Vehicles for people
or people for vehicles?





Vehicles for people *or* people for vehicles?

Issues in waste collection

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Opening words

'I carry all my waste in plastic bags from the residents in the flats. Sometimes the bags break and I get covered in liquid from the waste, and at other times glass or needles tear the plastic and injure me.'

A kapici (waste collector) in Ankara. (Ali 2001)

'I used to carry all the waste I collect from people's homes in a basket on my head. Such close contact with the waste badly scarred my hands and I had to spend much money on medical treatment for them.
Carrying waste is terrible because of what falls past your face – it is really unpleasant.

Since being given this cart my hands have healed and the work is much cleaner. I can also complete my work in a much shorter time because I can carry more, and have to make fewer trips to the local dump every day'

A door-to-door collector in South Delhi. (Rouse 2001a7)

'I depend on my cycle cart for my work, but it is not reliable. It is too heavy to cycle so I push the cart using the handlebars, and I have removed the pedals because they cut into my leg. The wheels, forks and handlebars break frequently because they are too weak, and the tyres are usually punctured. Emptying the cart is difficult and I have to wait for a friend to help me tip the cart up because it is so heavy. There is nothing I can do to get a better vehicle – I have no knowledge or money.'

Adapted from an interview with a waste collector in a wealthy Delhi suburb. (Rouse 2001a2)

About the authors

Jonathan Rouse is an Assistant Programme Manager at WEDC. Originally an Applied Physics graduate, Jonathan graduated from the University of Sussex with an MA in Rural Development in 1999. His work at WEDC primarily focuses on the livelihoods of the urban poor involved with solid waste management in low-income countries. He also pursues his interest in participatory research and household energy issues. Jonathan has spent considerable time overseas as a teacher, fieldworker and project manager, particularly in South Asia. He undertook research for this project in Delhi and Lusaka in 2001.

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* More detailed biographies of these collaborators can be found in Appendix 1.

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All photographs are by the authors unless otherwise stated.





Contents

Key definitions

Small Waste Collection Vehicles (SWCVs)

The term SWCV includes wheelbarrows, trolleys, handcarts, cycle carts, animal carts and some small motorised vehicles. The names used in this document for each of the vehicle types are shown below. Note: in some instances the same vehicle has different names in different countries.

Wheelbarrows

Handcarts
Also known as cart, pushcart and trolley. May have two, three or four wheels

Cycle carts
Also known as tricycles, cycle rickshaws and rickshaw vans.

Animal-drawn carts
For example donkey cart (shown) or ox cart.

Motorised vehicles
For example motor-rickshaw van (shown), also known as ‘baby taxi’.

A number of other simple means of transportation are referred to in this book including sacks, baskets, buckets and yokes.

Equipment
Equipment includes shovels, forks, sorting spikes and various other tools specific to local situations.

The poor
A vulnerable group of people who are poorly endowed with some or all livelihood assets: financial, social, physical, natural and human.

Livelihoods
A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living.

Glossary

Kapici	A Turkish word that refers to a waste collector employed by the residents of a block of flats.
Transfer point	A term also known regionally as transfer station and transfer facility. An intermediate place where waste is deposited and stored before being transported to the final disposal site.

List of acronyms

CBO	Community-based organisation
DCC	Dhaka City Corporation
DFID	Department for International Development (UK)
KaR	Knowledge and Research
KMC	Karachi Metropolitan Corporation
MCD	Municipal Corporation of Delhi
MUD	Ministry of Urban Development (Delhi, India)
NDMC	New Delhi Municipal Corporation
NGO	Non-governmental organisation
RWA	Resident Welfare Association
SLP	Sustainable Lusaka Programme
SWCVs	Small waste collection vehicles
SWM	Solid waste management

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Foreword

This book is an interim output of the DFID KaR R7880 project 'Toolkit for Solid Waste Vehicles for the Poor'.

Chapter 1 provides the background to this research, describes its purpose and outlines the methodology used. The principles of solid waste management and stakeholder groups are also described.

The next five chapters are devoted to issues relating to small waste collection vehicles that have arisen from the literature and fieldwork in five different countries. Chapter 2 discusses social issues and how vehicles affect people and their livelihoods. Chapter 3 presents the main types of small waste collection vehicles, from simple baskets through to small motorised vehicles. Technical issues such as materials and component selection and maintenance requirements are described in Chapter 4. Chapter 5 examines many of these technical issues from the perspective of local authorities and other organisations responsible for managing vehicle users. Chapter 6 considers the design process and how best different stakeholders can be involved in the design of appropriate vehicles.

The final chapter summarises the findings, considers how best changes can be implemented and looks at where the next steps in this work should be taken.

A note on chapter headings and categories of issues

Issues in this book have been categorised under five main headings in Chapters 2 to 6. It is important to note that it is not, in reality, possible to categorise issues in this way. Issues have been placed where it was felt they best belonged, but there is considerable overlap between many of the chapters and the issues they address. For example, *technical* problems with vehicles rarely exist in isolation, because they impact the way people work (*social* implications) and may be a result of the way employers or local authorities design and manufacture vehicles (*institutional*).

For the sake of clarity, some repetition has been unavoidable.





Chapter 1

Introduction

1.1 Background

A large number of the urban poor in low-income countries (some estimates say up to 5 per cent) depend on waste-related work for their living. Most work in very poor conditions and for low wages. Many provide waste management services to wealthier parts of cities, but they themselves suffer from inadequate waste management services in the areas in which they live.

Small waste collection vehicles (SWCVs) such as wheelbarrows, handcarts, cycle carts and animal-drawn carts are well-suited to the work of small-scale waste collectors such as sweepers, door-to-door collectors and recyclers. The size and manoeuvrability of SWCVs also makes them well suited to serving the narrow, unpaved streets of low-income areas (LIAs). These simple vehicles are easy to adapt for specific tasks and relatively cheap to buy and maintain. Despite their low cost, a vehicle can be a waste worker's most valuable livelihood asset. Relative to income, the vehicle often constitutes a significant investment.

Box 1. The importance of SWCVs: Testimonies from country studies

The following testimonies from Bangladesh and Turkey illustrate the demand for door-to-door waste collection services, the good sense of using small-scale collectors and the importance of SWCVs to these waste workers.

- In many areas of Dhaka, people will not carry waste from their houses to communal bins because they are distant or inconvenient to reach. People from such areas depend on local initiatives (e.g. local entrepreneurs or community organisations) to collect their household waste, and they pay money for this service. These collectors rely on low-cost vehicles to transport waste (Kazi 2001).
- In Dhaka, the streets are mostly flat and labour is cheap so the local authority uses a labour-intensive method for city conservancy. Handcarts and cycle carts play an important role in such waste collection methods (Kazi 2001).
- Handcarts enable collectors to transfer waste easily and increase the amount they can collect. They also save people time and decrease the contact with waste. The alternative in Ankara would be to carry waste in plastic bags over the shoulder. This has been shown to cause injury to workers (Ali 2001).
- The Yeni Mahalle Municipality in Turkey has problems collecting waste from the narrow and steep streets in its area, especially during the winter when snow falls. Large vehicles cannot pass through the lanes. Carefully designed small vehicles, suited to the terrain and narrow lanes, could provide an effective and low-cost solution to this problem (Ali 2001).

Why this research?

Waste workers, mostly the urban poor, are the main users of SWCVs. The vehicles themselves are often not owned by the waste workers, however, but are provided by their employers. Employers include small businesses, community based organisations (CBOs), non-governmental organisations (NGOs) and local authorities. Many users have little or no say in selecting their vehicle types and play no part in vehicle design.

Many employers do not consider vehicle types, designs or maintenance a high priority, and overlook health and safety issues altogether. One reason for this is the cost implications of providing better designed and maintained vehicles. In addition, however, it is simply considered unimportant and beyond the capabilities of designers, and users do not feel confident or able to request better vehicles. The voices and needs of the poor are neither being heard nor considered.

Many waste workers are using uncomfortable, poorly designed vehicles which reduce their productivity and cause both short and long-term health problems.

Well-designed SWCVs could make their job more efficient, increase their income earning opportunities and make their work safer and easier.

The ultimate aim of this DFID-funded KaR project is to produce a set of guidelines in the form of a 'Vehicles Toolkit'. These will aim to increase the availability to the poor of better-designed SWCVs, thereby improving both livelihood opportunities and service provision in the low-income areas.

Why this book, and who for?

This book consolidates and distils literature, research and fieldwork undertaken in five countries during the first year of this project. It presents and discusses the emerging issues related to SWCVs. It will be of interest to:

- those who are interested in urban poverty and livelihoods issues;
- users and suppliers of waste collection vehicles;
- organisations (e.g. NGOs, donors) working in solid waste management in low-income countries;
- resident welfare associations (RWAs) interested in broader development issues and serving their waste workers well;
- senior and junior level officers in municipalities concerned with solid waste management; and,
- those who are involved with design or responsible for liasing with designers of SWCVs.

According to demand, certain parts of this book may be developed into local language or picture-guide form.

Although this book is limited to raising issues it is intended to be of practical value. This book could be of great use to those interested in gaining a comprehensive overview of the issues associated with waste collection vehicles, such as project planners, vehicle designers and municipal authorities.

