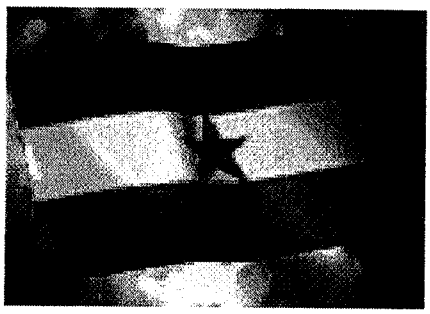
Kumasi

Cost effective Solid Waste Management Systems
in developing countries



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Introduction

Chapter 1

This case-study paper is written as part of the course URPA, URban Planning in Africa. The course consists of two papers, in which the first one focused on the making of an overview of the organisations, problems and opportunities concerning Solid Waste Management in the South.

The second assignment, as discussed in this paper, goes beyond the first paper. It calls out for a system to combat the Solid Waste Management problems in Atonsu, a neighbourhood in Kumasi (Ghana), the second largest city in the country. Since Solid Waste Management is one of the most important environmental issues in developing countries in the modern age, a solution is crucial. Since an acurate solution has both financial, social, political and juridical implications it is therefore difficult to implement in a country in the 'South'.

In this paper we have tried to come up with two alternative solutions. Both will be discussed thoroughly. At the end of this paper an advice will be given to both the inhabitants and the municipality of Kumasi, in which we have tried to show them which alternative suits the situation best.

Amsterdam,
June 1998

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Solid Waste Management Problems

Chapter 2

Infrastructure services, including power, transport, telecommunications, provision of water and sanitation, and safe disposal of wastes, are central to the activities of households and to economic production. This reality becomes painfully evident when natural disasters or civil disturbances destroy or disable roads, bridges powerstations, and water mains. Major infrastructure failures quickly and radically reduce communities' quality of life and productivity. It is not very surprising that especially in low developing countries the availability of these infrastructure services is still largely lacking. Rapid urbanisation, traffic congestion, a limited income base, and inadequate management capacity at the municipal level, are some factors briefly mentioned that explain the governments inability to cope with the most basic issues.

This paper will focus on one of the most crucial infrastructure services, especially in highly populated urban areas; *the collection of domestic solid waste.* Despite the lower level of commercial, industrial, and institutional activity, as in the developed countries, the solid waste in developing countries is not necessarily devoid of hazardous wastes because the regulatory framework and enforcement system to control such wastes are usually non-existent or dysfunctional (International occupational and environmental medicine, edition. 1). In contrary to high income countries, where a great deal of attention is given to environmental impacts of solid waste management, developing countries the health-related underpinnings of solid waste collection still need to be addressed. According to the United Nation Centre for human settlements (1991) 'in absence of a regular solid-waste collection system, waste is dumped in open spaces, on access roads and along watercourses. Dumps are invaded by scavengers and animals which scatter the wastes, and so serve as breeding grounds for disease vectors, primarily flies and rats. Leachate from decomposing and putrifying garbage percolates into soil and nearby water resources, and the resultant contamination of food, water and soil could be responsible for the transmission of many diseases. Uncollected waste also finds its way into open drains, which become blocked and, thereby, promote the breeding of mosquitoes.

It can be said that the efficiency of the waste collection service is low. Irregularity has led to complete loss of rapport between authorities and public, and little, if any, co-operation can be mustered from the public to support the service. Less than half the wastes generated in urban areas are collected by municipal authorities entrusted with their disposal. In absence of a regular solid waste collection system, waste is dumped openly on the streets and along watercourses. They serve as breeding grounds for disease vectors.

The Solid Domestic Waste collection management experiences frequent breakdowns of collection vehicles. Excessively high downtimes are often accompanied by slow rates of repair and return to service. Efficiency of service and productivity are both low and service is commonly irregular. According to UNCHS (1991) there are five major problem areas that can be distinguished in the solid domestic waste collection service of developing countries. For each of these problems we tried to give a direction in which solutions can be found.

1) Inadequate resource mobilisation

In developing countries low-income communities, especially urban squatter communities, because of their illegitimate status, pay no municipal taxes.

However recent experiences in African cities, indicate that these communities often consider the payment of municipal taxes and service charges a positive means of obtaining governmental recognition of the existence of their illegitimate plots and a fundamental way of being integrated in the overall processes of the urban economy. Another very important feature worth mentioning, is the growing awareness of the public to the need for this service. Nowadays most residents are willing to pay assumed that the service quality is adequate and reliable guaranteed.

2) Over-reliance on imported equipment

Solid-waste management projects that were heavily reliant on foreign exchange have proved to be capital-intensive and have also encountered problems in obtaining continued sources of foreign exchange to operate and maintain assets.

There is need for donors to standardise their procurement rules to ease the administrative burdens on recipient countries. Donor aid that excludes finance for local costs can also bias the choice of technology for public works in favour of capital-intensive methods that are unsustainable for the recipient country.

3) Inappropriate methods of finance

Refuse-collection equipment has a short life. Even so, most developing countries finance refuse equipment through borrowing from sources, such as international lending agencies on medium-term and long-term financing.

Tied in aid and contractual credit from bilateral sources and private companies to supply specific, often sophisticated, refuse-collection equipment have led some governments into accepting equipment without regarding to its appropriateness.

It has been clear that the current governmental solid waste management is characterised by inefficient institutions and organisational problems, such as the lack of co-ordination. The top of the local government usually is not interested in waste and yields the field to the lower echelons of the public sector. These are not equipped to deal with new tasks and technology. The difficulties are often solved on an ad-hoc basis and not as a result of any long term planning (Heymand and Langendijk, 1997).

