors exist and its removal reduces the recovery rate to 38%. This value is likely closer to the actual recovery value but it is expected that the recovered material estimate should increase with the consideration of the glass reuse which occurs in the bottled nut industry (this is not considered here). It is logical that the glass recovery rate is the highest of the four as it is the most developed recycling sector.

With the missing industrial and commercial components, the paper and plastic recovery rates must also be underestimated. Referring to the Beetham characterization data, approximately 10% of the total waste stream were paper and cardboard materials located in the industrial and commercial waste streams (for plastics this value was approximately 1%). There is also significant source separated material in both sectors. For example, the source separated paper wastes collected in SWMCOL's and ACE Recycling's paper recycling programs. PET plastic bottles also frequently become litter. Those which are

collected and transferred to the landfill will become part of the characterization data but others may not be considered (e.g. if they remain as litter). As the plastic recovery sector is still in its infancy, it is expected to carry a small recovery rate. A 25% recovery rate for paper materials is also not unreasonable but with a deeper investigation it would be expected that these values would increase.

In conclusion, the estimated recovery rates may contain significant error. This is due to the utilization of waste characterization data as the available material estimator. A much better estimator of this value would be a combination of the production and import values of the various materials. This would present the inputs into the marketplace which could be compared against the recovered material values to produce accurate recovery rates. This exercise carries stringent data requirements which were beyond the scope of this project thus the limitation to the waste characterization data and the flawed recovery rate estimations. The estimated rates are still useful at a broad planning level and as such will be utilized in Chapter 5.

# Chapter 5: Formation of a Sustainable Waste Management System in Trinidad

The characterizations of both the formal and informal waste management sectors displayed both their strengths and weaknesses. This chapter will examine the introduction of a sustainable waste management system which will utilize both these sectors to create an efficient system which considers the social, environmental and economic spheres. The discussion will call upon the theoretical basis for such a sustainable system, presented in Chapter 2, along with the characterization data presented in the previous chapter.

The discussion begins with a suggested procedure for the development of a sustainable system. This is a five step iterative process which will allow for the proper information gathering, conceptualization, design and operationalization of the sustainable system. Next the sustainable system is broken down into its various parts, including waste management policy/legislation, collection, disposal and recovery/diversion, to explore their details. The related discussion for each area will first examine its theoretical purpose in the larger sustainable system and then contrast this against its existing characteristics, illuminating the required changes for its transformation; these are then addressed specifically with recommendations towards their implementation. Not all recommendations are direct as in many cases additional research must be completed before the ideal course of action can be decided. Where this is true the discussion will instead examine the steps that should be taken to reach such a conclusion. In its entirety, the chapter will present a vision of a sustainable waste management system in Trinidad. The chapter will conclude with some suggested additional research which will continue and complement that which is presented here.

## *5.1 Suggested Structure for the Development of the Sustainable System*

This section will present a suggested structure for the development of a sustainable system. The activities which comprise the development process are presented below:

1. Data Collection
2. Participatory Actions
3. System Design/Decision Making
4. Contractual Decisions and Construction
5. Operationalization

The following discussion will examine each operation, including its purpose and expected outcomes. The overall structure is iterative in nature to allow for revisions, where necessary, to create an ideal sustainable waste management system.

### 5.1.1 Data Collection

The purpose of the data collection phase is to acquire a detailed knowledge of the waste management situation which the sustainable system will service. As a first step, a complete list of required information is defined to allow data collection activities to begin. As the operation progresses, additional data requirements will become apparent and absorbed into the collection list. The variables of interest may be classified into the categories of waste characteristics and system characteristics. Table 5.1 below lists some important data requirements for each category.

**Table 5.1: Important Data Points for Sustainable System Design**

| Waste Characteristics | System Characteristics |
|---|---|
| • Expected mass of waste stream<br>• Various components which comprise the waste stream<br>• Chemical and physical properties of each component<br>• Socio-Demographic characteristics of waste generators | • Policy/Legislation basis<br>• Knowledge of potential system actors & agencies including their abilities and expertise<br>• Current waste management technologies<br>• Cost estimation: for both development and operation of the system |

The waste characteristics will provide for the engineering design of the various system elements to be utilized and are traditionally collected through waste characterizations (see Section 4.1.3.3). In addition to the traditional waste characterization methodologies, socio-demographic data may also be tied to the characterization data (see section 4.1.3.4) to provide a more complete understanding of the wastes which the system will service.

Data pertaining to the system characteristics is equally important. The applicable waste management policy/legislation provides the basis for the waste management system thus

an understanding of its intricacies is essential. Research activities may also include a review of the policy/legislation framework of other similar systems. Similarly the potential entities (e.g. government organizations, private waste contractors, salvagers etc.) which are to form the new system must also be understood to allow for their proper placement within the new system. Cost information and knowledge of the current waste management technologies available for utilization are also required for planning and design purposes.

### 5.1.2 Participatory Actions

Participatory actions allow for the incorporation of stakeholder input into the development process. The waste management needs of the stakeholders define those of the sustainable system and allow for its design, thus stakeholder involvement is required during the project's initial design stages. It may be utilized later in the design process to refine and improve ideas. The appropriate amount of stakeholder involvement will be defined by the project needs, willingness of the stakeholders to participate and any legislation that dictates its inclusion.

Initial stakeholder contact should result in the definition of their individual requirements and desires for the sustainable system. These will provide the basis for the design of the system and can be combined with the background data to formulate possible system configurations. Also important here is the adoption of a waste hierarchy which will guide the selection of waste system elements. This may be assisted through stakeholder input. Gathering and recording stakeholder input into a useful package is no easy task and significant literature exists which explores the specifics of the exercise.

Stakeholder involvement may also form a useful tool during the design stage. Expert committees may provide input towards the development of system configuration scenarios or assist in the refinement of those under development. The choice as to the level of stakeholder involvement during the design phase is crucial as it may benefit design activities but may also result in unnecessary delays. Often the inclusion of stakeholder input is legislated but its inclusion outside of that mandated should also be

considered. Where included, its expected outcome should be clearly defined along with its boundaries to allow for a beneficial partnership rather than one which hinders the process.

Stakeholder involvement is essential during the final decision stage. Stakeholder approval insures that the chosen system design satisfies the needs for which it has been designed. If none of the developed scenarios allow for this approval, then further refinement must occur before the final decision can be made. Although it will be impossible to fully satisfy each stakeholder, it is important to attempt to incorporate as many of their requirements/desires as possible. This will result in the most applicable system.

### 5.1.3 System Design/Decision Making

The goals of system design/decision making activities are to assimilate the data obtained in first two stages to formulate the final design of the sustainable system. A useful strategy is to develop multiple system configurations amongst which the optimal system can be chosen. This removes the need to discover the optimal solution during design and instead allows for the problem to be tackled from different angles. The final decision stage can become difficult and again there is a vast literature relating to decision making procedures. These methods may or may not be useful.

There are considerations to be made towards the organization of the design phase. For example, is the design to be completed in house by the municipality or contracted out to a consultant; there may also be cause for completing only certain design aspects externally. Stakeholder input may also be utilized to allow for further input towards the development and refinement of system configurations (see Section 5.1.2). Stakeholder input is crucial during the initial and final stages of the design process to insure that the chosen system will facilitate their waste management needs; if it fails to do so it will be of little use. The level of stakeholder involvement in the actual design process may be extensive or tempered as deemed fit.

Once a collection of possible system configurations has been completed, the process moves to the final decision phase. As discussed above, methods exist which aim to facilitate the decision process and may be utilized if deemed appropriate by the municipality. As the design process is iterative by nature, it is most likely this stage will be repeated multiple times. The final system choice will be that which satisfies the majority of stakeholder needs in the economic, social and environmental spheres

### 5.1.4 Contractual Decisions and Construction

With the design completed, construction can begin. This will likely involve the procurement of experienced contractors to complete construction activities. The included system elements may be significantly varied (e.g. incineration, anaerobic digestion, material recovery facilities) and thus may require the procurement of multiple construction firms, experienced in the required areas. In any case, a budget should be applied and the various options examined.

The utilization of a consultant for construction management purposes is useful. They will act as an intermediate between the municipality and the contractors to ensure optimal value for the municipality. The consultant can also provide an independent body for the tendering process. There are many possible contract configurations which may be utilized between the municipality and its contractors. For example, a design build type contract may be entered with a consultant/contractor. Another option is an agreement between a private firm and the municipality which calls for that firm to construct and operate the system. The return for the firm could be in the form of a flat fee, guaranteed business or even a stake in the operation revenues. An example is a private firm who agrees to construct and operate an anaerobic digestion facility in return for a guarantee that a minimum of 20,000 tonnes of wastes per year will be delivered for processing at $20/tonne. The different options available for the completion of the construction phase results in some complexity. However the goal remains to construct the chosen system design to the highest quality and an optimal value.

### 5.1.5 Operationalization

The operationalization phase aims to implement the system in the most efficient manner. This may include selectively phasing in elements according to financial and/or strategic considerations. Pilot studies may be utilized to determine important aspects of the phase. Such studies can shed light on unknowns such as public reactions, system performance and implementation and operation costs. In this case of waste management systems, implementation is extremely important towards public perception and thus participation. If public participation is required as part of the systems operations, operationalization should be carefully considered.

The iterative approach may be taken to operationalization to allow for discovery of the optimal method. Pilot programs are useful towards this end. For example, a pilot community composting project will give insights towards both the positive and negative aspects of its operations. This would aid the implementation of the final system as the problems encountered during the pilot phase can be accounted for. Pilot programs will also allow for a further understanding of the expected public response. It may be discovered that a negative public reaction resulted in insufficient participation, shifting the optimal choice to another strategy. An iterative philosophy allows for the identification of flaws which can be subsequently removed from future iterations. This is recommended for areas where uncertainty is high.