This book also highlights areas of good and bad practice and of exemplary design and management processes. It is hoped that this research will facilitate the transfer of such practices, and help avoid the duplication of certain mistakes.

1.2 Research methodology

Workshop and literature review

This project began in January 2001 with a workshop. This was an opportunity for the core research team to discuss the issues, focus, scope and direction of the research. Terms of reference, fieldwork methodologies and the literature review were also discussed. A detailed literature review was then undertaken. This provided some detailed technical information relating to issues raised in fieldwork, but also highlighted issues from previous studies undertaken by others.

Most literature on SWCVs covers *technical* issues relating to vehicle design including bearings, frame strength, wheels types, payloads and brakes, etc. (Dennis and Smith 1995, Hathway 1985, Homel 1969, Intermediate Technology 1986, Thoma 1979). Some literature compares and describes the relative merits of different types of vehicles (World Bank 1975a and b) and other literature relates to small motor-powered vehicles (Barwell and Smith 1988).

Moving away from purely technical issues the amount of literature decreases. Relatively little information exists relating to ergonomic issues: the interaction of the user with the technology. Some literature discusses 'tractive efforts' in relation to incline and load (Intermediate Technology 1986, World Bank 1975a). This may be valuable and is certainly relevant, but is not covered in great detail.

There is a notable lack of literature covering social and institutional issues relating to waste vehicles. The UNCHS manual (1988) deals with some of the institutional aspects of vehicles for waste collection, but this is based mainly on larger, motorised vehicles. Social issues relating to livelihoods, gender and users of vehicles are not covered in detail by any of the literature. This constitutes a significant gap in existing understanding and literature.

Beyond technology

As with any technical subject, the consideration of social and institutional issues is essential. While purely technical issues are important, it is only by considering these in their broader context that a technology's appropriateness and sustainability can be ensured. This is particularly valid in the case of small waste collection vehicles, where the user group is varied and complex. In addition to technical integrity, the uptake of new vehicle designs is dependent on a number of factors including price, perceived convenience, gender attitudes and even culture and tradition.

Identifying these 'software' issues as a gap in research to date was an important finding and this research promises to fill this knowledge gap. The city studies have exposed many social, institutional and ergonomic issues. It is hoped that this book will take the first steps towards combining technical and non-technical problems and defining appropriate solutions.

Country studies

Fieldwork for this book has been undertaken in five countries chosen to highlight a broad range of issues. The research was centred around waste collectors, but officers from the municipality, waste dealers, recyclers, vehicle manufacturers and householders were also consulted. The research method was informal and flexible, but mainly involved detailed observation and informal discussions / semi-structured interviews. The TOR for the fieldwork is outlined in Appendix 2. Research was undertaken in the following cities:

- Lusaka, Zambia. (Jonathan Rouse, February 2001)

  Formal waste collection services exist in Lusaka but there are also smaller scale door-to-door collection services in low-income areas. The latter service providers are the main users of small vehicles.

- Ankara, Turkey (Azhar Ali, March / April 2001)

  In Ankara waste collectors (referred to as kapicis) are employed by blocks of flats and are issued with wheelbarrows and handcarts. Informal waste work such as waste picking is illegal in Turkey, but some takes place nevertheless. Waste pickers also use SWCVs.

- Delhi, India (Jonathan Rouse, January 2001)

- Dhaka, Bangladesh (Dr Noor Kazi, March / April 2001)

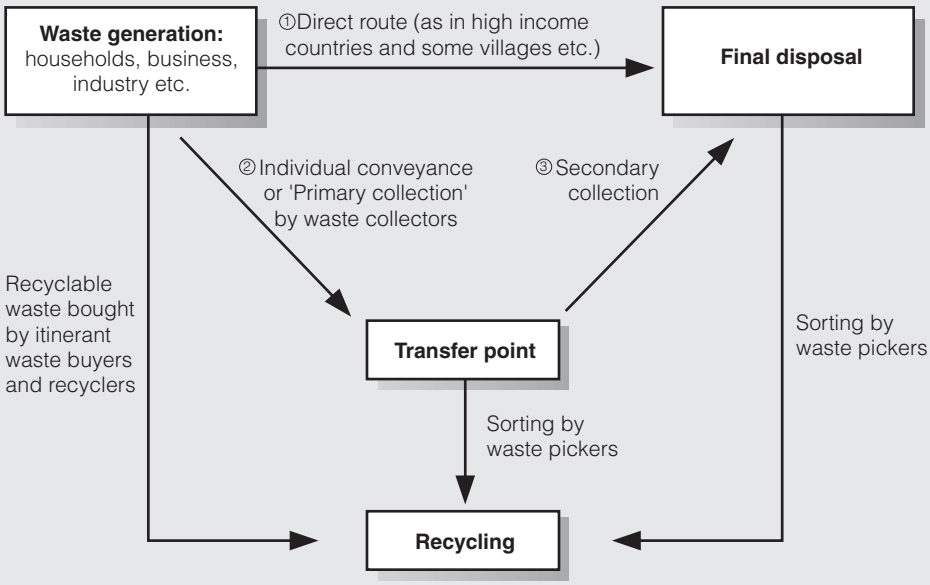
- Karachi, Pakistan (Engr SM Shakaib, March / April 2001)

  Delhi, Dhaka and Karachi all have extensive and well-organised informal sectors responsible for primary waste collection. This industry is a major user of SWCVs. The municipalities are responsible for secondary waste collection and for providing wheelbarrows to sweepers.

1.3 Solid waste management

Solid waste is material which no longer has a value to its generator and is hence discarded. This research is mainly concerned with household mixed waste. This generally comprises dry waste (paper, plastics, glass and metals) as well as wet organic matter (vegetable peelings and spoiled food). It may also contain hazardous objects such as spent batteries, used oil and clinical waste (sharps, used dressings, etc.). In certain circumstances faecal matter may be mixed with solid waste, for example where inadequate sanitation exists and open defecation is not an option.

Box 2. Solid waste management processes



Formal sector: includes local councils, environment agencies, municipalities and regulated NGOs and private sector contractors. Mostly responsible in urban centres for paths ① and ③, and occasionally ②.

Informal sector: includes all unregulated actors including waste pickers, self-employed waste collectors and waste buyers, dealers and recyclers. It may include employees of local initiatives and community development groups.

Good management of solid waste involves its removal from the point of generation, transport and final disposal or processing, all undertaken in a sanitary manner.

Waste is generated by households, businesses and industries, and requires collection and disposal. In most high-income countries, the collection and transportation of waste from point of generation to final disposal is the responsibility of local authorities, who remove the waste from the point of generation and dispose of it directly (see ① in Box 2).

In many low-income countries the local authority's responsibility for waste begins at a 'transfer point'. A transfer point is an intermediate place where waste is deposited and stored before being transported to the final disposal site. It can be anything from a plastic bin to a concrete construction, and is sometimes just an unplanned open space. Transfer points are known by a number of names, including *transfer stations*, *transfer facilities, transfer areas*, *midden boxes* and *communal bins*. The term 'transfer point' is used throughout this document for the sake of clarity and consistency. These variations are discussed in more detail in Chapter 4, and are relevant to discussions on vehicles because they play a part in dictating how they are used and emptied.

In low-income countries it is the responsibility of waste generators (householders, etc.) to get their waste to the transfer points. Many do this themselves, but wealthier households and businesses often employ a waste collector. This stage is indicated by ② in Box 2, and is referred to as *'primary collection'*. Local authorities then collect waste from the transfer point and convey it to the final disposal site. This stage is indicated by ③ and is referred to as *'secondary collection'*.

The recycling industry also plays a significant part in waste management in low-income countries. 'Itinerant waste buyers' purchase recyclable materials (e.g. glass, paper, metal) direct from households, and waste pickers sort through waste on the streets, at transfer points and at final disposal sites. Waste buyers and pickers both sell waste to recyclers, sometimes via a number of dealers.

Solid waste provides livelihoods for many thousands of waste collectors, buyers, pickers, dealers and recyclers. Many waste workers work in the informal sector and most constitute the urban poor. Many use small vehicles to transport waste.

Itinerant waste buyer in Karachi

1.4 Key stakeholders

Waste collector in Dhaka

Users of vehicles

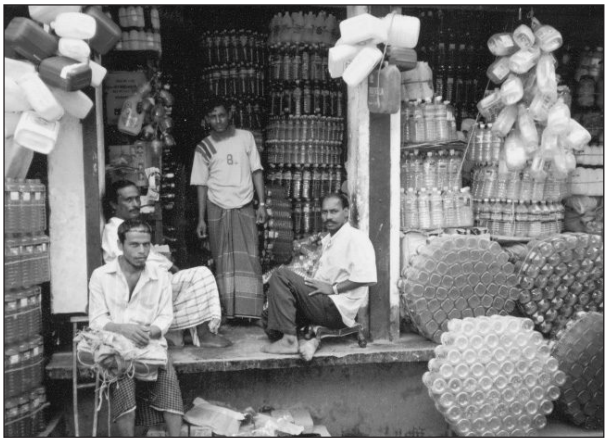
The biggest group of small waste collection vehicle users in low-income countries are door-to-door waste collectors and sweepers. These may be men, women or children, sometimes working together. In many low-income countries this group enjoys a low status in society and is marginalized from 'public' services. In parts of South Asia, for example, they will often be from lower castes and may be looked down upon by many as lower-class citizens.