One way for municipalities to enlighten this burden is by giving concessions, for collecting the solid waste, to private companies. Although this can involve high risks. One of this risks, is that only the rich areas will be served, but the poor will not. Using shorter contracts will give the governments a certain amount of control however on the other hand, this also means that there is the chance that companies will not invest in modern equipment because the risk of loosing the contract would be too high. It should be clearly understood that the degree of private participation in infrastructure services, and also in domestic solid waste collection in each country will depend much on the strength of the private sector, the administrative capacity of the government to regulate private suppliers, the performance of public sector providers, and the political consensus for private provision.

4) Use of inappropriate technology

Regarding the use of vehicles it can be said that the local governments often use vehicles that are inappropriate for either the refuse of the location. Old vehicles are often used, which are not maintained properly and governments introduces systems that do not align with local behavioural responses because of lack of appreciation of socio-economic and cultural factors which determine behavioural responses from the public.

Governments should keep in mind that different situations require different methods, as we will hopefully try to make the reader understand while reading chapter 4 and 5 is that there are more and less suitable ways in collecting solid domestic waste for each neighbourhood. Some waste collection systems encompasses highly technology for instance the use of a containertruck and garbage-container, while other systems have a more manual approach, such as the use of donkeys and buckets. Depending on the preference of the public (e.g. the amount they are willing to pay) and the quality of the roads, the right method of solid domestic waste collection should be chosen.

5) Inequity in service provision

Even when a service is proved in poor areas, the level of service is much lower than provided to middle-income and high-income areas.

The poor typically use fewer infrastructure services than the non-poor, but not only because of low incomes, they also have very low access. The failure to reach the poor has often been associated with flawed infrastructure pricing policies, too little emphasis has been placed on providing the poor with suitable options for the kinds of services of most value to them and for which they are willing to pay. Appropriate services for the poor are often lacking when decisions on investment and service are driven by assumptions about a 'needs gap' rather than by an assessment of effective demand.

We have tried to give an overall view on the problems of solid waste collection in Developing countries. Chapter 4 and 5 will focus with more detail to these problems.

We look at 2 alternatives which could help a community in Kumasi, Atonsu with one major problem: the collection of solid domestic waste.

The Kumasi Situation

Chapter 3

Kumasi

Situated in the centre of the country and in the middle of the tropical rain forest, Kumasi is the second largest city in Ghana, with a population estimated of one million present, scattered over a large area. It has a built up area which is larger than that of Amsterdam. The city is referred to as the 'Garden city'.

Kumasi is the capital of the Ashanti region, which comprises the districts of the former independent Ashanti state. The Ashanti tribe is the largest tribe and the most power tribe in Ghana and they are also the only ones who have a king. The traditional influence in Ghana and especially in Kumasi should therefore not be underestimated. Nowadays there is still a very influential traditional system which functions separately from the governmental one. Kumasi can therefore be seen as a place where traditional values and modern lifestyles coexist producing a mixed style of present urban development.

Kumasi's economy is based on timber processing and the exports of agricultural produce, in particular minerals and cacao. It has reasonable developed industrial sector where modern timber is being processed, large woodworking, light engineering and vehicle repairing activities take place. Still, despite Kumasi's economic potential, the majority of the population is caught up in the day to day struggle for survival. Most of the business in Kumasi is dominated by informal sector, in which many of its citizens finds work for instance in the informal wood related industries such as furniture making and carpentry. Thanks to Kumasi's location as a traversing point from all parts of the country, its here the largest market of Ghana and one of the largest of West Africa can be found. This makes it an ideal place for the development of commercial activity. All kinds of goods are sold; diverging from food to luxurious goods. Kumasi plays a meaningful role in the transportation system of the country. The city has a central location in the national

road network, and as a consequence it has a big influence on the distribution of goods across the country. Still the majority of the roads can be characterised as unpaved or badly maintained. Other means of transportation in Kumasi are the railway and the national airport.

Atonsu

Atonsu is a suburb of Kumasi, located in the south-east part of Kumasi on the road to Lake Bosumtwi. The area is still expanding. One of the reasons for this is because it serves as a dormitory town for the workers of the near bye rapidly developing industrial areas. The surrounding suburbs are Agogo in the north, with which Atonsu actually has grown together, Chirapatre in the east and Dompoase in the south-east. There is still a lot of open space in the vicinity of Atonsu.

Before it was moved to the present site, Atonsu was located three kilometres from Lake Bosumtwi. In the 1950s, the queenmother of Abrenkese, grandmother of the present Atonsuhene, approached a son of the Asentehene in a negotiation for a part of the Agogo stool lands. After the pact was signed with the Agogohene the queenmother and the sixty-five families living in the village moved to the present site (Sraha, 1981 quoted by Owusu, 1991). Old Atonsu and New Atonsu have chiefs that take care of the area. They resort under the Asantehene.

In 1953, Atonsu was declared as part of the statutory planning area of Kumasi. The planning scheme for the area was prepared in 1963. Because the scheme could not be implemented, a lot of problems were created in terms of e.g. social facilities, size of plots and sanitation. The necessity arose to prepare a new and better planning scheme in order to facilitate a better implementation. The new scheme was prepared in 1972. In 1984, a part of the 1972 scheme was revised for the southern part of Atonsu.

Before the 1972 scheme, the different chiefs from the various villages employed different surveyors. Because there were no adequate plans available, the distinction and the boundaries between the villages are not clear (Attipoe, 1992).

In the area are one official and two unofficial dump sites.