Education programs should form an important component of the implementation plan. Education will help to raise the environmental awareness of the population and thus should improve participation rates where required. Education programs will also better allow for the public to understand the workings of the sustainable system such that they can efficiently contribute to its operation.

## *5.2 Recommendations*

This section will examine the transformation of the existing T&T waste management system into a sustainable system.

### 5.2.1 Solid Waste Management Policy

The solid waste management policy defines the goals and operations of the waste management system. T&T's current waste management policy will require refinements to allow for the operation of the sustainable system but a strong basis is provided through the NEP. This document was created to allow for the sustainable use and conservation of T&T's environment for both current and future generations and provides some beneficial policies which can be built upon to create a stronger sustainable waste management policy basis. This section will begin by defining the goals of the sustainable system and then examine the policy options which will allow for its transformation; beginning with those already in place.

#### 5.2.1.1 Policy Goals of the Sustainable System

To define the policy base of the sustainable waste management system its goal must be defined. With reference to the NEP, the goal of T&T's sustainable waste management system can be defined as, "To process Trinidad and Tobago's wastes in a sustainable manner to provide for public health, environmental preservation and resource conservation". From this basis, the policy objectives can classified according to a simplified waste life cycle; namely production, consumption, and waste management processing. It is important to create sustainability at each level to the greatest extent possible.

At the production level products are manufactured for consumption. The manufacturing process assimilates material inputs to create final products and their related production wastes. A truly sustainable system is one which assimilates these wastes and their products, when they are no longer useful, back into the production cycle. This is the model to which production processes should aspire in the transformed system, and as such should be encouraged through the policy framework. Products and processes which create minimal wastes, of low environmental impact, while also reusing/recycling whatever possible are preferred. This policy direction is proactive in nature should encourage the development of clean production processes and technologies, including the substitution of environmentally neutral substances for their toxic counterparts. A policy

of product stewardship will further close the production loop placing the final burden of their products upon the manufacturers themselves. Here recovery and diversion become attractive as disposal costs are reduced.

The consumption of products produces further wastes, including packaging. Upon consumption, the packaging has fulfilled its original purpose and becomes waste, unless another purpose is defined. Certain policies applied at the production level become applicable at the consumption level. An example is a policy of minimal waste product design. This is applied at the production level but its benefits are seen at the consumption level. Those wastes which are produced upon consumption may be targeted to reduce their final disposal requirements. Policies of reuse, recycling, and consumption reduction will facilitate this. Finally, wastes may be organized at the consumption level (e.g. source separation into plastics, metals, glass etc.) to allow for increased efficiency when processed within the waste management system.

Wastes produced at both the production and consumption levels are processed by the waste management system. Here policy must define criteria to guide the processing operation. It is important that the Government clearly communicates the preferred waste management hierarchy (e.g composting of organics is preferred; combustion, with energy recovery, of paper and plastics is preferred to their recycling etc.). Such a hierarchy will guide the choice of waste system elements utilized in the sustainable system. Policy could also utilize consumers, be it residential, commercial or industrial entities, for source separation activities (this would then be legally introduced as legislation). It is also important to define the policy towards the informal sector at this level. If this sector is to become a part of the sustainable system it should be defined here along with a suggested organization. The policy of a sustainable system should encourage the efficient processing of wastes from an environmental, social and economic standpoint.

### 5.2.1.2 Sustainable Transformation from the Existing Policy Base

The policy transformation for the new sustainable system begins with an examination of the current policy basis and of how it can be incorporated into the new system. The

policies of the EM Act and the NEP which relate to solid waste management, broadly advocate:

- the polluter pays principle
- the prevention of the environmental harm of wastes
- the development of clean technologies
- the utilization of waste reduction and diversion strategies
- the abolishment of unsolicited dumping
- the utilization of economic incentives to encourage environmentally beneficial actions
- community building for environmental activities

Applicable to the production stage, T&T's existing waste management policies outline philosophies of waste reduction, clean production processes and technologies along with product stewardship, in the form of the polluter pays principle. Its mention in the NEP is broad in nature and does not offer specific direction, stating the polluter should bear the costs of prevention and mitigation of detrimental effects. This directs some responsibility towards the manufacturer but stronger still is the assignment of life cycle responsibility. The same can be said of the existing policy references towards waste reduction and clean technology development. The policy basis of the sustainable system should be stronger in language and more specific in its intentions, clearly encouraging and mandating sustainable activities at the production level.

The consumption stage is where waste reduction and diversion strategies become applicable, attempting to divert and reduce the waste stream requiring processing through the waste management system. Source separation may also be introduced here as a basis for reuse and recovery strategies. Applying source separation at the consumption level will provide significant returns when these wastes arrive for processing in the waste management system. An important component of the NEP's rhetoric is the discussion of community building to encourage environmental activity and awareness. This should form a key strategy for steering the current population towards participation in the sustainable system. A community which feels closer to its environment becomes aware of and protective of its existence. Community building also creates a collective mindset which can be encouraged towards sustainable actions, such as abolishing uncontrolled

dumping. The EM Act specifically directs the EMA to examine the use of economic incentives to encourage environmentally beneficial activities. This strategy could be employed at both the production and consumption levels. Economic incentives have been utilized throughout the world to positive environmental ends.

Ideally the policies applied at the production and consumption levels will reduce those wastes requiring processing by the sustainable waste management system; those wastes which remain may also be organized at the consumption level to aid in their processing. The policies applicable to the waste management system itself outline its design and operation. From a design perspective, it is clear that policies of waste reduction and recovery are essential to the establishment of a sustainable system. Although these are adopted in the NEP, the nature of their use within the system is vague. Within the sustainable system policy this should be clarified by providing specific directions, such as a waste hierarchy. Formally defining certain waste system elements and techniques as preferential will allow for a focused design and operation of the system. This could be as simple as adopting the commonly recognised waste hierarchy (see Chapter 2) or more specific criteria applicable to T&T may be developed. Within this criteria may be included the utilization of sanitary landfills for final disposal. Currently the NEP calls for disposal activities which are not harmful to human health or the environment. Sanitary landfills would significantly improve upon the current disposal system and could add to its sustainability with the recovery of landfill gasses etc. Finally, policy outlining the involvement of the informal sector within the sustainable systems must be developed. It is clear that such an inclusion can form an integral part of the new system, and if this is to be, it should be formally defined in the waste management policy.

Some additional policies which may also be beneficial are listed below.

- a commitment to participatory actions in waste management planning
- a commitment to local data gathering activities
- partnership with the private sector to build the import/export capabilities of the recycling sector
- Attraction of specific industries to develop Trinidad as a regional hub of recycling activities.

The strengths and weaknesses of participatory actions have been discussed (see Section 5.1.2). A commitment towards data collection would assist decision makers towards the design/planning, implementation and operation of waste management system. Currently there is a lack of such data in T&T. Quarterly waste characterizations would better outline the seasonal variation in disposal activities and socio-demographic waste characterization data will allow further insights into waste generation trends and general environmental population characteristics. Further recommendations related to waste management data collection will be discussed in Section 5.3.

Finally, there is an opportunity to grow the recycling operations in Trinidad. Its relative infancy in the Caribbean could allow for T&T to step up and aggressively court recycling industries into its economy. This could establish T&T as a regional leader in the sector, providing a steady demand for recovered materials and bolstering stability within the recovery operations of the waste management system. This type of activity could be provided through a private/public partnership.

This section provides only a brief overview of the various policy directions available to the sustainable system. These and other choices should be examined in greater detail to develop the appropriate policy base. In summary, waste production can be reduced and diverted at both the production and consumption levels while the remaining wastes are organized for processing in the waste management system. Policy related to the waste management system itself, must provide a sustainable framework for its operations which will allow for its dynamic growth according to its ever changing demands.

### 5.2.2 Solid Waste Management Legislation

The purpose of waste management legislation is to provide the legal basis for enforcing the established policy framework. Thus the legislation introduced for the reformed sustainable system will be dependent on its final policy formation. For this reason this section will not present specific recommendations, but rather explore various legislative instruments which may be useful towards encouraging the established policy basis. The transformation of the waste management legislation into that which will service the

sustainable system begins with a review of the existing legislation (this was completed in Section 4.1.2). From here the existing legislation can be modified to fit the needs of the sustainable system. The discussion begins with an overview of the suggestions which arose from this review to upgrade the current waste management legislation. From here possible legislative instruments that support the discussed policy directives are explored. The final section explores the existing organization of the formal sector and how it will translate into the sustainable system.

### 5.2.2.1 Required Legislative Upgrades

The review of T&T's current solid waste legislation (Section 4.1.2) illuminated certain aspects which could be immediately improved with some suggested upgrades. These upgrades are summarized below in Table 5.2.

**Table 5.2: Recommended Waste Management Legislative Upgrades**

| Recommended Upgrade | Reason for Upgrade/Suggested Actions |
|---|---|
| Update of the Public Health Regulations | • Rules were written 55 yrs ago<br>• Provide for the sanitation/public health basis of SWM<br>• The rules pertaining to SWM should be removed from this document and placed in compiled SWM document |
| Municipal Corporations Act | • Should dictate that local collection and disposal are delegated to MCs while regional disposal operations, such as the Beetham Landfill, are overseen by the MOLG<br>• These formal duty definitions of the MCs should be combined with the Public Health basis of SWM to allow for a clear view of the services owed the public<br>• Combine these aspects into the overall SWM document |
| Litter Act and The House Refuse Bylaws | • The contents of these regulations should also be combined into the larger SWM document |
| Create SWM legislation Document | • This document will provide for all the legislation pertaining to SWM to remove the confusion its current scattered nature<br>• Either introduced as its own document or as a chapter of an existing document |

The suggested upgrades are meant to update and improve the existing waste management legislation. The creation of a dedicated waste management document, combining all related legislations in one volume, would improve upon the current segregated nature and efficiently present the material. Any contradictions or overlaps between legislations can be identified and removed to ensure the unhindered communication of the government's

waste management vision. With these upgrades in place, the question of new legislation to support the newly formed policy can be tackled.