Many collector's livelihoods rely heavily on their waste collection vehicle. For example, without a vehicle, door-to-door collectors have to carry waste by hand in small loads, slowing down their work and making it more unhygienic. The design, comfort, durability, reliability and, if privately owned, initial cost of vehicles, impact this group the most.

Householders

Householders are generators of waste. The livelihoods of many collectors depend solely on being paid by householders for the service of collection.

Waste dealers and recyclers



Plastic bottle dealer in India

Waste dealers and recyclers buy recyclable waste such as paper, glass, plastic and metals from collectors. They either recycle it themselves or sell it on for recycling.

In some countries a supportive relationship exists between dealer and collector. Sometimes dealers lend money to collectors to buy vehicles (Rouse 2001b).

The design of vehicles can affect the dealer's businesses. Some designs ease segregation of waste, for example, thus increasing the quantity and quality of recyclable waste sold to dealers.

Employers and decision-makers

Employers and decision-makers include businesses, community-based organisations and local authorities employing street sweepers and collectors. In many cases employers provide vehicles to workers.

Vehicle designers

This group consists of government designers (officers or municipal engineers), technical advisory units (e.g. a part of a university) or independent designers (ranging from qualified engineers to roadside workshop workers). In some cases designers work directly with waste collectors, but more often have very little contact with users. In addition, many designers have little or no experience of using the vehicles or understanding of the work for which they are intended (Coffey 2001).

Manufacturers and repairers

Manufacturing a handcart in Dhaka

This is a diverse group ranging from large municipal manufacturing and servicing units down to roadside workshops which undertake basic repairs and maintenance, such as puncture repair.

Chapter 2

Social issues

2.1 Users of vehicles: A closer look

The users of SWCVs are mainly poor people, working in primary waste collection, street sweeping and drain / sewer cleaning. Waste work is often stigmatised and in many countries those who undertake it hold a low status in society. It is possible to generalise the characteristics of users of SWCVs across the countries studied. They are generally:

- poor people living and working in urban areas;
- mostly, but by no means exclusively, men;
- from lower social / caste groups; and
- a mixture of individuals working independently ('informal sector') and employed by local authorities, businesses and NGOs.

A large number of vehicle users work as part of the informal sector. Not falling under any formal legislative structure, entrepreneurs are free to work as they wish, and there is often a complex social and institutional structure which supports the fabric of their livelihoods. Informal sector workers are often vulnerable and powerless over changes 'from above', (e.g. government legislation, large-scale private sector competition, etc.), which do not always recognise their work. In addition, informal sector workers rarely enjoy the rights, status, powers or respect of formal employees, and have less bargaining power with their employers.

Of the workers in the five cities studied, one group in Ankara stands out as being well respected and treated. In Ankara the law dictates that each block of flats over five storeys must employ a waste collector (called a *kapici*) to remove waste to a transfer point. Because of their more formal status k*apicis* enjoy fair pay, social

security, healthcare and free housing and command higher levels of respect and bargaining power with their employers (the householders) than waste workers in other countries (see also Box 20) (Ali 2001).

By contrast, the situation for *harijan* (low-caste) workers in Dhaka is representative of many waste workers encountered during fieldwork in other countries. Box 3 describes their situation.

Box 3. *Harijan* collectors in Dhaka

More than 7500 *harijan* live in Dhaka working as waste collectors and cleaners. They are originally Indian migrants and more than 50 per cent are women. *Harijan* literally means 'children of God', a name given to this low-caste group by Gandhi. They traditionally work in low-status jobs. Sandha Rani lives with her husband and four daughters in a single-room flat with acute water and sanitation problems in Dhaka. The flat is in the City Colony, and is provided by her employers, Dhaka City Corporation. Recently more people have arrived from India to work as sweepers. These are mostly Muslims and there is reportedly competition for work. This may indicate rising urban poverty and shortage of employment.

(Kazi 2001)

Attitudes to their own work

Waste workers' attitudes to their work vary considerably. Many said they were content doing waste collection work (Rouse 2001a) although this may simply constitute an acceptance of lack of alternatives. In Ankara a number reported that they would rather be doing different work, such as painting and poultry farming (Ali 2001).

Two men in Central Delhi, Subir and Mukej, are employed by a fast food store to take waste to a transfer point. They use a wheelbarrow and partially sort the waste to sell recyclable items. Before getting this job Subir was a rickshaw-taxi cyclist, and said he preferred this work because it was easier. He also said he would happily become a door-to-door collector if given the opportunity. Mukej felt that this work was dirty and unpleasant but said that he had no choice and that he could not do any other work (Rouse 2001a).

In the Indian subcontinent, waste work is not considered a stepping stone to other, better jobs, and many workers said they had no intention of changing (Rouse 2001a2, a6, and a8). Waste collectors working for the local authorities in Delhi

and Karachi have often been doing so for many years and consider their jobs to be secure. This is the same in Bangladesh, where a number of Dhaka City Corporation employees have worked as collectors for up to twenty-five years. The biggest threat to their livelihoods is a change in the way DCC collects waste, such as a move towards private companies undertaking door-to-door collection. In contrast to findings in India, 70 per cent of waste collectors in Dhaka intended to change and improve their livelihoods in the future, aspiring to become recyclable waste dealers or open a small shop. If collectors in Dhaka lost their jobs many men said they would operate cycle rickshaws and women said they might become maids.

Kazi (2001) reports that some workers in Dhaka find the work exhausting and that the constant lifting causes fatigue and back problems. There seems to be little regard or concern for health and safety among waste workers or authorities in general. Throughout Delhi, Dhaka, and Karachi working conditions are poor and unsanitary, and workers rarely take precautions against injury or infection from waste. This is true of almost all low-income countries.

Other livelihood opportunities

The waste collectors' most common income supplement is from the sale of the recyclable items they collect from households (e.g. paper, metals and glass). This practice is widespread even among local authority employees for whom it is generally illegal. Fieldwork in Karachi suggests that up to 50 per cent of collectors in middle-income areas separate waste. Those who collect from many houses are less inclined to separate waste because they earn a sufficient amount from collection charges alone. In some instances a waste collector will work with a waste picker. The latter separates the waste as the collector brings it to the vehicle.

Some collectors clean the streets around the houses on their round for extra money. One female collector called Mira said that she was paid extra by some households to clean the toilets; also considered to be a 'low-status' job in India (Rouse 2001a8). Collectors also sweep people's yards for extra payment, particularly, in higher income areas.

In Dhaka, Kazi (2001) describes how informal waste collectors often serve relatively few householders and so have time to undertake other work such as rickshaw cycling, selling vegetables, and recycling waste after completing their collection work. Sweepers working for Dhaka City Corporation rarely undertake additional jobs, though many earn money from door-to-door waste collection in areas where they are employed to sweep the streets.

Mutual support among waste collectors

DFID define strong social capital as 'a supportive and cohesive social environment' resulting from good relationships between individuals and their colleagues, friends and family (1999: 2.3.2). Where the poor are often lacking other forms of capital, their social capital is often strong (Rouse and Ali 2001).

In a suburb of Delhi, collectors described how they knew all the other collectors in the area. Often collectors were related, or at least from similar castes, backgrounds or religions. This affected both how people got jobs and conflict resolution amongst the workers. Many collectors consulted in Delhi and Dhaka said they secured their jobs (formal and informal sector) in waste through social networks (Rouse 2001a2). Local authorities in Delhi (DMC and NDMC) also reported that they would sometimes recruit workers based on recommendations from existing sweepers.

Collectors in Delhi said that arguments over round size were rare because everyone knew who should be collecting from where. Good social relations make conflict resolution easier and reduce competition.

Strong social ties existed across the wide wealth and caste barriers in Delhi, where householders remained faithful to certain collectors even when other services became available. This was because good relationships existed and householders recognised the collectors' employment needs. The good relationship and trust are valuable to householders too, because collectors often enter homes to collect waste.

Ali (2001) relates an example of *kapicis* helping waste pickers in Ankara. The *kapici* would sort the waste and leave the recyclable portions aside for the pickers to collect. This meant that the *kapici's* job was easier because the pickers would not break his bags open, and the pickers would get cleaner and ready-sorted waste. It is possible that financial transactions were also involved though these remained undisclosed to the fieldworker.

2.2 The effect of SWCVs on people and their livelihoods

'Since being given this cart my hands have healed and the work is much cleaner. I can also complete my work in a much shorter time because I can carry more, and have to make fewer trips to the local dump every day.'

A door-to-door collector in South Delhi (Rouse 2001a7).

Without a vehicle, waste is carried by hand, under the arm, on the head in a basket or over the shoulder in a sack. These methods:

- limit the amount which can be carried and rely heavily on the fitness and strength of the worker. Strength is often related to gender and age, and was raised as an issue in Lusaka and Delhi (Rouse 2001 a and b). Carrying heavy loads can cause strain and injury; and

- require closer contact with waste than using a cart or barrow. Carrying waste on the head is particularly unhygienic because it can fall on the face.