Housing

Atonsu is part of the indigenous sector. The predominant house type is the single-storey compound house. There are also multi-storey compound houses, but these are very few in number (Van Donkelaar and Van der Laan,1994). The compound houses are built in a square around a central courtyard. Generally, shared facilities will make up one side of the compound. The other sides three sides together will have approximately ten rooms, most of them with a veranda facing the courtyard. There is only one entrance which can be locked, thus securing the whole compound.

As is typical for the indigenous sector, the layout of the houses do not follow any planned pattern. A lot of houses are built on sites which were originally reserved for other purposes. There are houses in the middle of what should have been a road, on sites planned for schools and refuse dumps. The houses are built too close together leaving limited space for access to some of the houses. Some houses are only accessible by small paths (Van Donkelaar and Van der Laan).

Roads

Most of the roads are full of potholes. These are almost constantly filled with water, which is an ideal breeding place for mosquitoes. Often parts of the road are washed away by the rain. Most of the roads function as drains as well, because there are no real drains in most areas. This causes a lot of erosion and stench. Heavy erosion as a result of the bad drainage system and use of the dirt roads when they are wet, have made some roads almost impassable for vehicles at certain points. In general, the quality of roads in Atonsu is poor, except for Lake Road, the main road, which is paved and serves as the main traffic drag. Some areas cannot be reached by car, because there is no road or it is in very bad condition. A lot of (unauthorised) stalls are put up alongside the roads, which tend to narrow the road and give the area an untidy appearance.

Waste Management in Kumasi

The solid waste management (SWM) has always been a "public good" and as such has been the domain of the city authority.

The management of solid waste is performed by the Kumasi Metropolitan Assembly - Waste Management Department (KMA-WMD) and the Environmental Health Division (EHD) of the Ministry of Health (MOH). KMA-WMD takes care of the bulk of the collection, haulage and disposal. EHD handles the cleaning of the streets, drains and public areas, and the software components of hygiene education and inspectorate support.

The creation of KMA-WMD was prompted by the implementation of the ODA-sponsored Kumasi Waste Disposal Project in order to streamline the previously fragmented oversight of field operations and vehicles between the EHD and the Mechanical Engineer's Department respectively. The definition of departments under the KMA as in Act 462 and the evaluation of technical departments under the KMA as in act 462 and the evaluation of technical departments under the GOG/World Bank -Urban II project proposes the consolidation of all aspects of environmental sanitation in one KMA- Waste Management Department. Hitherto, private sector participation (PSP) in waste management services in Kumasi has been absent.

The city's expansion both spatially as in population terms has meant that the demands for environmental quality cannot be met.

The open-air furnaces were not longer acceptable because of the proximity to growing residential areas and air pollution concerns.

The practice of open dumping at outskirts and inner city has been stopped, according to the KMA (1996). This requires haulage of refuse over increasingly greater distance with controlled dumping. Current coverage is only 42-45 % of Kumasi's population.

All this indicates that responsive strategies are needed.

In the areas which are serviced, baskets, card boxes, wooden boxes, galvanised metal bins and plastic bins varying sizes are the primary storage modes for domestic sources. The most common mode of storage is by secondary storage using metal containers (skips) which are shared by a number of houses.

Collection

In Kumasi, collection from the immediate source of generation is usually manual where headloads, wheel carts and wheel barrows are used to send refuse to dumps or skip containers or transport disposal. Headload collection is the main mode for the domestic source category.

Treatment

No category of solid waste is subjected to any kind of treatment prior to discharge at landfill. There is also no important recycling of the waste stream in Kumasi apart from material recovery at transfer stations and disposal sites where scavengers remove items like bottles, rubber slippers, planks and a host of miscellaneous items for re-use. The main recycled waste items are spent grain and malt mash from the breweries which are recycled into animal feed.

Disposal

The KMA is practising open controlled dumping at its final disposal site located about 12 km from the city centre, at Truba-Kenyaase near the Limex-Bau quarry in the north-east of the city. Only about 30% of residential areas are effectively covered by the service.

The present refuse disposal site situated at Truba-Kenyaase is rented by the KMA from the landowners for two years ending in 1997, after which another three years may be negotiated. The inability of the city to secure a landfill site has been largely influenced by lack of forward planning and also maintenance of acceptable disposal operation principles. One of the city's urgent requirement is the construction of

sanitary landfill appropriately located to ensure at least a fifteen-year operational life.

Issues and constraints

Institutional Arrangements:

Private Sector Participation is one outlet for harnessing investments and management expertise to provide sustainable delivery. PSP if implemented as proposed for the Urban Environmental Sanitation Project (UESP/Urban IV) will be the commencement of the shift of the city authority from a direct service provider to a promoter of cost-efficient services.

Finance:

A constraint is the unsustainable maintenance management of equipment and weak financial base of KMA to meet replacement costs. The over reliance on external agency interventions has promoted the syndrome of 'use-to-do-destruction-and-solicit-aid'.

Because solid waste management is seen as a public good which has to be provided has also precluded the running of waste management services on commercial base.

There is also absence of payments from beneficiaries of the predominant communal container service.

Technologies:

The use of container transfer stations involve the community for headload transport to the depots. Whilst this method ensure large payloads, allow a wider city coverage and provide more people per area with service, and also reduce significantly vehicle loading times, the interfacing with fees collection and site husbandry limit its cost-effectiveness.

The requirement to improve coverage and match it with beneficiary contributions could be ensured with the introduction of Compaction Vehicles and the extension

of House-to-House to cover all High Cost, New Government and selected Tenement areas.

Policy and Planning:

A Letter of Sector Policy from the Ministry of local government and rural development (MLGRD) concerning the implementation of UESP (Urban IV) seeks to, among other things, to strengthen and promote private operators in the delivery of environmental sanitation services.