### 5.2.2.2 Possible Legislation to Support Established Policy Directives

This section will provide a brief overview of possible legislative instruments to support the various policy directives discussed at the production, consumption and waste management processing levels in Section 5.2.1. The final chosen legislation for the sustainable system will allow for the implementation of its established policy directives.

At the production level, legislation may be introduced to encourage the development of closed loop production processes. Product stewardship legislation would aggressively service this goal, placing the lifecycle responsibilities of products upon their producers. The legislation could be applied to specific products or implemented on a broader scale. A less aggressive strategy might restrict specific production inputs and outputs to encourage sustainable activities. For example, toxic chemical inputs may be heavily taxed or banned outright. Emissions may also be regulated with command and control type legislations. Each of these strategies will encourage the utilization of sustainable materials and processes, if correctly applied, although proactive strategies are preferred.

Packaging may also be targeted at the production level to encourage sustainable product design. Producers who are liable for their products will have a vested interest in their life cycle effects, and should therefore look to create product and packaging designs which create minimal wastes upon consumption. Legislation which restricts packaging wastes should have such an effect. Further, the inclusion of recycled content in packaging materials could be mandated; say 30% recycled content in plastic beverage containers for example. The creation of demand for secondary materials allows for their utilization once recovered and is crucial for the sustainable vision of the system.

At the consumption level, legislation should aim to foster demand for secondary products while enhancing environmental education and participation in the sustainable system. Introducing a bias towards sustainable products will provide for their demand and allow

for their environmental benefits to be realized. Such a bias may be created through many different strategies, such as taxing unwanted products or subsidizing preferred products. Legislation at this level should also work to increase the environmental education of the general public as well as encourage their participation in the sustainable system. These strategies are related in that an increase in environmental awareness should spur participation. Depending on the structure of the sustainable system, participation may be required through activities such as source separation. The greater the participation rate in a source separated recovery system, the higher the recovery rate will be. To enhance participation, economic incentives may be utilized to encourage specific activities. An example of this is the proposed Beverage Container Deposit Bill (see section 4.1.2.8). In fact the EM Act currently calls for the EMA to examine the use of economic incentives wherever possible to encourage environmental good. Further to this strategy is the creation of legislation which mandates such participation. Here it becomes illegal to abstain from recycling and source separation activities. Such legislation may be highly contentious and should be considered only after all other options have been expended.

Legislation towards the organization and operation of the waste management system is also required. In T&T, this basis exists in the current waste management legislation, assuming the recommended improvements are implemented. Additional specific improvements may also be applied such as the implementation of a certification program for externally contracted collection services (see Section 5.2.3 below). Additional improvements may also be applied to the current organizational structure to facilitate its improved operation as a sustainable system. These details are discussed below.

### 5.2.2.3 Formal Organization of Sustainable Waste Management System

The waste management legislation should also clearly define the intended formal sector organization. It is important in a sustainable system that each entity is clearly aware of their responsibilities and those of others so they may understand and maximize their contribution to the overall system. This section will examine the transformation of the current defined organizational structure into that which will suit the sustainable system.

The structure and operation of the sustainable system should be clearly defined in the waste management legislation. This will allow for a clear understanding of all entities as to their individual role in the greater sustainable system. The current legislation does not fulfill this role, leaving a somewhat unclear vision. For example, the Municipal Corporations Act allows for MCs to provide for collection and disposal but does not require them to do so. Who then is to insure that the essential services of collection and disposal are carried out? Further, in the area of disposal the current practice is for local operations, such as collection and local landfills, to be overseen by the applicable MC/RC. The MOLG then oversees the larger regional landfills. This system is efficient and may continue although its operation should be allowed for within the legislation. A well defined legislative structure will allow for the efficient operation of the sustainable system while also insuring that the waste management needs of the public are accounted for. This is important, for example, when formal responsibilities are contracted to private entities. A clear understanding of their responsibilities will allow formal entities to ensure these are covered in any private contracts.

The current bureaucratic organization also seems somewhat unclear. SWMCOL acts as an expert consultant to the MOPUE and the EMA, who carry the legislative power. The EMA is meant to oversee the environmental management system in T&T and allow for a greater understanding and improved treatment of the environment. By this definition one would assume the EMA should provide for the environmental education of the public. In practice the related waste management education is left to SWMCOL. This is not troublesome, as SWMCOL personnel are qualified for these activities, but ambiguity exists here in the form of bureaucratic confusion. It is implied that SWMCOL is equivalent to a crown corporation, separate from the bureaucracy, yet it is given bureaucratic roles. These roles, such as that of solid waste management education, blur the bureaucratic hierarchy. If SWMCOL is in fact a private consultant, then the EMA should carry the education portfolio and employ SWMCOL's expertise where needed. Such an arrangement would truly separate SWMCOL from the bureaucratic arm of waste management system. Otherwise SWMCOL should become part of the bureaucracy and be utilized accordingly.

There are positive theoretical aspects to the bureaucratic separation of SWMCOL. Such a structure creates separation between the operation and management arms. Those in charge of operation may contribute expert advice but do not make final decisions. Neutrality is then provided to those making the decisions, in this case the Minister of Public Utilities and the Environment, to decide what is best. Unfortunately reality erases this neutrality. Waste management funds are delegated from a common government pool where allocation decisions relate to the political realities of the time. Thus the final decision is not necessarily the best for the public from a waste management perspective. In the past this has been a problem in T&T. Lobbies from SWMCOL and other informal sector entities have been lost in frequent governmental changes. This may be tempered with the establishment of a dedicated waste management arm in the MOPUE. Such an organization would include expert waste management personnel who are familiar with T&T's waste management situation. These individuals would then report directly to the Minister, allowing the uncorrupted communication of expert opinions. This should improve the visibility of waste management such that it receives proper funding and planning through policy and legislative considerations. With this, the EMA would be free to concentrate on its broader mandate and provide input when required. SWMCOL would remain central to the operation of the sustainable system and continue to lobby and provide expert opinion but would remain separated from the bureaucracy. Such an arrangement should prove reliable and efficient for the sustainable system.

### 5.2.3 Collection

The purpose of the collection system is to introduce wastes into the waste management system. T&T's current collection system is satisfactory but improvements can be introduced to strengthen it. This section will examine and evaluate possible improvements to the collection system for its utilization in the sustainable system.

T&T's current waste management collection system has proven to be capable and robust. The majority of the collection services are completed by private contractors who have invested significant capital in their operations and equipment. These contractors have

proven their ability to adjust to and overcome problems that may arise (see section 4.1.3.1). Weaknesses can be found in the requirements applied to waste management contractors. Currently contracts are awarded through the consideration of the collection equipment to be utilized, its condition and the overall proposed costs of the contract operations. This leaves significant control in the hands of the contractors which has lead to some operational and safety concerns.

If it is the intention of the government to utilize the private sector for collection services, there must be a mechanism in place to insure that this essential service will be fulfilled. The current practice of inspecting vehicles at the commencement of collection contracts, combined with some inspection of collection operations is not sufficient. The inspection/selection process should be proactive in nature, requiring that contractors prove their ability to meet the terms of the contract in an appropriate manner. This can be done through formal accreditation. Here the MCs can define the requirements which must be met in order for a private waste contractor to qualify for waste management contracts. If the criteria are properly defined and met, the MC can be sufficiently sure that the contractor will be able to supply the essential service.

Accreditation will also allow the government some level of control over contracted entities in the area of health and safety. Field observations suggested that health and safety practices are lacking amongst collection workers. Employees of private collection firms should be afforded proper safety equipment and education in work safety practices. Municipal corporations can exert this control through safety requirements built into the accreditation process. There may also be cause for examining some minimal remuneration requirements for collection workers, although this would influence the contractor's financial competition ability. This is most probably justified though if it provides for the safety and well being of collection workers. It has been reported that compensation levels are erratic amongst contractors with average compensation hovering between TT$56-$86 per shift with gloves and boots provided, while some contractors pay less than TT$40 per shift and provide no safety equipment (SWMCOL, 2000).

### 5.2.4 Disposal

The purpose of the disposal system is long term containment of wastes which have no further use. This is the final step of any waste management system although it is considered in a sustainable system only once all other options have been exhausted. Within a sustainable framework, disposed wastes should not cause environmental damage. A sustainable system therefore utilizes sanitary landfilling techniques while hazardous materials are identified and processed separate to the general waste stream.

Currently within T&T neither a true sanitary landfill nor hazardous waste landfill exists. The sustainable system will require that both of these systems are introduced. Sanitary systems are important as their utilization will lower the risk of environmental harm due to disposal. The Beetham landfill currently exerts environmental harm on its local surroundings (the actual effects have yet to be quantified), which include a wetland and the Beetham Estates development (see Section 4.1.3.2), which cannot be tolerated in a sustainable system. It is also preferred that any landfills employ environmental control systems which increase the sustainability of the disposal operation. An example is that of a bioreactor landfill design which aims to maximize the landfill gas production for capture and utilization. Captured leachate is reintroduced into the landfill providing the moisture and nutrients required for optimal bacterial degradation. Captured landfill gases are typically utilized as fuel for electricity production or other processes. Bioreactor landfills biologically stabilize their wastes (lowering the probability of environmental damage) while capturing their remaining energy (a sustainable practice).

The special consideration of hazardous wastes is also essential for the sustainable system. The added environmental toxicity of these wastes dictates that they cannot be processed as part of the general waste stream and the expanding industrial sector in Trinidad makes their consideration of utmost importance. A hazardous waste system will identify and process the appropriate wastes accordingly, operating separate and parallel to the general waste management system. This topic is beyond the scope of this research but has been addressed elsewhere (SWMCOL, 2000).