Access to well-designed SWCVs can make waste collection work more efficient, lucrative and safe. Small vehicles enable the user to carry more waste further, with much less effort than by hand. This levels out gender inequalities and means that weaker or disabled people could undertake similar waste collection work. In circumstances where transfer points are far from the collection area, travel times can be significantly reduced by using hand or cycle carts because of both increased speed and increased capacity, meaning more waste can be transported per journey (Rouse 2001a and Ali 2001). Containerised vehicles (see Section 4.3) enable the user to sort waste easily, which can help collectors supplement their incomes by selling recyclables. They also minimise the direct handling of waste.

It is important to note that small vehicles are used for a variety of purposes other than waste collection. In Delhi, when their waste collection work is finished, some collectors hire out their cycle-carts to builders or merchants wishing to transport goods. This is a further potential source of income.

2.3 Gender

An elderly woman called Mira used to collect waste from many households in a wealthy suburb in Delhi. The number of customers she serves has fallen since the

Resident Welfare Association formally contracted a private waste collection company. She says:

'the contractors will only employ men. We women are powerless and can't say anything. There is no chance of being employed by the contractors. Also, the men dump rubbish further away [because they can carry it more easily] which the householders and contractors like.'

In another area of Delhi, women collectors reportedly charge less than men for (according to residents) a *better* collection service in the same area. While men just collected waste, the women collected waste and carefully swept the streets. This may be because one or both parties are giving incorrect figures for what they charge or pay, but may be show the differences between men and women's earning potentials, particularly in the informal sector (Rouse 2001a7 and a8).

Gender issues arise in various parts of this book, but this chapter seeks to raise some of the general issues.

Physical strength

The physical strength of men puts them at a relative advantage in waste collection work. In general, men are able to carry greater loads further and faster with less risk of injury or strain. In Lusaka, for example, members of a women's CBO who had designed their own cart and collection system employed men to push their carts around the collection area simply because, they said, they were not strong enough[1] (Rouse 2001b).

Woman in waste workers' family in Dhaka

The easiest way to empty many carts is to upturn them, which can be very physically demanding. This is discussed further in Section 4.3 but there are certain gender-specific issues which are explored here. Women or weaker users are often unable to do this alone, and this may mean they have to work in pairs which may reduce individual earnings. Alternatively, in order to avoid heavy lifting, they may empty the cart by hand. This is slower and increases contact with the waste and hence their chances of contracting disease.

[1] The difficulty in pushing vehicles in this instance was compounded by the uneven and muddy road surfaces

Most vehicles are designed with men in mind, and are suited to their strength and height. There are some examples where technologies have been adapted for women. In Delhi, the height of a hand cart issued by the municipality was said to have been altered to enable women to use it, and a front wheel added to help carry the weight (Rouse 2001a3). In other places women have been issued with shorter brooms more suited to their height.

Societal, cultural and religious norms and practices

Certain societal, cultural or religious norms or practices dictate the activities and roles of women. In certain cases these limit what women do and what vehicle they can use. For example, fieldwork revealed that women could not use cycle carts in Delhi because 'they do not traditionally cycle' and in Dhaka because riding a bicycle would require a woman to wear different clothing (i.e. trousers) which is considered inappropriate. As a result they are restricted to the use of wheelbarrows and handcarts.

The range and capacity of wheelbarrows and handcarts are generally less than for cycle carts, so this taboo might effectively be imposing a ceiling on the number of houses from which a woman can collect on a given day. This would in turn limit their earning potential. There are also time implications which may give men using cycle carts a further comparative advantage over women using handcarts. A man with a cycle cart can reach a transfer point faster than a women with a handcart and would have to empty it less frequently because of its greater capacity.

An interesting issue emerged in Delhi, where an NGO provided women with a cart with solid tyres but provided men with cycle carts with pneumatic (inflatable) tyres. While the NGO accepted that pneumatic wheels were superior to solid (see Section 4.4), they did not put these on the women's vehicles because 'women do not know how to mend punctures'. This statement is likely to have meant 'women do not know how to mend punctures because they are not traditionally expected (or perhaps *willing*) to undertake this kind of work', because of course most people regardless of sex or age can easily learn (Rouse 2001a).

Entering houses

The women consulted in this research often considered themselves, and were considered by others, to be more vulnerable to attack (particularly of a sexual nature) than men. Waste collectors often enter homes to collect waste from a courtyard or kitchen area. The threat of attack may make women reluctant to enter houses and thus they miss out on work. In certain situations, however, women have an advantage over men. In Islamic countries such as Bangladesh and

Pakistan a system of *'purdah'* operates wherein households, or parts of households, are out of bounds to all men other than close family, to preserve the privacy of the women. Women and children are permitted to enter these areas, however, which means that householders will often feel more comfortable with a woman or boy collecting their waste than a man.

In Hyderabad in Pakistan, men and women work together. The man pushes the cart while the woman goes into the homes to collect the waste. Thus, they can get waste from all homes and the woman feels safe.

Two further examples of ingrained attitudes towards vehicles and their use are described in Box 4. They further illustrate the power of social norms.

Box 4. Who rides bicycles?

Attitudes towards who uses what vehicle apply to groups other than just women in Bangladesh.

- In Dhaka the wealthy can easily afford bicycles but, because of the status (even stigma) associated with those who ride bicycles, only the poor use them. Gallagher (1992:212) notes that 'this is very much the situation in India where bicycle ownership is highest among the skilled working class and lower middle class people but declines at higher income levels'.
- In parts of Africa it is not acceptable for a man to 'do the work of a donkey' and so handcarts are not used, except perhaps where poverty forces people to neglect this social norm (Coad 2001).

2.4 Complaints and expectations

This section explores people's expectations of comfort and safety and their attitudes towards vehicles, maintenance and their employers.

Why don't people complain?

To learn how waste collectors feel about their vehicles, a number of collectors in Delhi were asked what improvements they would like to see to their vehicles. Most users replied 'It is not possible – we have no power to change the design. They are fine.' Box 5 below describes a similar situation elsewhere in Delhi and some of the possible reasons for people's unwillingness to feed back and complain.

Box 5. Feedback from users

An NGO in Delhi provided vehicles to people in their waste collection programme. They have never received any complaints about their vehicles. This may be because:

- users are genuinely happy with the vehicles and see no reason to complain; or,
- no complaints / feedback procedure is in place so complaining is simply not possible.

It may, however, be because:

- users do not believe anyone will listen to their complaints so do not bother to complain;
- there is no general 'culture of complaining' amongst users – the poor. They are neither expected to, or used to, complaining;
- users' expectations of their vehicles are low. They are resigned to 'make do' with poor technology which is inconvenient and uncomfortable and so complaining does not occur to them; or,
- although they experience problems, users do not know that their vehicles *could* be better, so find no reason to complain.

These point to two things: an unwillingness to complain, and low expectations of technology.

It is interesting to juxtapose these attitudes with those in the West. In much of Europe and the US there is a high awareness and expectation of comfort and safety and people are aware of their rights. As a result people are inclined to make demands on their employers and authorities, who are bound to respond. Indeed people are often encouraged to feed back and complain.

In many developing countries it is only the wealthy who feel sufficiently empowered to speak out, and it is the wealthy who are most likely to be heard and elicit responses from authorities. The poor, however, may face difficulties at many levels. Even gaining access to those in power could be a problem – for example many may not feel comfortable entering a government office if they do not own a shirt and shoes. When the poor do reach authorities they are often not taken seriously, and it is often justifiably assumed that they are powerless to take complaints further. This is often true, though there are some remarkable examples of where the poor have mobilised forces and brought about change.

While the educated throughout the world have high expectations of what technology will deliver, this may not be the case for the poor. They are accustomed to using poor technology which facilitates work rather than makes it easy. Many waste collectors' work is drudgery, and their expectations for help from technology may simply not be there.

Why don't people fix things?

Throughout this research examples of problems with carts emerged which were sometimes met with great ingenuity, but at other times not dealt with at all.

'Why don't people fix things?' is a question which fieldworkers cannot help reflecting on when studying SWCVs. To take an example from Delhi: a cycle rickshaw belonging to a collector in Delhi had three flat tyres, making the heavy cart almost impossible to push. The waste collector could not say why he had not fixed the cart. It may be that he just decided to 'make do' or that it had not occurred to him to fix it (could this really be?). Or it may be because he simply could not afford to buy new inner tubes, or because, having repaired the tyre many times, he realised that this design and specification of tyre was simply not *worth* repairing because it failed so frequently. Understanding issues like this is important for this study as they point to important attitudes of users and should guide aspects of design.

Box 6 takes this a step further using the example of waste collectors employed by the local authority in Delhi.

Box 6. Broken handcart handles in Delhi

Throughout the fieldwork in Delhi many wheelbarrows and handcarts were found to have broken handles, often leaving sharp metal stubs. While a number of users bound the handle stubs with cloth to make using the vehicle safer and more comfortable, many had not and continued using the cart in this state. Why did users not make this simple improvement?

Ali (2001) describes how the handles of a handcart used by a collector in Ankara had broken, again leaving sharp metal stubs. When asked why he did not repair this the collector replied 'I only use the cart for a very short period each day. It is a low priority.'

What about those users who push their carts for many hours every day? Time is unlikely to be a constraining factor as binding the handles would be a quick job, and finding cloth would never be a problem for a waste collector. Other possible reasons include:

- users had become used to the stumps and hardly noticed them now;
- in relation to other concerns it is a low priority; or
- it simply did not occur to them. Their expectations for comfort are low and they simply accept such inconveniences.