Sustainable delivery of SWM services has not been achieved, so far, owing mainly to the inability of KMA to provide adequate resources. The on-set of privatisation will stretch the city to its limit if it would want to support private operators solely from own-sources. The expansion of house-to house service has been identified as a readily available option to cover service costs with collection fees.

Present situation in Atonsu

Refuse is a big problem in Atonsu. The collection of refuse is a privately arranged matter. People dump their refuse in nearby streams, on open plots or on the overfilled dumps of which only one is officially recognised as such. The only official dump site is located near the new market at the beginning of Lake Road. This site does not have the capacity to cater for the needs of the whole area. It is also too far away for most households, because of the de-central location. One is located behind the trotto/bus terminal opposite the Agogo Health Centre and another one behind the KTC sawmill.

A container for the collection of waste is located on the spot behind the trotto/bus terminal. This spot was never mend to be used as a dump site because of a transformer is located there. Open space left around the transformer as a safety measure was getting used as refuse dump, because the official one near the market, is too far away for most residents of Atonsu.

Therefore, a container was located here. Due to technical problems at the WMD, this container could not be emptied for a long time. Only recently(1994) has the site been cleaned and the container been emptied.

Apart from the dumps, refuse is dumped in streams and gutters, which get blocked. Sometimes potholes in roads are filled with waste. In the rain season refuse gets washed away onto people's plots. Burning of refuse is often the only way to get rid of it. This practise causes stench and pollution in the area.

In table 3.1 the composition of Atonso is shown. Zone 2 is the highest populated zone and therefore produces the most domestic solid waste. Every inhabitant produces 0,45 kg of solid waste. 20.000 inhabitants divided by 1000 compounds, with an average of 5 households per compound, results in a total number of 4000 households in Atonsu.

Table 3.1 Production of waste

Zone	Inhabitants	Waste kg/day	Waste m3/day	Houses	Households
1	5,481	2,466	6	365	1,096
2	8,840	3,978	10	354	1,768
3	5,880	2,646	7	294	1,176
Total	20,201	9,090	23	1,013	4,040

Unfortunately, the ability of local authorities is been deteriorating, caused by the increasing gap between demand and the provision of solid waste collection and the financial position of the authorities.

The Transfer Station Solution

Chapter 4

In this first alternative we focus on a method of solid waste collection in which a transfer station is needed. The area Atonsu is divided into three zones. In each zone the solid waste is collected and then brought to a transfer station site where a container is present. Each zone has its own transfer station (Appendix I). From the location of this transfer station the domestic waste is collected and transported to the appropriate dumpsite .

Before we decide on which system in Atonsu will be best for the collection of the waste and transportation from the station to the dumpsite, we choose to examine the financial possibilities of every method. This approach emanates from a single economic point of view were we look at the cost for collection and transport of every individual unit.

Table 4.1 shows the repayment costs, which are spread out over 5 years. The maintenance costs (20%) and the salary costs (2 persons/unit, 70.000 cedi/year) is also included in this table. Looking at the table it is obvious that the donkey with cart system the cheapest system is, although this way less waste is being tranported. Based on the fact that a donkey can transport 4.5 m^3 a day, while a power lifter can transport 6 m^3 a day, and a tractor 10 m^3 a day, we conclude that more donkeys will be needed to collect all the waste according to the cheapest system.

Table 4.1, Cost of one donkey, tractor or power lifter

Post	Donkey	Tractor	PowerLifter	Containertruc
Cost	700.000	25.000.000	2.500.000	250.000.000
Cost/year	140.000	5.000.000	500.000	50.000.000
Maintenance	140.000	5.000.000	500.000	50.000.000
Salary	1.680.000	1.680.000	1.680.000	1.680.000
Total	1.960.000	11.680.000	2.680.000	101.680.000

(all costs in cedi, 2000 cedi is 1 US$)

This first alternative encompasses a transfer station for the collection of the solid waste whereas the use of a container truck is inevitable. However, based on our research, we discovered that the sum of the total waste in all zones (23 m^3) still do not fulfil the complete capacity of the truck which can be seen in Table 4.2. Merely 35% of the truck's capacity is utilised. That is why we decided to take one third of the containertruck costs into account and not the complete amount of 250 million cedi. The unpaid part of the containertruck will be covered by other communities in Kumasi who also make use of the truck. In this way communities all share the same truck which lowers the total cost for each group. In terms of maintenance costs it is obvious that each community only contributes his relative share based on the percentage capacity usage of the truck.

Zone	Waste in m3	% usage truck
1	6	9%
2	10	15%
3	7	10%
total	23	35%

Table 4.2, containertruckuse (max capacity 65 m^3/day)

One donkey or transport unit is not sufficient to collect the total waste produced, that is why we decided to calculate how many units we need for every separate zone in Atonsu and how much the costs amount. In table 4.3 and 4.4 we include the transfer costs from the station to the dumpsite. This had to be done separately for a *collective* solid waste system and for a *door-to-door* waste collection system. since a collective systems requires more material to be used and more collective bins. When calculating the costs the different collective systems, we also mixed the costs of the collective bins in each system (table 4.3), as it is only naturally that each zone will have its own collective bins. The table shows that even though you will need to use more donkeys than power lifters for collecting the total waste produced in Atonsu, the donkey system is still slightly cheaper when using a collective system (a difference of 252.512 cedi a year).