The design of the sustainable system will define the organization and configuration of the final disposal component. One configuration proposed previously utilized a central landfill serviced by an island wide transfer station system (SWMCOL, 1999). Alternatively, smaller regional landfills may be utilized. The optimal configuration is that which optimizes the sustainable system as a whole and as such the contribution of the collection and recovery/diversion systems will require consideration in the design of the disposal system. The design and operation of the recovery/diversion system is discussed below.

### 5.2.5 Recovery/Diversion

The purpose of the recovery/diversion system is to reduce the need for final disposal through the reuse and recycling of wastes. The system is at the heart of the sustainable philosophy and will require significant consideration here. Trinidad's current informal recycling sector is both extensive and impressive, recycling over ten thousand tonnes of material each year and will form the basis for the recovery/diversion sector within the sustainable system, with the appropriate transformations. To begin a comprehensive review of the existing informal sector is required (see Section 4.2). With this complete, the philosophy of the recovery/diversion can be established and it structure and operations examined. A final system design will not be completed here. Rather an exploration of the philosophies and issues which should be addressed during the system design will be completed.

#### 5.2.5.1 Considerations for the Transformation into the Sustainable System

The recovery/diversion system will facilitate the reuse and recycling of a specific portion of the general waste stream; diverting these wastes from final disposal. In the context of the sustainable system, the goals of the recovery/diversion system focus purely on environmental good. This differs from the current economic basis of the informal sector which results in many of its inefficiencies. For example, salvagers compete for limited glass materials rather than joining forces and maximizing their recovery operations. This is because glass holds the greatest value and this is paramount to a salvager, not the

sustainable benefits of diversion. Salvaging activities would increase their benefit to the sustainable system if environmental considerations were included. For many salvagers though, profits will always remain their primary concern. Can a system be created which satisfies the economic concerns of the salvagers to allow for the incorporation of their expertise for the benefit of the sustainable system?

This little example shows the conflicting nature of economic and environmental philosophies in the waste management context. Any solution which considers too much of either extreme is not sustainable by nature, thus the ideal philosophy is one which finds some common ground. This is the premise of salvager cooperatives (see section 2.3.6) which focus on the greater good of the collective rather than the individual and allow for a common ground between environmental and economic considerations. The individuals in the collective are organized such that their efforts maximize the collective good with some collecting lucrative materials while others focus on the remaining materials. Such a philosophy can be applied to the formal recovery/diversion system.

The government will head the system, organizing the various entities to optimize the system according to the combined environmental/economic considerations. It is important that the environmentally beneficial activities are completed, such as maximizing the diversion of material from disposal, but economics must be tied to these activities as the funds for an environmentally ideal system are most likely unavailable. Some typical concerns which should be addressed are listed below.

- How will the recyclables be collected?
- What are the appropriate target materials?
- What are the appropriate waste system elements?
- How will the informal sector be incorporated?
- How will the general public be involved and will they participate?

### 5.2.5.2 Recycling Goals for the Sustainable System

One important consideration is the choice of recyclables upon which the system will focus. The major materials of the current informal system are glass, paper, ferrous/non-ferrous metals and plastics (see Section 4.2.3). These materials should remain the focus of the sustainable system with some additional specialized considerations such as derelict vehicles and tyres. The current economic foundation of the informal sector dictates that only those materials which carry a demand are recovered. In the context of the sustainable system it also follows that only those materials which can be utilized should be recovered, but here utilization may include recycling, incineration or composting. For example, a sustainable system may incinerate those materials which carry a high heating value, recovering their inherent energy, but lack demand as secondary materials. Conversely, organic materials may be composted to produce energy and useable compost. This section will explore the recycling goals for the sustainable system through comparison of the estimated values produced in Section 4.2.4.3 (paper – 25%, glass – 81%, metals – 107% and plastics 3%) to those appearing elsewhere in the world.

A comparison of the estimated recovery rates in Trinidad to those achieved in other parts of the world will define the recycling goals of the sustainable system. Germany places an emphasis on recycling as part of their waste management system and therefore forms a point of reference. The introduction of the German Packaging Ordinance in the early 90s obliged manufactures and distributors of transport, secondary and sales packaging wastes to ensure for their recycling. Products are licensed with Duales System Deutschland AG, who enables their recovery and recycling after primary utilization (Duales System Deutschland [DSD], 2005). Table 5.3 lists the recovered material quantities along with the German Packaging Ordinance recycling goals and the actual recycling rates achieved in 2004.

**Table 5.3: DSD 2004 Recycling Figures[18] (DSD, 2005)**

| | Collected Quantity (tonnes) | Target Recycling Rate (%) | Actual Recycling Rate (%) |
|---|---|---|---|
| Glass | 2,084,118 | 70 | 98 |
| Paper/cardboard | 949,439 | 75 | 111 |
| Plastics | 521,730 | 60 | 98 |
| Composites | 271,441 | 60 | 71 |
| Tinplate | 258,243 | 70 | 98 |
| Aluminium | 43,047 | 60 | 156 |

The city of Edmonton, Alberta also operates an ambitious waste management system. In 2003 a total of 40,135 tonnes (15% of total residential waste stream) of material were recycled while approximately 80,000 tonnes (28% of total residential waste stream) of compost were produced through the cities aerobic composting facility (City of Edmonton, 2005)

The DSD mass flows are very large when compared to Trinidad's; it is estimated that T&T's total 1999 waste mass flow was around 354,000 tonnes (see Appendix B SWMCOL, 2000). This shows that it is possible to process T&T's mass flows, but speaks nothing to the cost effectiveness of such an operation. Edmonton's mass flows are closer to those of T&T and are therefore more applicable for comparison purposes. Coincidentally, the total estimated recovered material mass in Section 4.2.4.3 is equal to that recovered in Edmonton in 2003 (40,100 tonnes). Due to the expected errors in the numbers produced in Section 4.2.4.3, this may not represent reality; although it is interesting to ponder that the current informal recycling sector could reach Edmonton's recovery levels. Further, if the organic mass flow diversion could reach the 80,000 tonnes composted annually in Edmonton (City of Edmonton, 2004), over 68% of T&T's estimated 116,700 tonne annual organic waste stream would no longer require disposal. Such results would equate to a total diversion level exceeding 33%.

Diversion levels topping 30% are very respectable. Toronto's residential waste diversion rate was 36% in 2004 for a city of 2.4 million people (City of Toronto, 2005). A diversion goal of 30% would therefore provide a suitable target for T&T. Such a result

[18] Note the recycling rate calculation is based on the total amount of material licensed with DSD for recovery compared to the actual amount recovered. This accounts for recycling rates greater than 100% as this simply means that non licensed materials were collected by DSD.

would require the diversion of over half of the organic waste stream. This is no small order, and any reduction in the mass of diverted organics would require an equivalent increase in the overall recycling rate. An important consideration for the sustainable system is the role of recycling and organic processing strategies within its framework. Should there be a greater focus on recycling strategies or will organic processing activities provide better sustainable results?

The formalization of recycling activities within the sustainable system will result in improvements to the recycling rates. With the system reorganized to increase efficiency, and improve recovery, the individual recycling rates should improve over those seen currently. What is unknown is the amount of improvement that will occur and whether it will be worthy of the effort required to achieve it. Of the four major recycling sectors, the paper and plastic sectors carry the smallest recycling rates at an estimated 25% and 3% respectively. Both sectors are underdeveloped and provide potential to increase the overall recycling rate. These materials are estimated at approximately 10% of the general waste stream and an increase to a 50% recycling rate would result in an additional 23,800 tonnes of material diverted annually. The paper recovery sector benefits from the established informal infrastructure provided by SWMCOL and Ace Recycling. The plastics sector is much less developed and only recently has PlasticCo begun collecting post consumer wastes. Both sectors access the residential population solely through those materials salvaged at the landfills. Materials disposed in residential areas provide a great potential recovery source for either material and should form an area of focus in the sustainable system. Recovery operations in the public and private institutions, along with schools and public spaces, should also increase. The proposed beverage container deposit system is relevant to the recovery of plastics. The utilization of monetary incentives may provide for the stakeholder participation required to increase recycling rates. Another strategy employs the utilization of itinerant buyers purchasing recyclables from individual households and businesses. This presents a demand for these materials which can be accessed through the source separation of recyclables. Combine with this increased environmental education which outline the benefits of such activities to the greater good

of the nation and participation should move towards the positive, increasing recycling rates.

The glass and metal recovery sectors carry higher estimated recovery rates (81% and 107% respectively[19]) than those seen in the plastic and paper sectors. This dictates that their growth potential for recovery is also smaller by comparison. Yet the established nature of these sectors may provide for greater recovery results per effort expended. Glass and metal materials are recovered domestically through CGL and ISPAT and their existing collection infrastructures access the industrial, commercial and residential sectors. Their formalization should allow greater access to materials and thus an increase in recovery rates. The residential sector provides increased recovery potential as the metallic cans and food containers currently salvaged at the landfill could be recovered at source with greater efficiency. Glass recovery could be extended to all glass materials, rather then just beverage containers, and would also increase in efficiency if recovered at source. Materials may also be gathered from the offices of public and private institutions along with schools and in public spaces. Although these activities are not expected to yield as large a relative growth, they may result in a larger effect on the overall diversion rate. It seems that it would be beneficial to concentrate first on paper and plastic material recovery. The existing informal collection systems for glass and metals may then continue and adjust with these new recovery systems accordingly; eventually becoming assimilated into the sustainable system.