There may be other less obvious reasons:

- If they bound the handles in cloth they would get wet and uncomfortable after rain, or become dirty and difficult to clean after handling with soiled hands.
- Users want a proper repair undertaken by their employer and are concerned that if they alleviate the problem, the repair would never be undertaken.





Chapter 3

Vehicle types

This section introduces the range of methods used for carrying waste in the countries studied. It begins with the most simple examples (head baskets and sacks) and ends with the most expensive and complex (motorised vehicles).

3.1 Head baskets and sacks

Where they are found:

- Delhi
- Dhaka
- Lusaka
- Karachi
- *Many other places*

Waste picker filling his sack using a basket

Waste workers in Karachi lifting waste onto their heads

Characteristics

- Cheap and can be locally manufactured
- Suit all terrain, but have a limited range
- Light weight
- Little chance of theft
- Hygiene issues associated with close contact with waste and liquid leaking through the basket
- Relatively little waste can be carried in this way. The individual carries the full weight (i.e. it is not shared by wheels)

This is the most basic form of transporting goods, and is used by most waste pickers in South Asia who cannot afford a vehicle. The boy shown in the photograph above has no shirt on and risks injuring himself as he slings the sack over his shoulder, as sharp pieces of metal or glass could break through the sack. When waste is carried on the head in a basket, waste or leachate leaks through. This is an unpleasant health hazard.

3.2 Yokes and simple back frames

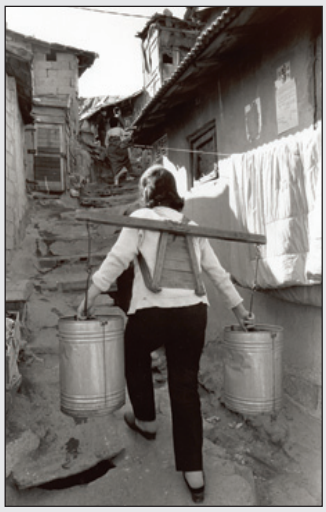
Where they are found:

- *None of the study countries use these for carrying waste, though they are used for carrying goods like vegetables.*

Characteristics

- Low cost, easy to use, can be locally manufactured and is low maintenance.
- Manoeuvrable in crowded alleys and up steep hills and steps where wheeled vehicles cannot operate.
- Can be a safe and comfortable posture for carrying.
- Full weight is borne by the user, so payload smaller than most wheeled vehicles.
- Range limited by strength of user.

Back frames and yokes used for carrying waste were not encountered during this research, though milkmen and vegetable sellers in South Asia often use them. These can offer a hygienic and comfortable way of carrying waste away from the body.



Woman using a simple back frame in a steep alleyway (Mark Edwards/Still Pictures)

3.3 Wheelbarrows

Wheelbarrows are the most basic of wheeled vehicles. Broadly speaking, two main forms of wheelbarrows exist: the 'Western wheelbarrow' and the 'Chinese style wheelbarrow'.

Western wheelbarrow

Where they are found:

- All fieldwork areas
- *Many other places*

Characteristics

- The most basic of wheeled vehicles
- Wheelbarrows are cheap and can be locally manufactured
- Excellent manoeuvrability

Typical Western wheelbarrow, Lusaka

- Higher payload than yoke / back frame, but usually a relatively small volume
- The user bears a large proportion of the weight but less than when using baskets or yokes
- Poor posture for user during operation (crouched)
- Unstable compared with vehicles with more than one wheel
- Cannot be used on all terrain and unsuitable for long distances
- Wheels with good quality bearings are preferable as these make the vehicle much more efficient. Bearings are more expensive however.

Wheelbarrows encountered during fieldwork were exclusively of the Western type, though there are variations on this design. Most are of the classic pressed-steel design as in Lusaka (above), Dhaka, Karachi, Delhi and Ankara. They are issued as standard SWCVs to employees of the municipalities in Delhi. They are also very common on construction sites. Other designs include the traditional design shown opposite.

Traditional wheelbarrow

The Western wheelbarrows had a number of recurrent problems:

- The handles often snap off leaving sharp stubs.
- The wheels have primitive plain bearings and become stiff to move when they become dirty.
- They have a short range.
- Users find them difficult to push; and,
- Users have to lift much of the weight of the load (Rouse 2001a6 and b).

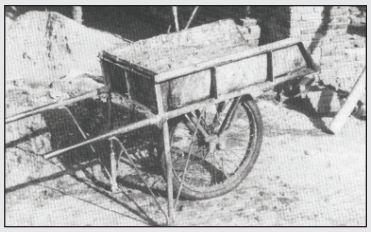
A wheelbarrow is simply a lever. The wheel is the pivot, the weight of the load pushes down and the user pulls up. Ideally, to minimise the lifting required by the user, the wheel should be situated directly under the load, so that it (rather than the user) takes all of the weight. This means that all the user has to do is push the wheelbarrow *forward*, rather than lift the weight *as well as* push it forward. The main disadvantage of a Western wheelbarrow is the fact that the user bears most of the weight of the load, because the centre of gravity of the load is situated far back from the wheel.

The concept of a wheelbarrow where the wheel is situated directly under the load, reducing the distance from the load to the pivot and thus the moment to almost zero, is realised in the Chinese-style wheelbarrow.

The Chinese wheelbarrow

This might be considered a hybrid vehicle – combining characteristics of the Western wheelbarrow with some of a handcart.

Advantages: A Chinese wheelbarrow is designed so that the single wheel is situated directly under the load, meaning that the vehicle is balanced. The wheel is also generally larger than on Western wheelbarrows, making it easier to push over uneven ground. This design means that only a small proportion of the load is supported by the operator.



Photograph reproduced by kind permission of IT Publications

Disadvantages: Has a high and relatively unstable platform for loading, is difficult to balance because of the high centre of gravity, and requires some skill to operate. Widely-spaced handles (and sometimes shoulder straps) help to balance the load.

(Adapted from Hathway 1985:33)

3.4 Handcarts

Where they are found:

- Ankara
- Delhi (also some containerised handcarts)
- Dhaka
- Lusaka
- Karachi

Characteristics:

- More expensive than a wheelbarrow but simple and can be locally made
- Requires solid and relatively level surfaces for operation
- Larger payload and longer range than Western wheelbarrow
- If well designed, user supports little of the weight of the load
- Wheels with sealed bearings are preferable, though these raise the price

The handcart in its simplest form is a small step up from the Chinese wheelbarrow – the main difference being that it has more than one wheel and is therefore usually more stable. As with wheelbarrows, if the axle is placed near the centre of gravity of a two-wheeled handcart, the user will not need to support much of the weight. Some handcarts have three wheels and the user then need only propel the cart and not lift at all. One such example was found in Delhi where women had an extra (front) wheel added onto their two-wheeled handcarts for this reason.

The problems associated with the handcart are the same as with wheelbarrows and concern poor balance and limited range. Handcarts with smaller wheels and poor bearings are difficult to push, and recurrent problems such as handles snapping off are common.

Simple handcart with motorcycle wheels, Lusaka

Crude iron handcart in Delhi

Waste picker's trolley in Ankara (Azhar Ali)

3.5 Cycle carts

Where they are found:

- Delhi
- Dhaka

Characteristics

- More expensive, but can use adapted local bicycle / rickshaw parts and technology
- Often very low-cost designs are ergonomically poor and inefficient
- Large payloads possible of up to ~ 500kg
- Wheels with sealed ball bearings essential – though again these increase the price and require maintenance

Heavily laden cycle cart in Delhi
Note the bags for sorted (recyclable) waste hung around the container, strengthened front forks, lack of pedals, and use of normal bicycle wheels

- Requires firm and level road surfaces for operation
- Precision parts (e.g. bearings) may need to be imported, which will increase the price

Cycle carts are used for waste collection throughout South Asia and other parts of the world. They enable the carriage of goods far heavier than an individual could carry alone or using a wheelbarrow or handcart. Their design is often based on an adapted front half of a standard bicycle with the addition of a rear cart section with two wheels.

Cycle carts share the same basic design as cycle rickshaws (also known as 'cycle taxis'), the popular mode of transport in many Asian cities. Gallagher (1992) undertook a detailed study of cycle rickshaws in Bangladesh. He found that the majority of cycle rickshaws (and hence cycle carts) were not well designed and were difficult – and dangerous – to use. Box 7 outlines some of his findings, all of which are transferable to cycle carts.

The research with cycle carts in Delhi revealed certain common and recurring problems. In fact nearly every component except the main cycle frame was described as being problematic or too weak by one or more of the collectors consulted. Some particular, recurring, complaints were that:

- the carts are too heavy to cycle when full so are pushed from the handlebars. The handlebars and forks then snap off because of the pressure;
- when pushing the cart the pedals hit the user's legs and so are often removed; and
- the wheels, tyres and inner tubes used on the carts are often just normal bicycle parts and not suitable for the weights transported. Buckling of wheels and punctured inner tubes are frequent occurrences and cost the users and contractors money and time. Fear of damage to wheels may also lead to collectors wishing to empty their vehicles more frequently and this results in more travel time to transfer points / dump areas (Rouse 2001a2 and a7).