Table 4.3 The Number of units (#) and costs ($)/year (in cedi) of the different collective systems)

zone		$ coll. bins	# donkeys	$ donkeysys/y	# tractor	$ tractorsys/y	# PL	
1	F	328,860.00	1.4	10,221,517	0.6	14,737,861	1.0	10,
2	F	530,400.00	2.2	16,485,716	1.0	23,769,876	1.7	16,
3	F	352,800.00	1.5	10,965,612	0.7	15,810,732	1.1	11,
total	F	1,212,060.00	5.1	37,672,845	2.3	54,318,469	3.8	37,

(PL = Power lifter)

Table 4.4 The Number of units (#) and costs ($) /year (in cedi) of the different door-to-door systems

zone	$ buckets	# donkey	$ Donkeys/y	# tractor	$ Tractorsys/y	# PL	$ PL sys/y
1	3.650.000	2,1	14.885.502	0,8	19.859.509	1,5	14.988.271
2	3.540.000	3,3	21.661.116	1,2	29.683.416	2,5	21.826.866
3	2.940.000	2,2	14.993.412	0,8	20.329.512	1,7	15.103.662
total	10.130.000	7,6	51.540.030	2,8	69.872.437	5,7	51.918.799

(one bucket/house, costs spread over 5 years, PL = power lifter.

In the above table 4.4 we see that the situation could be different, a door-to-door system costs more, but on the other hand people are prepared to pay a higher contribution for this systems. The reason why the door to door systems still cost more is because more units and buckets are needed.

Table 4.5: the total cost of the different systems including transfer station costs

	Collective			Door-to-Door		
Zone	Donkeysys	Tractorsys	Plsys	Donkeysys	Tractorsys	Plsys
1	20,867,234	49,228,584	49,228,585	25,531,219	25,531,219	25,633,987
2	33,042,756	78,785,201	78,785,202	38,218,156	38,218,156	38,383,906
3	22,313,507	52,739,478	52,739,478	26,341,307	26,341,307	26,451,557
Total	76,223,497	180,753,263	180,753,265	90,090,682	90,090,682	90,469,451

(all cost in cedi on yearly basis)

Within the given assumptions of this research we choose to work out one alternative which emanates from a waste collection system with transfer station. However, before we conclude which of these systems are the most effective, it is important to consider how much contribution each household wants to pay for the collection of their household waste. The KMA assumes that although the waste collection is a public task and therefore responsibility lies naturally in the hands of the municipalities, local inhabitants should also nonetheless play a role in the provision of solid domestic waste collection. Research in this local area concludes that for a collective system each household is prepared to contribute a minimum of 750 cedi to a maximum of 1000 cedi a month. The door-to-door system

contribution varies from 1250 to 2000 cedi a month. In table 4.6 we calculated the percentage of coverage by a minimum collective contribution of 750 cedi and by a 1250 cedi minimum door-to-door contribution.
Whereas in table 4.8 the calculated percentage of coverage both collective as door-to-door by a maximum contribution is portrayed.

Table 4.6 The percentage of coverage by minimum contribution.

	Collective				Door-to-Door			
Zone	Revenue	Donkeys	Tractors	PL's	Revenue	Donkeys	Tractors	PL's
1	9.865.800	47,3%	38,9%	47,1%	16.443.000	64,4%	53,9%	64,1%
2	15.912.000	48,2%	39,5%	48,0%	26.520.000	69,4%	57,4%	69,1%
3	10.584.000	47,4%	39,0%	47,3%	17.640.000	67,0%	55,7%	66,7%
Total	36.361.800	47,7%	39,2%	48,8%	60.603.000	67,3%	55,9%	67,0%

(costs include technical, maintenance, salary, transfer, tranfer station and containertruck costs; the revenue is on a yearly basis)

Table 4.7 Saldo in cedi of different systems with a minimum contribution.

	Collectief				Door-to-Door			
Zone	Revenue	Donkeysys	Tractorsys	Plsys	Revenue	Donkeysys	Tractorsys	Plsys
1	9,865,800	-11,001,434	-15,517,778	-11,069,946	16,443,000	-9,088,219	-14,062,226	-9,190,987
2	15,912,000	-17,130,756	-24,414,916	-17,241,256	26,520,000	-11,698,156	-19,720,456	-11,863,906
3	10,584,000	-11,729,507	-16,574,627	-11,803,007	17,640,000	-8,701,307	-14,037,407	-8,811,557
Total	36,361,800	-39,861,697	-56,507,321	-40,114,210	60,603,000	-29,487,682	-47,820,090	-29,866,451

(costs include technical, maintenance, salary, transfer, tranfer station and containertruck costs; the revenue is on a yearly basis)

Table 4.7 shows merely the absolute coverage shortages for each system (just as a more accurate illustration of table 4.6). Comparing both tables 4.6 and 4.8 it is clear that the door-to door systems all have higher coverage percentages. The percentage of coverage of the donkey- and the power lifter system do not differ much.

Table 4.8 The maximum percentage of cover of the different systems

	Collective				Door-To-Door			
Zone	Revenue	onkeysys	actorsys	Plsys	Revenue	Donkeys	Tractors	Plsys
1	13,154,400	63.0%	51.8%	123.6%	26,308,800	103.0%	86.2%	102.6%
2	21,216,000	64.2%	52.6%	128.1%	42,432,000	111.0%	91.8%	110.5%
3	14,112,000	63.2%	52.0%	124.4%	28,224,000	107.1%	89.1%	106.7%
Total	48,482,400	63.6%	52.2%	125.8%	96,964,800	107.6%	89.4%	107.2%

(costs include technical, maintenance, salary, transfer, transfer station and containertruck costs; the revenue is on year basis

When the contribution is higher than the minimum the situation looks *rosier.* When looking at a maximum contribution, both the donkey/ and the Power lifter

door-to-door system can support themselves. They even make a profit. This extra money could be used for the durability of the system. We still prefer the donkey system, because we don't think there is enough money (US$ 3.000/year) to invest in the road system. Additionally, the donkey system creates extra jobs.