An organic processing system should most definitely be included in the sustainable system. As is commonly seen, a significant portion of T&T's waste stream is compromised of organic materials (33%), and therefore their processing provides significant diversion potential. Organic processing can be simple in nature, in the form of simple windrows for aerobic composting, or of greater complexity, including energy recovery, in anaerobic processing systems. Organic materials also form a significant source for the environmental contaminants produced in landfills. The promise of energy recovery provides for additional benefits associated with the introduction of organic

[19] Section 4.2.4 discusses the accuracy of these results.

processing systems. Aerobic composting activities may take place at the community level where neighbourhoods operate compost piles or individual households compost on site. Anaerobic digestion of organics would require significant capital investment and specialized operations and therefore would only apply on a larger municipal scale. Community composting projects may encounter difficulties with participation as citizens may not be willing to engage in composting activities. The government can counter this with environmental education and incentives. The MCs might provide the required materials for those interested parties. Another strategy may include the formation of independent groups to operate community compost facilities such that citizens need only deposit their materials. In Trinidad such activities may be provided for by CEPEP crews, who produce organic wastes with their landscaping activities, or even salvagers. Community activities would cater to the residential population while those organics produced in the commercial/industrial sectors, public spaces and dense urban areas would most likely require municipal collection and processing at a designated site. The structure of the organic processing system could take many forms thus its final design should be that which best suits the overall sustainability of the system. Stakeholder input will be important here.

The recycling goals of the sustainable system essentially involve diverting the largest amount of material, in a sustainable manner, as is possible from the final disposal system. A diversion level of 30% can provide an initial target level but a truly sustainable system would continue to improve above this level. Processing of T&T's organics provide the single largest diversion potential and should garner significant design consideration as no current system exists from which to improve. Paper and plastic materials provide the greatest diversion potential amongst the major recyclables and thus should provide the basic focus for the recycling system. Glass and metal materials may then be incorporated into the system once it is established. The following sections will explore the design of the recycling system in general terms relating to its input, processing and output systems.

### 5.2.5.3 Input System

The input system design will significantly affect the efficiency of the recovery/diversion system. If materials cannot enter the system, they cannot be recycled. Quality is also an issue here as higher quality inputs will allow for higher quality outputs. The current informal system inputs materials mainly through corporate/industrial collection and salvager recovery operations. There is also some recovery of domestic recyclables through CGL's glass recovery system, but generally the direct access of the domestic sector for recyclable recovery is small. The closer to source that materials are captured, the higher their quality should be. This is because materials captured at source avoid contamination with the general waste stream. Collection at source will also improve the quantity of materials recovered as it is more efficient than recovering those recyclables intermingled with other wastes. Thus within the sustainable system, salvager operations will appear in a different form.

Quality and quantity issues can both be addressed by targeting the recovery of materials at source. The recovery sources may be classified as corporate/industrial/institutional, commercial/public and residential. Each source carries individual characteristics which will dictate the appropriate collection system combined with the required energy and economic inputs. Energy inputs include the physical effort which is required to collect, sort and move materials; also important is waste producer participation. Economic inputs include the cost of the infrastructure and labour required for operation. Each input is significant and dependent on stakeholder participation which may or may not be available. Where stakeholder participation is not available environmental education combined economic incentives or disincentives may help to encourage participation. Legislation may also be utilized to legally obligate stakeholders to such participation but enforcement here would be required and if significant, may render this strategy unattractive.

Corporate, industrial and institutional entities may be described as private organizations each with their own internal structure. To enable source recovery, an appropriate

collection system is devised for each entity. This system should cater to employees by conveniently allowing them to participate and complete the source separation activities. For example, receptacles could be provided to employees to place their waste paper materials in. These receptacles could then be collected and emptied by adjacent staff and pooled with other collected paper materials. This system could be mirrored with other recyclables or different approaches could be taken. To collect PET beverage and food containers it may be efficient to have only one receptacle placed in a central area, the lunchroom for example, where employees could deposit these materials. Similarly for industrial operations, systems may be implemented to collect and classify waste materials into separate streams. Here energy inputs will be required for the operation of any collection. Most likely one or more employees will be required to collect and transport the materials to a central location. Additional processing may also be required for example if the plastics are collected in bulk and then classified into their various resins after collection. Materials placed into inappropriate containers may also require removal and placement into the correct recyclable stream. Economic inputs will include the capital required to purchase or produce the various receptacles and other required equipment along with the labour requirements for system operation.

Commercial and public entities produce only post consumer wastes produced in public spaces such as malls, commercial areas and parks. Recovery in this sector is dependent on accessibility to both the waste producers and the collection system operators. Individuals in public spaces will most likely dispose of recyclables in the most convenient manner. Convenience will differ between individuals; one person might dispose their recyclables in the nearest receptacle while another might simply litter. Those who will search out a receptacle provide an opportunity to successfully capture that recyclable but the most efficient manner of doing so is something that must be examined. This will be done through the examination of a few different systems. One system might utilize individual receptacles for each recyclable stream, strategically placed throughout a public space. This should result in successful capture if the individual finds themselves near an appropriate receptacle when disposal occurs. Others may be willing to search out the appropriate receptacle or be aware of its existence again resulting in a successful capture.

Others still might find multiple receptacles confusing and simply dispose of their material in the closest receptacle (possibly causing contamination). Another system might improve on these results through the utilization of combination waste receptacles which have separate compartments for each stream (e.g. glass, plastics, organics, paper and general waste). These receptacles then are placed strategically among the public space such that those who are looking to dispose can access them. Once at the receptacle, the individual must place the material in the appropriate compartment to allow for a successful capture. Proper placement can be enhanced through the environmental education of the public and also through educational media on the receptacles themselves (e.g. different colours, descriptions and pictures portraying the appropriate wastes for each compartment). A final system might simply collect wastes as a common stream and physically recover recyclables after the fact. This system requires less from the user but greater energy requirements for operation. With this system recovered materials may also be of lower quality due to their commingling with other wastes. Each of these systems will require labour for the operation of the system. Capital will also be required to purchase or produce the system infrastructure and provide the labour with the appropriate tools for system operation (this may include a vehicle for the collection of materials or safety equipment such as masks and gloves).

Recyclables generated in the residential sector will appear as post consumer wastes. This sector is characterized by small volumes at a vast number of nodes. Domestic capture of post consumer recyclables is simple within a household. Recyclables are simply deposited in separate containers upon disposal. These containers may be supplied to the residents through the municipality. In such a system the municipality covers the economic inputs while the resident supplies the energy inputs. Multi-unit residential complexes require more complex systems such as those discussed for corporate, industrial and institutional entities. Here internal energy and economic inputs would be required for each system in each residential complex. Environmental education is of importance here to educate the public towards the proper utilization of the system and also to encourage the completion of the energy inputs required. As discussed in Section 4.1.3.4, there may be opposition towards participation in such systems in Trinidad.

Once the recyclables are collected and classified internally, they can enter the recovery/diversion system as inputs. This will require a collection system operated under the formal sustainable system. The structure and operation of the collection system is again something which could take many forms. One orientation might utilize salvagers as itinerant buyers. This would apply mostly to the commercial/public and residential sectors where salvagers could operate a specified collection route, purchasing recyclables from the various entities. This may be door to door in a residential area or perhaps a buyback centre where residential or commercial entities may sell their recyclables. Larger private collection contractors would be better equipped to collect the larger volume loads seen in relation to commercial, industrial and institutional entities. In a system where salvagers act as itinerant buyers, larger collection contractors may service the corporate/industrial/institutional sector exclusively. Another system orientation may utilize collection contractors in all three sectors bypassing the itinerant buyer strategy.

As a final topic the concern over the population's willingness to participate in any recovery/recycling operation is addressed. In T&T the environmental education of the public is relatively low and their actions point to a disposal culture. With this in mind it seems appropriate that incentives be included where possible. One area where these could be included is in the aforementioned collection system. Buyback centres or door to door purchasing of recyclables would provide monetary incentive for stakeholder participation in the corporate/industrial/institutional and commercial/public sectors. Further positives should emanate from the salvager contingent with such a structure as their skills would be utilized in manner which is not far removed from their former incarnation in the informal system. Here they would purchase materials already classified and could avoid all of the potential negative health effects garnered from their former operations in the landfills. This structure would also allow for the development of competitive markets where salvager cooperative type organizations, or even independent salvagers, could compete for collection contracts. Competition would encourage improvement within the system adding to its sustainable nature. Private collection contractors could then be utilized for larger volume corporate/industrial/institutional

sector. Here incentive is provided by the free waste collection of the recyclables. As commercial/industrial entities are responsible for their waste management, in areas such as POS, any diverted wastes will reduce these costs. This incentive could be further enhanced through tax reductions for participation or fees for disposal of eligible recyclables. The government may also choose to make participation mandatory. There should also be provision for the design and implementation of the interior recycling systems where desired. It only makes sense that similar programs to those currently provided by SWMCOL and CGL, for their glass recovery system, are continued. This allows for experienced professionals to assist in the design process to create a system which will benefit the greater sustainable system.

### 5.2.5.4 Processing of the Collected Recyclables

Once collected, the recyclables become available for processing. The amount and type of processing completed will depend on the input system design and the final quality requirements. For example, a specialized input system which delivers classified material streams will require little processing compared to one where input materials are delivered commingled and require significant processing. Processing activities may also include cleaning, removal of contaminants and packaging for shipment. This section will discuss possible processing configurations.

The degree of input classification utilized will depend on stakeholder participation and cost. High quality source separated materials cannot be provided by the input system without significant stakeholder participation. As this is a concern in T&T, the input strategy may move towards bulk collection of recyclables, which would then require classification. MRFs are commonly utilized for such activities. These facilities receive commingled wastes and separate them into designated streams while also removing contaminants and completing cleaning and packaging activities where required. Often one central MRF is utilized for a specific area. For T&T this decision will depend on the efficiency of utilizing one large central MRF vs. multiple smaller regional facilities. With this decision in place, the classification process utilized within the MRFs can be tackled. A key design consideration is the degree of mechanization to be utilized. A highly

mechanized system can be devised which will be capable of processing large amounts of recyclables with high precision. Typically the cost of such a system would be higher than that which utilizes human labour for processing operations. Human labour based systems will inherently contain human error. Thus they cannot match the precision of their mechanized counterparts. Many designs opt for a marriage of the two strategies employing mechanized systems for certain tasks while human labour completes others.