Cycle carts are, however, an appropriate technology and are used widely by waste collectors for whom they are an invaluable asset.

Box 7. Problems with the cycle rickshaw in Bangladesh

The basic structure of cycle rickshaws and cycle carts are very similar throughout South Asia, so design faults and problems are common to both. Gallagher (1992) made a study of the design of rickshaws in Bangladesh and found that it was very poor and there was considerable potential for improvement. He found the following problems:

- *Unnecessarily heavy frame*. The frame of a rickshaw is often based around the front half of a normal bicycle with a crude rear chassis. By more careful design it is possible to make a chassis which is stronger and lighter, using the same materials.
- *Poor gearing.* Few rickshaws have more than one gear, and this is often set very high. This makes cycling uphill almost impossible even without a load, and for heavy loads makes cycling very difficult even on level ground.
- *Poor transmission.* The transmission (chain and gear arrangement) is often poorly designed, absorbs energy from the cyclist, and the chain often skips off its sprockets. In addition, only one rear wheel is driven because there is no differential (a component which distributes power through both wheels whilst allowing them both to move independently).
- *Inappropriate wheels and tyres*. Often normal bicycle wheels are used, which are simply too weak for the loads carried. See Section 4.4 on wheels for more details.
- *'Trail' on steering*. The front wheel of a bicycle is set to have 'trail', which means that the axis of the front fork extends to beyond where the tyre touches the road. This enables stability on a bicycle, but causes the handlebars to tend towards full-lock on a tricycle (i.e. a cycle cart or rickshaw). The front fork (highlighted by all users as a particularly weak point) needs to be re-designed to be stronger, and without trail.
- *Ineffectual brakes.* Many rickshaws only have one brake on the front wheel. This means that despite carrying loads many times greater than any bicycle, they have less than half the braking power. As little as 18 per cent of the vehicle weight is on the front wheel which makes it liable to skidding, further reducing the effect of the brake.
- *Poor ergonomic design*. The arrangement of pedals, saddle and handlebars means that the cyclist has to adopt very poor posture to deliver sufficient power to propel a heavily laden rickshaw.

Adapted from *'The Rickshaws of Bangladesh'* Gallagher (1992)

Gallagher makes the interesting point that there is no reason for the rickshaws being so difficult, uncomfortable and dangerous to operate. He cites the example of the rickshaws which operate for tourists around parts of central London. These are lightweight, designed with ergonomics in mind and are easy to cycle, turn and stop (Gallagher 1992).

3.6 Animal carriage

Where animals are used:

- Delhi
- Dhaka
- Karachi
- Many other places

Characteristics

- Longer range – limited only by fitness of animal

Buffalo cart in Lahore

- Cart design can be simple and locally manufactured
- Buying and keeping an animal can be expensive, and the illness / death of the animal could result in loss of income
- Payloads of over one tonne are possible

Carts

Throughout the developing world domesticated animals are used to pull simple sledges or carts for transporting materials and people. Few animal carts were encountered during fieldwork except in Karachi, where they are used extensively for waste collection on the outskirts of the city. Animal carts can carry the largest possible amount of waste of all non-motorised vehicles. Dennis and Smith (1996) choose not to describe them in great detail in their book *'Low-cost Load Carrying Devices'* because they are relatively expensive. Waste collectors are generally amongst the poorest of the poor, and as such most could not afford to buy, keep, or have space for an animal and cart. There is also growing legitimate concern about the welfare of animals used for drawing loads. This is perhaps particularly relevant in urban areas which might be considered wholly unsuitable for animals.

Panniers

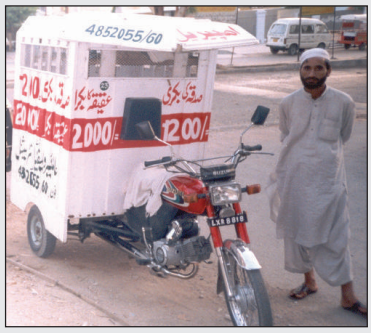
In cases where terrain is very rough, animals can also carry loads directly on their backs in panniers, and can traverse terrain which no vehicle could navigate. In South Asia it is common to see mules or donkeys with building materials or sacks of grain and rice slung over their backs. This method of carrying goods is very low cost, but it is important to design a basic frame properly to protect the animal from injury and ensure that it is comfortable. Because of the limited volume of panniers compared to a large cart, they are best suited to denser materials such as sand, rocks and grain, and so would perhaps not be an economic way to transport waste.

Other literature

There is literature devoted exclusively to animal-drawn vehicles. Dennis and Smith refer the reader to Barwell and Hathway (1986) for more information.

3.7 Motorised vehicles

Motor rickshaw adapted for hospital waste collection in Dhaka



Motorised vehicle based on a motorbike in Karachi

There is a growing trend towards motorisation in small vehicles, and motorisation was the main improvement that a number of collectors independently mentioned they would like made to their vehicles (Rouse 2001a6). This was more the case in the Asian case studies than in Ankara and Lusaka.

There have been a number of attempts to add motors to existing vehicle designs. Gallagher (1992) describes the process of motorising tricycles (i.e. cycle carts). He states that in fact these designs are inappropriate even for use at low-speed pedalling, so terrible if further stressed at higher speeds by a motor. Simply adding a motor to existing vehicles is not a viable option. If motorised vehicles are to be introduced, then it is necessary to design new vehicles or at the least carefully adapt existing vehicles.

Shakaib suggests that motor vehicles are the way forward for Karachi. He suggests using a small motorcycle converted into a three-wheeled vehicle (see photograph above) and a type of small and low-cost diesel vehicle already in use in China. He proposed that door-to-door activities would increase and there would be a financial benefit to workers (Shakaib 2001). The main hurdle to the use of motorised vehicles is cost – both in terms of initial outlay as well as ongoing maintenance.

This book is devoted mainly to non-motorised vehicles for a number of reasons. The most fundamental and important reason is that most waste collectors in low-income countries are now using non-motorised vehicles. In addition, non-motorised vehicles provide the lowest-cost and, if well designed and integrated into the rest of the solid waste management system, most appropriate and affordable transport solution for waste collectors.

Given population increases, more, faster-moving traffic on the roads and prohibitions on slower vehicles arising in some cities, it is important to remain open to small motorised vehicles as an option.

3.8 Other equipment

Examples:

- Brooms
- Rakes
- Hoes
- Hooks (for sorting waste)
- *Panjas* (two pieces of wood for picking up waste from streets)
- Drain scrapers

Sweepers using short reed brooms in Karachi

Waste collectors use a number of other items of equipment in addition to their vehicles. Some are approved and supplied by local authorities, while others are bought or made by collectors themselves to make their jobs easier (Kazi 2001).

Generally speaking the tools used in South Asia are of poor quality, not strong enough so they break frequently and are not comfortable to use. Heavy materials are often used for manufacture and little attention is paid to the size of users and their physical strengths. The size and type of brooms, for example, could vary considerably. Ideally, a broom is designed to enable sweeping to be undertaken without bending, but many brooms issued by authorities have no handles and require the user to crouch (see photograph above). In other instances long-handled brooms are issued to people of all heights. Smaller women find these cumbersome and uncomfortable, where a simple shortening of the handle could help prevent back strain. Some of these issues are revisited later.





Chapter 4

Technical issues

There is no one design of vehicle that would suit all waste collectors in all parts of a single town, let alone all countries. Vehicles need to be chosen and designed according to users' characteristics and needs, the job for which they are intended, and the resources available.

When deciding upon a design for a given job, user and situation, much can be learnt from observing what entrepreneurs are using at present and asking questions like 'Why is that kind of wheel used?' and 'Why is this material used?'. Reasons may range from international supply situations to taste and fashion, but all are important.

4.1 Vehicles for people or people for vehicles?

Users are the most important consideration in vehicle and equipment design. Waste collectors use their vehicles for many hours every day and their health, safety and comfort relies on the design of the technology. Despite this, users are rarely consulted during the design of vehicles, and as a result many use vehicles which are both uncomfortable and unsafe.

The woman shown pushing a cart in the photograph overleaf has been permanently deformed as a result of poor posture day after day.

A woman deformed from pushing a heavy iron cart (Manus Coffey)

Health and safety

The welfare of workers is often a low consideration for local authorities, and where 'health and safety' legislation exists, it is often ignored. Some of the health risks for waste collectors include:

- back problems through lifting waste, pushing heavy carts at poor angles and continuous bending whilst sweeping. Vehicles can be designed according to the specific needs of users (e.g. age, sex, height and strength) and be safe to operate;

- cuts from sharp edges of metal or poorly designed and maintained handles on carts. Careful thought is required in terms of both initial design as well as how parts will wear over time; and

- disease from contact with waste. Some contact with waste is unavoidable, but well-designed vehicles and tools minimise contact during loading and emptying. There are also risks from airborne diseases. Collectors handling clinical waste in Khulna, Bangladesh have been issued with protective clothing, as in the photograph opposite.

A rare sight: collectors provided with protective clothing in Bangladesh

The welfare of workers affects their work and productivity but also has wider implications. Ill health can necessitate a break from work which, for many of the poor who live hand to mouth, seriously affects their standard of living. Poor health can impact people's ability to take on other work, and some illnesses can be life threatening.