Just like table 4.7, table 4.9 is only meant to give a more precise illustration by showing the absolute coverage percentage of each system.

Table 4.9 Saldo in cedi when at a maximum contribution

	Collective				Door-to-Door			
Zone	Revenue	Donkeys	Tractor	Lichtmo	Revenue	Donkeys	Tractor	PL's
1	13.154.400	-7.712.834	-12.229.178	2.508.683	26.308.800	777.581	-4.196.426	674.813
2	21.216.000	-11.826.756	-19.110.916	4.658.960	42.432.000	4.213.844	-3.808.456	4.048.094
3	14.112.000	-8.201.507	-13.046.627	2.764.105	28.224.000	1.882.693	-3.453.407	1.772.443
Total	48.482.400	-27.741.097	-44.386.721	9.931.748	96.964.800	6.874.118	-11.458.290	6.495.349

(costs include technical, maintenance, salary, transfer, transfer station and containertruck costs; the revenue is on year basis

We have also considered just bringing in an extra container at the main road in table 4.9. However, this is not preferable because this extra container might be enough to cover all the waste in the area, but the distance from the houses will be too long. This was not preferable nor more cost effective (Net gain 12.000 cedi/y). We only calculated the minimum contribution, since the service would not give any reason to give a higher contribution.

Table 4.10 Just adding another container

Zone	Use Container	Use Truck	Revenue	Cost/Y	Saldo
1	47%	9,5%	9.865.800	9.859.160	6.640
2	77%	15,3%	15.912.000	15.901.290	10.710
3	51%	10,2%	10.584.000	10.576.876	7.124
Total	175%	35,0%	36.361.800	36.337.326	24.474

(all costs in cedi, including an extra container and truck costs)

Description of alternative 1:

After examining each possible collection system, our preference is given to the donkey system. This method includes several advantages. First of all it is not only economic the most desirable option, but also given the presumed conditions of the roads in Atonsu, this method is the most realistic one. Reasons for selecting this system above the rest, is to avoid the second problem portrayed in chapter 2: Solid waste management problems. Whereas the use of inappropriate technology is simply avoid here by choosing the donkey method. Looking at the location of Atonsu and the conditions of the roads, we discover that there is only one main road in Atonsu, the Lake Road (see appendix I) whereas the majority of the other roads are not aspalted. This indicates that during the rain season most roads in Atonsu are not accessible for every vehicle. But also when it does not rain, the poorly constructed, maintained and in general small roads prevent the usage of trucks collecting the waste inside Atonsu. This is the reason why we automatically assumed that the usage of the containertruck would not only be impossible for the collection of the waste in an area as Atonsu (inappropriate technology), but it would also be financially ineffective and unrealistic system.

However the donkey/cart system also includes a disadvantage.
It is clear that we prefer a donkey system especially because it has the indications of being the most appropriate system. Still this method also has a weaker side. The financing of this method. When using a door-to-door system with a maximum contribution, there is still a shortage of 29.487.862 cedi a year (see table 4.7).
However, since waste collection is primarily a task of the municipality, the responsibility of filling the gap lies originally with the KMA, which has to come up with alternative and effective solutions. One solution briefly mentioned here is by exploring different public-private involvement. For instance the KMA could decide to choose for a public ownership with operation contracted to the private sector. This option is typically implemented through lease contracts for full operation and maintenance of solid domestic waste. Arrangements between the KMA and a firm are set out in a contract that includes any regulatory provisions. The private

operator typically assumes all commercial risk of operation and shares in investment risk under concessions. The KMA would have a controlling function instead of a regulatory one, this implicates a major change inside the organisational structure of the KMA. Research has shown that involvement in private sector depends much on the administrative capacity of the government to regulate private suppliers, but also in the strength of the private sector, the performance of public sector providers, and moreover in the political consensus for private provision. Another way of financing this system is through Western donor organisations or an ultimate resource is the national government. Unfortunately, it is obvious that because of this rather complex subject we cannot give a precise and accurate solution in financing the shortage this system encompasses, as shown clearly in table 4.6 and 4.7. However in comparison with the other systems the usage of donkeys for the collection of collective and door-to-door solid domestic waste, is still the best possible alternative.

In short the donkey/door to door system is the best system when using a transfer station. Here the contents of the buckets of every household will be individual collected by donkeys with two operators. The donkeys will transport the collected waste in the cart and bring it to the transfer station (a raison de 1.000.000 cedi) situated in each zone. There the waste will be emptied in a container and transferred to the dump by a containertruck. Each zone will have a number of donkeys according to their size. Zone 1 and 3 will have 2 donkeys, while zone 2 has 4. Each zone has a tranfer station, these are located along the main roads of Atonsu, like the Monaco road (Zone 3 and Zone 1) and the Old Atonsu Road. From here to their zone, each donkey will have his own selected route (see appendix 1). We assume that the collection of the garbage will occur 2 days in the week for each zone, especially regarding the high temperature. It was our purpose to come up with the best possible proposal for the collection of solid domestic waste in a neighbourhood in Kumasi, purely and merely based on all the facts given in this case. We choose not to alternate any assumption, but to use most of the data. In the next chapter alternative 2 will be discussed where another angle is chosen in approaching this task.

The Direct to Dump Solution

Chapter 5

In this alternative we focus on the option to leave out the use of a transfer station in the method of waste collection. This, because we question the real necessity of a transfer station and think it will be better from a financial point of view. Our proposal is to bring the collected waste directly to the dump site.