If the degree of input classification is already high, central processing requirements would be much smaller. Here the classified streams would still require contaminant removal along with cleaning and packaging but processing may be limited beyond this. It is most likely unreasonable to assume that such a highly classified input stream is possible. For example, operating an input system which could provide source separated plastics classified into their various resins (e.g. PET, HDPE etc.) would be very difficult. It is more likely that plastics will arrive commingled and require classification. The same situation would likely apply to paper, glass and metal materials, each requiring classification activities. Salvagers may be utilized here as classification activities are their expertise and the improved working conditions provided within the MRF will allow for the reduction of their occupational and environmental health risks.

### 5.2.5.5 Output System

The final stage of the recycling process is utilization. For utilization to occur a market must exist for the recovered materials. This is the goal of the output system which will provide for the utilization of the processed recyclables. To maintain sustainability the government must look at ways to create and provide stable demand for the recovered materials. This section will examine possible strategies towards this end.

The recovery operations in Trinidad have limited domestic opportunities for utilization. Only recovered glass and metal materials are currently utilized on the island. This requires that the majority of recovered materials are shipped abroad for sale, adding to costs and reducing profits. As the recovery sector is economically based, if profits drop below a certain level operations will become unviable and cease. This is unacceptable in

relation to the sustainable system as these materials will then require final disposal. It is therefore in the interest of the sustainable system to stabilize secondary materials markets such that recovery/diversion activities may continue indefinitely. In theory this can be done by subsidizing the cost of operations or through the creation of demand, in the form of domestic markets. Strategic subsidies may be implemented to lower operation costs and boost profits in times of market recession. It is preferred that the government take a passive role where allowed. For example, in positive economic times there is no need for subsidies while market recessions may require intervention. Subsidies may take many forms. A lower boundary on recyclable prices, such that the government subsidizes any transactions below this level, is a possible strategy. Tax cuts may also be utilized to increase profitability within the sector. Another possible strategy is the subsidization of shipping costs. These can form a significant operating cost and are volatile in nature. Their subsidization should help to stabilize the shipping market and afford less risk to waste management operations.

The government should also look to creating domestic demand for recycled materials. This strategy is desirable over subsidization strategies as it is proactive rather than reactive; create an environment which provides good market conditions rather than sustain floundering markets. Any strategy which will boost market activities can be considered here. Environmental education programs may be utilized to encourage the purchase of products containing recycled content. This creates demand at the consumer level and drives the entire sector. A certain level of recyclable content may also be required directly through legislation or simply encouraged by the government. Finally, rather then demanding or encouraging the utilization of secondary materials, the government could aim to attract new businesses which specialize in such activities.

As the recycling industry is relatively new in the Caribbean there is an opportunity to attract recycling businesses to Trinidad. For example, a plastics recycling facility on the island could create regional demand and attract materials from others areas of the Caribbean or abroad. This would create jobs on the island and increase its environmental visibility. Domestic demand would immediately strengthen the overall viability of any

recycling operation. The current UPMCL and Trinidad Cement Limited (TCL) proposals cater to this strategy. The UPMCL plant would provide a steady domestic demand for the paper recovery sector. The production process of the plant requires high quality recovered materials which may be above what the current informal sector provides. They have expressed interest in contributing to the development of the paper recovery though as it will strengthen their business (Medsing *pers. comm.*). This is beneficial to the sustainable system as it is potential private investment which lowers the costs to the public. The TCL proposal aims to utilize recovered PET bottles, tyres, and oily wastes as fuel in their cement kilns (Wei-Muddeen, 2004). This again would provide stable domestic demand but unlike UPMCL, TCL is not eager to invest any of their own funds. They would simply accept and utilize the wastes for their needs. The government should be cautious with such arrangements as although their utilization of recyclables is much appreciated, the arrangement should be mutually beneficial. In the case of the Unicell plant, it was learned that the UPMCL was appealing to the EMA to increase those applicable emission level regulations (Scott *pers. comm.*). This can be compared to TCLs refusal to actively engage in the infrastructure development of the system which will feed their kilns with fuel. Yes they are providing an end use for recovered material but at the same time that material is fuelling their cement operations. This justifies remuneration for this energy which will be utilized to fund the material recovery, processing and transportation operations which bring these materials to the TCL kilns.

The output system described here is very important to the overall diversion/recovery system. Recyclables which cannot be utilized are essentially wastes. This is why efforts to proactively provide for such utilization are justified and only after these fail should reactive measures to stabilize falling markets be utilized. The development of domestic demand for recyclables would be extremely helpful but the government should not let these corporations gain the upper hand. All agreements should provide mutually beneficial results as these will be the most sustainable in the end. Instability within the markets will only have negative effects on the sustainable system

## 5.3 Future Work Suggestions

This section will outline some suggestions for future work to build on this research. As the project was exploratory in nature, it provides a basis for continued work and the expansion of the conclusions presented here. Chapter 5 explores the considerations for the transformation of the existing waste management system, now these actions must be provided for and carried out.

Future work suggestions which may be implemented immediately are studies which will improve the data basis for future waste management planning. Firstly, a methodology should be developed for the regular collection of waste management statistics. Those which would have benefited this study include improved waste characterization data, survey type data which explores the environmental attitudes of the general population, along with those specific to waste management issues, and a deeper quantification of both the recovery and utilization rates. There is also a need for an expanded exploration of each of the main recovery sectors. The activities completed here only provide an initial examination which can be expanded upon. Finally those sectors which were not covered in this study require examination. These include the bottled nut industries, recovered textiles and used tyres.

Another common suggestion throughout the text is that of stakeholder involvement. The importance of this to the development of the sustainable system has been outlined and thus activities can begin almost immediately. Increased discussions with the salvager contingent should also be completed. For this exercise it would be beneficial to illicit the help of locals, or those having established relationships with salvagers, to examine further their operations; again expanding upon that presented here. Such a study might be completed over a longer time period to allow for the building of relationships within the community. This should lead to better results. Monthly data collection would also allow for comparisons and examination of the seasonal effects.

The final suggestion is more specific in nature as it outlines a recycling pilot study based out of the University of the West Indies, St. Augustine campus. Pilot studies will be important towards the development of the sustainable system as they will allow for a dissemination of the expected results of certain initiatives. A recycling pilot at UWI will be specifically useful as it will provide for an examination of recovery operations in the commercial, institutional and residential sectors. The institutional sector in this case is represented by the daily office activities of the university. The recycling system examined here would provide insight and data towards those systems which would be implemented in other offices throughout T&T. Recovery operations related to commercial settings may be examined in the various commercial zones on campus, such as the various food service areas. Here a receptacle system can be designed to maximize the capture of recyclables in these areas and put to use. The observations of its operations should provide key data and experience. The university also contains residential areas in the form of student housing. Here a collection system could be designed to maximize the capture of recyclables in a high density residential area and again the observations of its operation should provide key results. Along with these systems, a further collection and processing system will require implementation to gather and process the recovered materials. Such a project at UWI would include many of the considerations discussed in this report and allow for the implementation of the theory discussed. The data and experiences from such a project would be invaluable to the design of the greater sustainable system.

# Chapter 6: Conclusions

The differing environmental practices and philosophies, with respect to waste management, of the developed and developing world originate with their respective constraints. The underlying motivation, in either case, is the preservation of human health; while the sophistication is tied to the constraints. The economic resources of the developed world allow for an increased environmental awareness, which drives policy decisions to incorporate sustainable operations into waste management systems. Famine, poverty and disease threaten survival daily in developing areas, demanding governmental resources. The depleted funds allocated to waste management systems often are not sufficient to simply collect and dispose of generated wastes. Thus sophistication is not an option and rarely seen in the developing world. The lack of a formal recovery sector does not remove the industrial demand for secondary materials. This demand remains and often private entities move to satisfy it. This is the basis for informal waste management sectors.

Sustainable waste management systems aim to combat the rising costs of environmental mismanagement, incorporating the philosophy of "waste as a resource" into waste management practices. Informal sectors may be utilized to recover and divert wastes from final disposal while also providing benefits for those employed within the informal sector. Formalization can remove salvager exploitation, consider their health and safety and provide benefits for their families. Formalization also allows for increased efficiency and the removal of corruption, providing for the economic gain of the informal entities while shifting the greater focus of the sector to that of sustainability.

T&T's formal waste management system provides a modern and robust collection system with an environmentally damaging disposal system. Its applicable waste management policy and legislation is dated, redundant and unclear in places. Its structural organization also produces inefficiencies between the MOPUE, SWMCOL and the EMA. A lack of political visibility, due to lagging environmental awareness, has slowed the progression of the sector and will hinder future development unless improved. Positively,

the required waste management expertise and experience is available within the existing sector to provide for the sophistication of the system.

T&T's informal waste management system was responsible for the diversion of approximately 40,100 tonnes of material in 2003; an estimated 41% of that available for recovery. The major material focus centers on glass, metals, paper and plastics. The glass and metal markets are the most developed while paper and plastic recovery operations began in 1993. The plastic recovery sector has suffered setbacks in the past, but has recently revived with the formation of a new corporation aiming to collect both post consumer and post industrial wastes. The ever increasing efficiency, activity and sophistication of T&T's informal sector makes its formalization attractive as part of a sustainable waste management system.

The transformation of T&T's waste management system into that which incorporates sustainable principles will require a structured approach. The iterative process will include the collection of background and design data, participatory actions to define the system criteria, the design and choice of final system configuration along with the construction and operationalization of the system. The sustainable system will require a reworking of the existing waste management policy and legislation. The waste management policy should encourage sustainable practices at each level of the waste life cycle including the encouragement of closed loop production processes and the reduction of packaging materials at the production level. At the consumption level waste reuse, reduction and recycling can be encouraged along with source separation activities to reduce the processing requirements within the sustainable system itself. Finally at the waste processing level a waste hierarchy must be defined to guide the system design and operation. The applicable waste management legislation will then provide the legal basis to enforce the established policy base. Important here is the defined structure of the sustainable system. The existing ambiguities and inefficiencies may be removed to improve the sustainable system operations.