The use of poorly designed vehicles has in some cases led to further problems in introducing new designs. Coffey (2001) describes how:

> *'over a period of time the sweeper or loader becomes adapted to the use of a particular handcart or tool and develops particular muscles or postures to suit that equipment. If he is then offered a more ergonomically designed version it may require the use of different muscles or a different posture than he has become accustomed to, so he will prefer to continue using the inefficient equipment'*

This is also described by Dufaut 1987.

Ergonomics

Generally, ergonomic issues are a low consideration for vehicle issuing organisations, with the exception of a few NGOs. In Delhi, the local authorities had not carefully considered ergonomics in the design of the vehicles they issue. They asked 'Would an improvement in vehicle ergonomics make my workforce more efficient or save labour?' This is perhaps a fair question, but although the answer may well be 'yes', it is difficult to show that a more comfortable workforce will be more productive. There are also misconceptions regarding the nature of ergonomic problems. The Delhi municipality sees the primary problem for waste collectors in their work as the loading of waste into vehicles. In fact it is generally more difficult to unload the carts, and loading them poses no difficulties.

Convenience and acceptability

Vehicles should be safe and comfortable to use, but they also need to be convenient to use. In Delhi a number of 'extra' features exist on cycle carts, such as hooks for hanging bags or a piece of cloth hanging on the back to clean hands after handling waste. Other cycle carts had places to store or attach tools, and some have a bell to attract the attention of householders. The photograph below shows a wheelbarrow in Karachi with a space for a broom and a basket for recyclable waste. Such features must not be overlooked in design (Coad 2001 and Rouse 2001a2).

Wheelbarrow adapted for carrying broom and recyclable waste

Colours and style may be important to the collector, and providing collectors with smart vehicles may make a difference to how they are perceived by themselves and the public.

4.2 Vehicles for the job

Having considered the people, it is important to consider carefully the conditions and work for which the vehicles are intended.

Housing density and road conditions

Housing density is an important factor in determining how far vehicles have to travel and road conditions dictate certain design features. On very poor road conditions, for example, larger wheeled vehicles perform better, though cycle carts do not operate well. In the case of very narrow alleys, only a small handcart or wheelbarrow may physically fit.

In certain wealthier areas of Lusaka housing density is very low, meaning that waste collectors have to travel long distances between houses. In this situation the ideal vehicle would be one capable of travelling longer distances, so a wheelbarrow would be terrible and a cycle cart much better. In contrast, in some of Lusaka's low-income areas housing density was very high, and roads were poor. The housing density made a small-scale collection scheme much more viable with high collection rates over small distances, and also meant that low-range vehicles (carts and wheelbarrows) would suffice. Small-wheeled vehicles could not be used because the roads and paths on the compounds were so pot-holed and muddy. The main vehicles used in these areas were handcarts, though wheelbarrows were employed to reach houses in particularly narrow streets (Rouse 2001b).

In Karachi poor road surfaces were described as a powerful disincentive to remove waste, simply because it is difficult to use any vehicle (Shakaib 2001). Similarly in Ankara, Ali (2001) also describes how some collectors cannot use any vehicle because road surfaces are so poor. The narrow streets and high slopes in Ankara also cause problems for the local authorities, especially during the winter snow falls. Because no vehicle can be used on icy, steep slopes, men transfer the waste bags manually to main collection points or lorries waiting on flatter, larger roads. By contrast, in Dhaka, 'street gradients are almost negligible and labour is cheap so handcarts are the most suitable means of waste collection' (Kazi 2001).

Finally, traffic type and volume in collection areas may be an important factor to consider. This normally varies during the day so different vehicles would be suitable according to when waste collection was undertaken.

Waste type

The following factors need to be considered with respect to waste type:

- **Density.** This helps determine the required capacity of a vehicle. Within Dhaka the density of waste from low-income areas can be double that of waste from wealthier households (Kazi 2001).

- **Corrosiveness.** Certain wastes are highly corrosive and it is important to build carts from materials which will withstand contact. Leachate from rotting organic waste can be very corrosive, and becomes more acidic the longer it is stored.

- **Abrasiveness.** Ashes and soil are highly abrasive and often form a significant part of waste in low-income countries.

The fuller implications of these factors are explored over the following pages.

Getting the capacity right

Increasing the capacity of SWCVs can be very beneficial to waste collectors, enabling them to cover many more houses in a day, and minimise the 'dead' time spent traveling to transfer points to empty the vehicle. The following box illustrates how capacity affected the work of collectors in Bangladesh and Vietnam.

Box 8. Vehicle capacity and livelihoods

'In Dhaka, the operator wants to carry as large a load as possible, particularly when he or she carries the waste some distance to a transfer point. The aim is to minimise the travelling time by maximising the load, so that the journey is made as few times as possible.'

(Kazi 2001)

'In Vietnam cycle carts are used for primary collection, bringing the wastes to [meeting] points where the carts wait for a truck into which they discharge their loads. Cycle carts may have to wait many hours for the trucks and so they collect the largest load possible to compensate for this waiting time.'

(Coffey 2001)

During fieldwork, many collectors in Delhi, Dhaka and Karachi complained that the capacity of their vehicles was not sufficient. Making the transition from small to larger vehicle can be difficult for the poor. Without the necessary capital, they will often need to rely on informal credit sources, such as the dealers to whom they sell their waste (Rouse 2001a).

Instead of buying larger vehicles, many collectors increase the volume of their vehicles by arranging wood or sheet-steel to raise the sides. An example of this is shown in the photograph from Karachi, below. Although this serves the purpose, it generally makes the vehicle unstable (Coad 2001 and Kazi 2001). It also facilitates overloading which can strain vehicle components and lead to increased rate of wear.

Sweeper in Karachi using wheelbarrow with sides raised using wooden boards

Another technique is similar in principle to the compactor trucks used for waste collection in higher-income countries. The following photograph shows a woman in Delhi compressing waste in her cart, again to optimise the capacity and reduce trips to the transfer point.

Woman compressing waste in her cart to maximise capacity

When designing vehicles and establishing capacity requirements, it is necessary to consider a range of issues. These are described in Box 9.

Box 9. Estimating required capacity for a vehicle

The following information is required to determine the required capacity of a waste collection vehicle:

- Number of households collected from, waste generation rates per household, waste density and collection frequency.
  These figures can provide an indication of what quantity of waste will be collected in total during a collection round.

- Location of nearest transfer point and housing density.
  If transfer points are close to the area of collection, a wheelbarrow may suffice because small loads could be taken frequently to the transfer point without adding much time or distance to the round. If, however, transfer points are situated far from the collection area, it may be better to use a vehicle with a larger payload and longer range so that the minimum number of trips need be made to empty the vehicle during a collection round. Consideration of location of transfer points alone is not, however, sufficient. Housing density is also important.
  If housing density is high, a smaller low-range vehicle may be appropriate unless transfer points are distant, in which case a larger, longer range vehicle may be more appropriate. Low-density areas will generally require larger capacity, longer range vehicles but if transfer points were situated at frequent intervals along a collection route a lower capacity vehicle may be considered.

- Road conditions and strength of user.
  If a collection round is undertaken in a very hilly area the maximum mass of waste to be carried in a cart will be limited by the ability of the brakes to stop it rolling downhill, and by the strength of the user to push or cycle it uphill. Tests would need to be undertaken with different vehicles, payloads and users. Routes to transfer points must also be considered. Collection rounds should be started higher than the transfer point so that the collector need never push the full cart uphill.

- How the waste vehicle is emptied.
  If a cart needs to be lifted and up-turned to be emptied, it is important that the weight when full can be lifted by the user.

Coad (2001) points out that it is important to make vehicles larger than calculations based on population densities would suggest. This is because with such small volumes, small changes in the nature of the waste make a large difference.

4.3 Emptying vehicles

There are three main issue relating to emptying vehicles:

- The direct handling of waste should be minimised to save time and avoid associated health problems.
- Heavy lifting (e.g. lifting or tipping an entire vehicle) should be avoided as this can cause injury and restrict who is able to use a vehicle.
- The transfer of waste from vehicle to transfer point should be easy, convenient, quick and hygienic.

Most vehicles are emptied simply by tipping the entire vehicle to the vertical position causing waste to fall out, others are lifted and tipped into containers, as in the photographs below.

Emptying a handcart at an open transfer point in Lahore

Collector in Africa being helped to empty his wheelbarrow

Lifting a wheelbarrow or up-turning a large hand or cycle cart requires considerable effort and strength. Waste collectors in Delhi were found to travel together to a transfer station in order to help one other empty their cycle carts because they were too heavy to do alone (Rouse 2001a2). Weaker collectors or children would not be able to lift a cart in this way, so they either have to use different vehicles or empty the carts using tools or their hands, which is unhygienic and unpleasant.

Some vehicles are even more awkward to empty in this way. The next photograph shows an extreme example of a donkey cart being emptied, also in Pakistan. With no quick release for the harness, the operators lift the entire animal whilst emptying – uncomfortable for the animal and extremely difficult for the operators.