On the one hand it will have a cost increasing effect. As transportation units (donkeys, tractors, PL's or trucks) will have to travel greater distance, the average collectable waste per day per transportation unit will be lower, so more transportation units have to be deployed to collect the same amount of waste during the same period of time. In the calculations we make the assumption that each transportation unit, after collection its maximum possible amount, only can make one trip to the dumpsite a day.

On the other hand this will have some cost reducing effects. As there will be a saving of an initial investment of 5 million cedi for equipping the transfer site (including a container) and a saving of an initial investment of 1/3 of 2.25 million cedi for the use of a container truck (when is assumed, as in chapter 4, that Atonsu can share the use of the container truck with other neighbourhoods).

In table 5.1 we can see what this will mean for the total costs of the different collective collection systems.

Table 5.1 Number (#) and Costs ($) involving collective direct to dump systems

Zone	$ Coll. bins	# donkeys	$ donkeys/y	# tractors	$ tractors/y	# PL's	$ PL's /year
1	328,860	4	15,592,897	2	25,540,912	3	15,798,434
2	530,400	7	13,525,203	2	41,193,516	5	25,480,416
3	352,800	4	16,728,012	2	27,400,212	3	16,948,512
Total	1,212,060	15	45,846,112	6	94,134,640	11	58,227,362

(all costs in cedi, including purchase-, maintenance-, salary- and transfercosts)

In this situation the donkey with cart system is cheapest, followed closely by the power lifter, and both are much cheaper than the tractor with wagon[1].
In the situation of door-to-to door collection we see the same: the donkey with cart is costing least, followed by the power lifter, and the tractor with cart is much more expensive than both (see table 5.2).

Table 5.2 Number (#) and Costs ($) involving door-to-door direct to dump systems

Zone	$ Trashcans	# donkeys	$ donkeys/y	tractors	$ tractors/y	# PL's	$ PL's /year
1	3.650.000	6	22.942.572	2,3	37.864.594	4,6	23.281.941
2	3.540.000	10	34.655.916	3,7	58.722.816	7,5	35.203.265
3	2.940.000	7	23.637.012	2,5	39.645.312	5,0	24.001.086
Total	10.130.000	23	81.235.500	8,5	136.232.722	17,1	82.486.291

(all costs in cedi, including purchase-, maintenance-, salary- and transfercosts)

If we then compare the total costs of the different waste collection systems, both collective and house-to-house, of alternative two with the total costs of these systems in alternative one (see table 4.5) we can conclude that although more transport units have to be used, alternative two, without the use a transfer station, is turning out to be cheaper.

Now we will look how far the contributions of the residents will cover the costs. It is assumed that the leaving out of a transfer station will not effect the contributions of residents as the residents will not notice a big difference in the service provided in comparison with alternative one.
In table 5.3 the minimum coverage percentage of the different systems is shown, both in the case of collective collection and house-to-house collection.

Table 5.3 Percentage of coverage in case of a minimum contribution involving direct to dump systems

	Collective				Door-to-Door			
Zone	Revenue	Donkeys	Tractor	PL's	Revenue	Donkeys	Tractor	PL's
1	9.865.800	63,3%	38,6%	62,4%	16.443.000	71,7%	43,4%	70,6%
2	15.912.000	63,3%	38,6%	62,4%	26.520.000	76,5%	45,2%	75,3%
3	10.584.000	63,3%	38,6%	62,4%	17.640.000	74,6%	44,5%	73,5%
Total	36.361.800	63,3%	38,6%	62,4%	60.603.000	74,6%	44,5%	73,5%

(all costs in cedi, including purchase-, maintenance-, salary- and transfercosts; revenue on a year base)

[1] For the same reasons as mentioned in chapter four we leave the option of the use of a truck aside.

Although a higher coverage percentage for each system can be observed compared to alternative one (see table 4.6), still the total costs for each system is not covered when assuming a minimum contribution of the residents.
A different situation can be seen for the door-to-door system when assuming the maximum contribution of the residents (see table 5.4).

Table 5.4 Percentage of coverage in case of a maximum contribution involving direct to dump systems

	Collective				Door-to-Door			
Zone	Revenue	Donkeys	Tractor	PL's	Revenue	Donkeys	Tractor	PL's
1	13.154.400	84,4%	51,5%	83,3%	26.308.800	115%	69,5%	113,0%
2	21.216.000	84,4%	51,5%	83,3%	42.432.000	122%	72,3%	120,5%
3	14.112.000	84,4%	51,5%	83,3%	28.224.000	119%	71,2%	117,6%
Totaal	48.482.400	84,4%	51,5%	83,3%	96.964.800	119%	71,2%	117,6%

(all costs in cedi, including purchase-, maintenance-, salary- and transfer costs)

The costs of the 'tractor with wagon' system is still not covered but the costs of the donkey with cart and the power lifter are more than covered!
The extra funds created this way, can be invested in the improvements of the roads or other infrastructure services in the neighbourhood. It can also be saved for the unfortunate situation in which a donkey (or donkey cart) or power lifter breaks down and has to be replaced before the end of the five year period of repayment. Alternatively it can be considered to lower the contributions of the residents.
Because of the quality of the roads in the neighbourhood, already discussed earlier, we advise the use of the 'donkey with cart' system. In this case the extra funds can be used to improve the roads so that in the future it can be considered to switch over to a higher technology system as the power lifter.

The organisation structure can be arranged the same as in alternative one. As the costs are covered by the contributions of the residents, it is not really necessary to introduce the private sector for cost recovery. But we think it the provision of the service is better guaranteed by private sector involvement. We also assume the division of responsibility is clearer as the government monitor the private sector provision of domestic waste.

The domestic waste is in Atonsu is collected seven days a week and with a frequency two times a week at each house. See appendix II for the itinerary .