Currently the collection system provides a good level of service while the disposal system requires significant upgrades to exist within the sustainable system. The collection system could be improved with moves to strengthen government control over its operations. A formal accreditation system would allow the government to insure that the waste collection contractors are capable of completing their assignments. This is important as these contractors are entrusted with essential waste management services. The increased governmental presence provided by such an accreditation system will also allow for an improvement in the health and safety practices of the contractors. The government could simply encourage such activities or mandate their implementation. The disposal system requires the construction of a proper sanitary landfill for general wastes as well as an additional facility to handle those materials deemed hazardous. The utilization of environmental control systems within these facilities will only strengthen the sustainability of their operations.

The implementation of a recovery/diversion system is essential to the sustainable system, and the incorporation of the informal sector into these operations is required. The formalization of the informal sector will allow for increased efficiency in its operations with improved working conditions. For the informal sector to work within the sustainable system its current economic basis must be shifted towards that of sustainability. This is enabled in the sustainable system by providing for the economic remuneration of the informal workers, who are utilized within the system to complete sustainable activities. This kind of arrangement is seen with salvager collectives, which may form a role within the sustainable system, where individual members work for the greater good of the collective. What is positive for the collective is also positive for its members. Within the sustainable system, T&T's informal workers will operate in less hazardous conditions and be able to provide for their families while completing an essential role within its recovery/diversion operations.

It is important that T&T consider and provide for the sustainability of their specific ecosystem along with that of the greater planet. The island ecosystems of both Trinidad and Tobago provide for the lives of the countries citizens yet these same citizens do not

recognize the fragility and vulnerability of these ecosystems which provide for their existence. Continued environmental damage will lead to certain destruction, thus the sustainability of these ecosystems must be provided for. Sustainability is important to many first world nations and as T&T hopes to be viewed in this light, they should also make such considerations. A sustainable waste management system will provide environmental returns by reducing the impacts of the wastes produced. If we ever hope to survive long term, these impacts must be reduced and eventually abolished. We must move away from a disconnected relationship with nature and realize that it is what provides for our existence, and as such should be prominent in our consciousness and future plans.

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# Appendix A

**Table A1: Chronological order of Interviews**

| Name | Position |
|---|---|
| Vincent Cooper | Lecturer, Civil Engineering, UWI |
| Richard Warren | Operations Manager , SWMCOL |
| Glen Goddard | Manager, EMA |
| Anthony Manswell | Director, Recycling in Motion |
| Aldwyn Clark | Director, Ace Recycling Limited |
| David Pased | Ecologist, MOPUE |
| Deborah Thomas | Director, MOP |
| Winford David | City Clerk, POSCC |
| Introductory visit to Beetham | |
| André Garraway | Beetham Landfill Manager, SWMCOL |
| First Salvager Interviews | Beetham Landfill |
| Shari Juarwan | Information Officer, SWMCOL |
| Michael Veighwig | Health & Safety Officer, Beetham Landfill, SWMCOL |
| Mr Jai Paul | Caribbean ISPAT |
| Sharon Jagroob | T&T Recycling Company |
| Akash Hanooman | Environmental Engineering Specialist, MOPUE |
| Richard Warren (2nd meeting) | Operations Manager , SWMCOL |
| David McGaw | Board of Directors, Carib Glassworks Ltd;<br>Senior Lecturer, Chemical Engineering, UWI |
| Jameel Mohammed | Technology Officer, MOLG |
| Honourable Penelope Beckeles | Minister of Public Utilities and Environment |
| Angelus Pilgrim | Senior Lecturer, Chemical Engineering, UWI |
| Errol Ramlakhan | Senior Purchasing Officer, Carib Glassworks Limited |
| Mr Medsing | Project Engineer, Unicell Paper Mills Caribbean Limited |
| Alban Scott | Manager, SWMCOL |
| Second Salvager Interviews | Beetham Landfill |

# Draft Interview Questions

**Dump Scavengers**

***Livelihood Questions***

Do you process the materials you find before sale?
Do you work exclusively at the landfill site?
What are you typical daily working hours?
How many days a week do you work and what days?
Do you have any previous work experience?
Are you happy with your job?
Do you aspire to another position within the informal sector?
Do you travel far to the landfill?
Why work at the landfill vs the street?
How long have you worked as a landfill scavenger?
Have you ever worked in other areas of the informal sector and if so for how long?
Do you have contact with middleman?
Do you sell your wares exclusively to one middleman?

***Economic Questions***

What kind of materials do you collect?

What is the average weekly mass of the various materials you collect?
Do you have any other sources of income?
What prices do you sell the various materials for?

***Power Questions***

Do any middlemen have power over you?
Have you ever been threatened or pressured for power purposes?
Are you harassed by the police or landfill employees?
Do the landfill employees allow anyone to enter?
Do landfill employees require any sort of compensation or fee for entrance?
Are you aware of any collusion between the landfill employees and government officials?

***Health Questions***

Do you have any heath problems?
Are these problems chronic?
Do you have access to social/medical services?
Do you use any drugs for working purposes?
Do you use recreational drugs?

***Demographic Questions***

What is your age?
Are you married?
Do you have any children?
How many of your relatives are involved in the informal sector?
What are their relations to you?
What is your education level?
Can you read and write?
Are you a resident of Trinidad?
Do you pay taxes?
What kind of dwelling do you live in?
What is the condition of your home?

**Itinerant Buyer/Street Scavenger Questions**

***Livelihood Questions***

What kind of materials do you collect?
What is the average weekly mass of the various materials you collect?
Do you process materials before sale?
If so, what processing methods are utilized and on what materials?
Where is your traditional area of operation?
What are you typical daily working hours?
How many days a week do you work and what days?
Do you have any previous work experience?
Are you happy with your job?
Do you aspire to another position within the informal sector?
How far do you travel to your traditional area of operation?
Why work at the street vs the landfill?
How long have you worked as a landfill scavenger?
Have you ever worked in other areas of the informal sector and if so for how long?
Do you have contact with middleman?
Do you sell your wares exclusively to one middleman?
Is there a hierarchy of collection areas and are these contested among buyers?
Do you pay any fees for the right to your collection route?

***Economic Questions***

What prices do you sell the various materials for?
Do you have any other sources of income?

***Power Questions***

Do any middlemen have power over you?
Have you ever been threatened or pressured for power purposes?
Are you harassed by the police?
Are you aware of any collusion between the informal sector and government officials?

***Health Questions***

Do you have any health problems?
Are these problems chronic?
Do you have access to social/medical services?
Do you use any drugs for working purposes?
Do you use recreational drugs?

***Demographic Questions***

What is your age?
Are you married?
Do you have any children?
How many of your relatives are involved in the informal sector?
What are their relations to you?
What is your education level?
Can you read and write?
Are you a resident of Trinidad?
Do you pay taxes?
What kind of dwelling do you live in?
What is the condition of your home?

**Dealer Questions**

***Livelihood Questions***

How long have you worked in this position?
Do you have any previous work experience?
Do you have any other sources of income?
Have you ever worked as a scavenger?
What is your relationship to other middlemen or dealers?
Is there competition within the sector?
Do you work with specific dealers?
How many days a week do you work and what days?
What are you typical daily working hours?
Do you specialize in specific materials?
If so, why choose these materials?
Do you actively recruit scavengers and do you covet specific scavengers?
Where do you store your purchased materials?
Do you process the materials before sale?
If so, how and what materials?
Do you have paid personal which do any processing?
Where is your base of operations?
What mode of transport is utilized to transfer materials from the dump or the street?
Are you happy with your job?
Do you aspire to another position within the informal sector?
Do you ever deal with industry specifically?
Do you keep any records of your business activities?

Do you have access to business infrastructure (phone, fax, computer, internet)?
If so, how often do you utilize them?

***Economic Questions***

What weekly mass of materials do you collect?
What weekly mass of materials do you sell?
What are your various buying/selling prices?
Do these fluctuate often and by what margin?
What amount of seed money do you provide to a typical scavenger weekly?
How does this process of giving seed money work?
Do you provide seed money to scavengers?
If so, how many different scavengers?
To iterant buyers only or dump scavengers also?
What do you require to give seed money?
Are you selective about those you provide with seed money?

***Power Questions***

Do you utilize violence at all?
Do you provide those that work with you with gifts or incentives?
Have you ever been threatened or pressured for power purposes?
Are you harassed by the police or landfill employees?
Do the landfill employees allow anyone to enter?
Do landfill employees require any sort of compensation or fee for entrance?
Are you aware of any collusion between the landfill employees and government officials?
Do you have contact with government officials?
Do you provide them with any compensation to benefit your position?
Are you aware of any interaction between government officials and other middlemen or higher up?

***Health Questions***

Do you have any heath problems?
Are these problems chronic?
Do you have access to social/medical services?
Do you use any drugs for working purposes?
Do you use recreational drugs?

***Demographic Questions***

What is your age?
Are you married?
Do you have any children?
How many of your relatives are involved in the informal sector?
What are their relations to you?
What is your education level?
Can you read and write?
Are you a resident of Trinidad?
Do you pay taxes?
What kind of dwelling do you live in?
What is the condition of your home?
What is your social status?

**Wholesaler Questions**

***Management Questions***

***Livelihood Questions***

How long has your business existed?