We developed this alternative to provide a more cost-effective alternative. This approach did not result in a as cost-effective system as we had hoped, but it is still more cost-effective than the first alternative.

It can be thought that when all the donkeys will come to the dump directly it will be to chaotic but we think that a this can be organised in a proper way: Some donkeys have there route close to the dump and others have to travel further so they have different arrival times at the dump site. Also some routes can be scheduled later than others.

This option provides for the residents in the neighbourhood the same service as option one, in the way that it collects all the waste of the neighbourhood at the minimum of twice a week which is required in that climate, and provides it against the costs which can be covered by the contributions of the residents.
This alternative is good for the employment in Kumasi. As more donkeys are used also more garbage collectors have to be employed.
When the extra funds are spend on road improvement, will this of course not only benefit the collection of waste. The living conditions in the neighbourhood will also be improved.

Policy Proposals

Chapter 6

We choose for the second alternative as proposed by us. This is done, because it is the best financially, it allows to improve the roads and offers the most extra employment.

It might not be the standard method for solid waste management as opposed to alternative 1, but we think it offers more to the people and the government of Kumasi than the other solution. It has social, financial and environmental advantages. Additionally, it is easier to implement in the current situation than the first alternative, where transferstations have to be placed into Atonsu.

Atonsu is a dynamic part of a dynamic city. Environmental problems as solid waste have to be managed in an effective and affordable manner. Our alternative can provide such a system in Atonsu, and probably in whole Kumasi. After the initial investments the alternative will pay for itself and can therefore be implemented in a more suitable way.

We hope that in providing this alternative we have learned which difficulties and problems one has to overcome when implementing such a system in a developing country.

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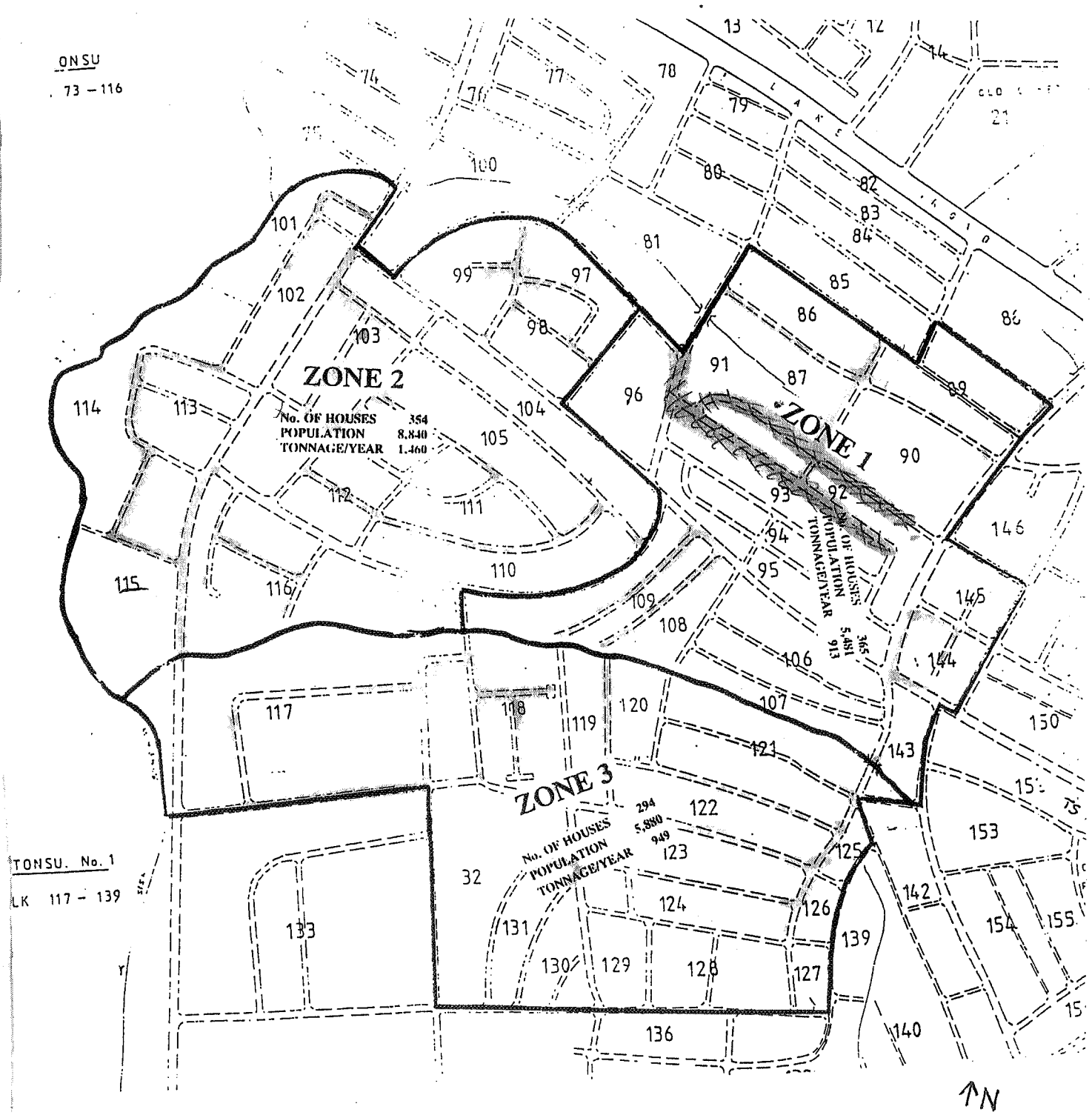
Appendix II

Itinerary alternative 2



Appendix I

Itinerary alternative 1 and location of tranfer station sites