Do you have any previous work experience?
Do you have any other sources of income?
Have you ever worked as a scavenger?
Do you actively recruit scavengers and do you covet specific scavenging traits?
Do you provide seed money to scavengers?
If so, how many different scavengers?
To iterant buyers only or dump scavengers also?
Are you selective about those you provide with seed money?
If so what traits are you selective of (e.g. personality, scavenging abilities, trustworthy)?
Do you have any stipulations for those that receive your seed money?
What is your relationship to other middlemen or dealers?
Is their competition between dealers?
Do you work with specific dealers?
What traits do you look for in dealers you work with?
Are the services of certain dealers sought after?
Do you provide dealers with loans?
Do you have any stipulations for those that receive loans?
Do you specialize in specific materials?
If so, why choose these materials?
Do you transport materials and what method of transport?
Where do you store your purchased materials?
Do you process the materials you buy before sale?
If so, what type of processing and for what materials?
Do you have paid personal which do any processing?
Where is your base of operations?
How many days a week do you work and what days?
What are you typical daily working hours?
Are you happy with your job?
Do you aspire to another position within the informal sector?
Do you keep any records of your business activities?
Do you have access to business infrastructure (phone, fax, computer, internet)?
If so, how often do you utilize this infrastructure?

***Economic Questions***

What weekly mass of materials do you collect?
What weekly mass of materials do you sell?
What are your various buying/selling prices?
Do these fluctuate often and by what margin?
How do you set your prices?

***Power Questions***

Do you utilize violence at all?
Do you provide those that work with you with gifts or incentives?
Have you ever been threatened or pressured by government officials or others in the informal sector?
Are you aware of any collusion between the landfill employees and government officials?
Do you have contact with government officials?
Do you provide them with any compensation to benefit your position?
Are you aware of any interaction between government officials and other wholesalers or dealers?

***Health Questions***

Do you have any heath problems?
Are these problems chronic?
Do you have access to social/medical services?

Do you use any drugs for working purposes?
Do you use recreational drugs?

***Demographic Questions***

What is your age?
Are you married?
Do you have any children?
How many of your relatives are involved in the informal sector?
What are their relations to you?
What is your education level?
Can you read and write?
Are you a resident of Trinidad?
Do you pay taxes?
What kind of dwelling do you live in?
What is the condition of your home?
What is your social status?

***Employee Questions***

***Livelihood Questions***

Do you have any previous work experience?
Do you have any other sources of income?
Have you ever worked as a scavenger?
Are you happy with your job?
Do you aspire to another position within the informal sector?
How many days a week do you work and what days?
What are you typical daily working hours?

***Health Questions***

Do you have any heath problems?
Are these problems chronic?
Do you have access to social/medical services?
Do you use any drugs for working purposes?
Do you use recreational drugs?

***Demographic Questions***

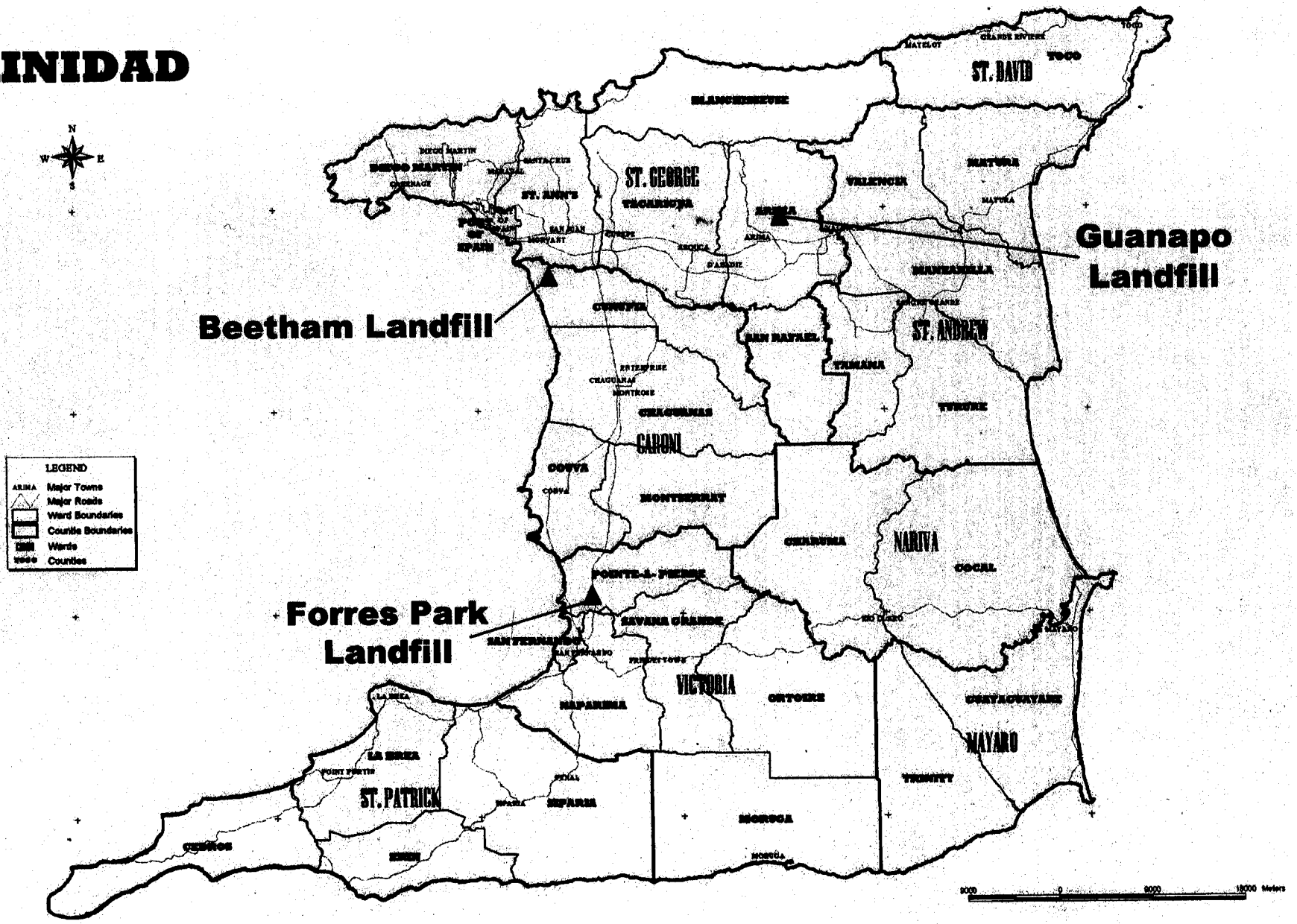
What is your age?
Are you married?
Do you have any children?
How many of your relatives are involved in the informal sector?
What are their relations to you?
What is your education level?
Can you read and write?
Are you a resident of Trinidad?
Do you pay taxes?
What kind of dwelling do you live in?
What is the condition of your home?
What is your social status?

# Appendix B

**Table B1: Waste Characterization Data in Tonnes/Day (SWMCOL, 2000)**

| Waste Type | Beetham | | | Forres Park | | | Guanapo | | | Total 1995 | | | Estimated Total 1999 | | | Estimated % 1999 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Household** | **221** | | | **163** | | | **84** | | | **469** | | | **483** | | | **50%** | | |
| **Plastics** | | 44 | | | 21 | | | 17 | | | 82 | | | 84 | | | 9% | |
| HDPE | | | 13 | | | 4 | | | 5 | | | 22 | | | 23 | | | 2% |
| PET | | | 8 | | | 7 | | | 4 | | | 19 | | | 19 | | | 2% |
| Film | | | 15 | | | | | | 4 | | | 19 | | | 20 | | | 2% |
| Other | | | 8 | | | 10 | | | 4 | | | 22 | | | 22 | | | 2% |
| **Paper** | | 44 | | | 30 | | | 18 | | | 91 | | | 94 | | | 10% | |
| Kraft | | | 14 | | | 10 | | | 6 | | | 37 | | | 38 | | | 4% |
| Hard White | | | 2 | | | 3 | | | 2 | | | 19 | | | 19 | | | 2% |
| Writing | | | 21 | | | 3 | | | 4 | | | 7 | | | 8 | | | 1% |
| Other | | | 8 | | | 15 | | | 6 | | | 29 | | | 30 | | | 3% |
| **Organics** | | 35 | | | 10 | | | 14 | | | 59 | | | 61 | | | 6% | |
| **Foodstuff** | | 23 | | | 64 | | | 9 | | | 96 | | | 99 | | | 10% | |
| **Glass** | | 23 | | | 13 | | | 5 | | | 41 | | | 42 | | | 4% | |
| **Metal** | | 23 | | | 13 | | | 8 | | | 44 | | | 46 | | | 5% | |
| **Textiles** | | 16 | | | 7 | | | 8 | | | 31 | | | 31 | | | 3% | |
| **Rubber/Leather** | | 12 | | | 3 | | | 6 | | | 21 | | | 22 | | | 2% | |
| **Fines** | | | | | 3 | | | | | | 3 | | | 3 | | | | |
| **Commercial** | **74** | | | **36** | | | **29** | | | **140** | | | **144** | | | **15%** | | |
| **Industrial House Cleaning** | **5** | | | **6** | | | **3** | | | **13** | | | **14** | | | **1%** | | |
| **Industrial Process** | **47** | | | **42** | | | **11** | | | **99** | | | **102** | | | **11%** | | |
| **White Goods** | **5** | | | **3** | | | **2** | | | **9** | | | **9** | | | **1%** | | |
| **Construction** | **34** | | | **6** | | | **8** | | | **47** | | | **48** | | | **5%** | | |
| **Yard and Garden** | **121** | | | **22** | | | **15** | | | **158** | | | **163** | | | **17%** | | |
| **Institutional** | **5** | | | | | | **2** | | | **6** | | | **6** | | | **1%** | | |
| **TOTAL** | **510** | | | **277** | | | **153** | | | **941** | | | **969** | | | **100%** | | |

# TRINIDAD


N
W
E
S
LEGEND
Major Towns
Major Roads
Ward Boundaries
Counties Boundaries
Wards
Counties
ST. DAVID
ST. GEORGE
ST. ANDREW
CARONI
NARIVA
VICTORIA
MAYARO
ST. PATRICK
Guanapo Landfill
Beetham Landfill
Forres Park Landfill