Up-turning carts can be made easier by ensuring that the centre of gravity is close to the pivot – usually the wheel axle. Emptying can also be eased by ensuring that the waste can easily leave the main container. Some cycle carts in Delhi had removable front panels so that the vehicle did not need to be tipped as far, or waste could be scraped out using a shovel or rake. The vehicle designer in Lusaka was

The flying donkeys of Faisalabad (Manus Coffey)

also designing handcarts with sloping panels to make emptying easier and was experimenting with removable front panels. However, anaother of his carts was designed with a strengthening 'lip' running around the rim of the container, a feature which blocked the passage of waste (Rouse 2001a2 and b).

Containerised carts

One solution to the difficulties of emptying carts is to arrange waste in smaller containers within the cart, which can be removed and emptied individually by hand without up-turning the vehicle. This means that waste can be transferred with less direct physical contact and that transfer is less reliant on physical strength or the efforts of more than one person. Containerised handcarts also enable waste to be sorted more easily. The full benefits of containerised carts are only realised when transfer points such as demountable containers are used or waste is simply deposited on the street and then has to be handled by someone else for secondary collection.

A number of containerised handcarts have been introduced in India, an example of which is shown opposite. The main problem with containerised handcarts is that their capacity is lower (Rouse 2001a4 and a7). The total capacity of the

containers is only a little under the space they occupy in a cart, but usually non-containerised carts are piled high above the sides. This is still possible with containerised handcarts, but the benefits of the containers are then lost, i.e. it becomes impossible to cleanly and easily remove individual containers. Problems with capacity aside, most collectors consulted said that they found containerised carts much easier to empty. It often meant the difference between up-turning an entire cycle / handcart and unloading it container by container without undue effort or contact with waste. Asnani has undertaken considerable field work with these carts in Ahmedabad, India (Rouse2001a4).

A containerised cycle cart in Delhi

Security

The use of containerised handcarts raises security issues. If stored outside, each container needs to be secured during the night, as thefts are common. This had in fact happened to the containerised cycle cart shown above: one of the containers had been stolen, and in this case was replaced by a smaller tin (front right corner). In this case the handcart was owned by an NGO, and this loss raises questions about who is responsible for replacing the containers. If the NGO readily replaced containers users could conceivably sell the boxes to supplement their income.

Users may also feel a lack of ownership / stake in the vehicle and not take due care. Joint responsibility might be a solution, where the user would have to contribute towards replacement containers.

Transfer points

An intermediate place where waste is deposited and stored before being transported to the final disposal site.

The design, management and location of transfer points directly affects the work of waste collectors and pickers and cuts across the technical, social and institutional themes:

- The location of transfer points affects vehicle choice (see Section 4.2 Getting the capacity right).

- Distant transfer points have been found to cause waste collectors to overload their vehicles in an attempt to reduce the number of trips and save time. This results in increased rate of wear and damage to vehicles.

- Distant transfer stations may also mean that only those with cycle carts or those who are strong enough to carry waste long distances can collect waste, thus limiting the livelihood opportunities of certain poorer / weaker groups. In some cases distant transfer stations are so inconvenient that areas receive a very low level of collection service as a result (Shakaib 2001).

- Poorly designed transfer points cause inconvenience to collectors, and some necessitate double-handling of waste, i.e. vehicles are emptied onto the ground then waste is shovelled into a container, as in Karachi (Shakaib 2001).

- In many countries, it is only when waste reaches the transfer points that the responsibilities of the local authorities begin. The local authority are also responsible for their design and upkeep. The attitude of local authorities towards their workers and primary collectors will dictate the attention they give to providing safe and convenient transfer points.

Box 10. Waste transfer in Dhaka

Kazi (2001) reports that transfer points are readily available in Dhaka, and in most cases a waste collector will empty his or her vehicle at a transfer point two or three times per day.

This photograph shows a woman emptying her handcart in front of a demountable container in Dhaka. It is common for waste to be left beside containers in this way, where it is sorted by waste pickers and later transferred to the container for removal by local authorities. This arrangement:

- soils the city environment, making areas around containers permanently dirty;
- necessitates double handling of the waste which has associated health risks (Kazi 2001); but,
- benefits waste pickers as they gain easy access to waste.

Note: If this woman was using a containerised handcart she would be able to easily transfer waste directly into the container. This would keep the area clean and remove the need for double-handling of waste. It may, however, inconvenience waste pickers.

Box 11. Typical transfer point in south Delhi

This photograph shows a waste transfer point in a high-income suburb of Delhi, India. It is little more than an open dumping area in which vermin and grazing livestock can be found. It contains organic material mixed with plastics, glass, rubble and even clinical waste. The local authorities clear the area daily using a bulldozer and lorry. Because of the design, however, the transfer point is never completely cleared and because the floor is simply soil it is not possible to clean or disinfect the area (Rouse 2001a2).

Poorly maintained transfer point in Delhi suburb

It is possible to design transfer points which are appropriate for the prevalent method of emptying vehicles. The photograph below shows an example of a transfer point in Khulna consisting of a skip which is removed and emptied daily by the local authorities. Instead of collectors dumping waste on the ground, they wheel their handcarts, cycle carts or wheelbarrows up a ramp (on the right of the photograph) and empty them directly into the trailer. This minimises the waste spilled onto the ground, keeps the area cleaner, and eliminates secondary handling of waste.

Ramp transfer system in Khulna, Bangladesh

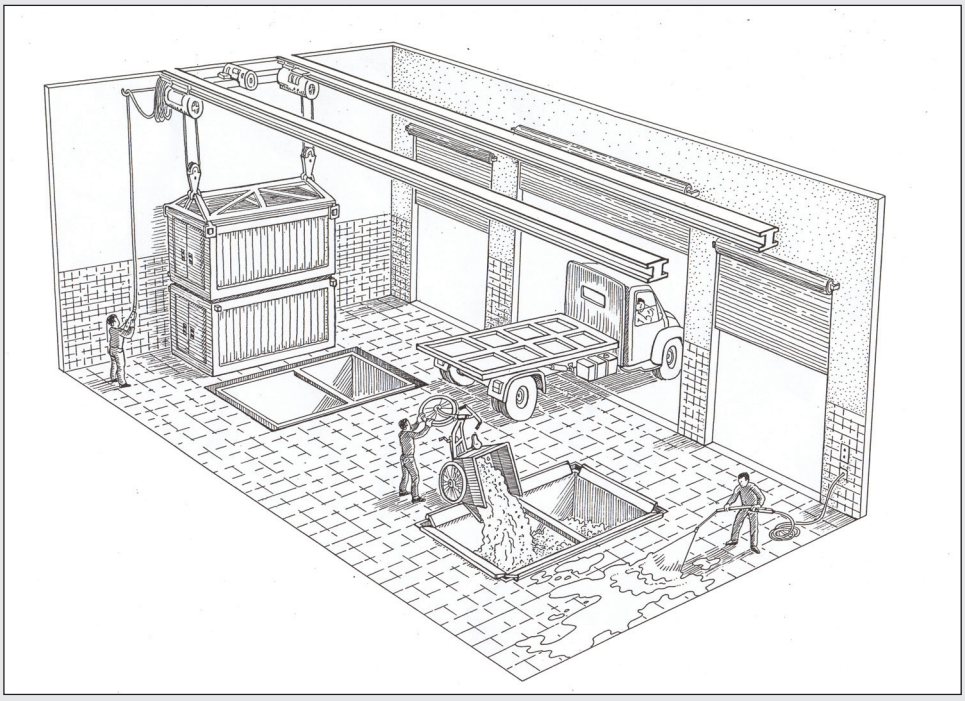
When ramps were suggested to the municipality in Delhi their response was predictable: 'there is not enough room' (Rouse 2001a). Ramps take up considerable space and this is simply not available in dense urban areas such as Delhi. Ramps were successfully introduced in Khulna because it is a smaller, lower density city. Where ramp transfer points are used it is important to consider what load can be pushed up the inclines by different users of different vehicles. Could a woman push a loaded handcart up the slope?

Box 12. Chinese-style transfer points

An innovative transfer point has been designed and introduced in parts of China. It is designed to take up minimum space in crowded urban areas and enables the easy, safe and sanitary transfer of waste from SWCVs to demountable containers for carriage by lorry. The sketch below shows the layout of this transfer point. Cycle carts enter from the front into the transfer room, where two demountable containers sit in depressions so that their tops are flush with the ground. The cycle cart operator can empty waste into the containers without any lifting or intermediate handling. Filled containers are lifted from the holes and loaded onto trucks which can also enter the transfer room.

There are toilets for the workers and storage facilities for the cycle carts, and valuable urban space is used effectively by including office facilities and apartments above the transfer area. Providing the facilities are properly used and maintained, offensive odours are not created.

Details and sketch from Coffey and Roychowdhry in Coad 1997.



There are many other issues relating to the removal of waste from transfer points to lorries for transport to final disposal, but these are beyond the scope of this research.

4.4 Wheels, bearings and brakes

Wheels and bearings are often the only moving parts on SWCVs. The combination of tyre, wheel rim, spokes and bearing type are critical in determining the cost, reliability and usability of vehicles (Diaz 2001). Unsuitable wheels and poor bearings results in vehicles which are difficult to use and frequently breakdown.

From the literature

Wheels and bearings were described in considerable detail in literature. Coffey (2001), Dennis and Smith (1995) and Thoma (1979) all describe the design of wheel types, bearings, options for vehicle design and methods of construction.

Some of the issues which emerge from the literature include the fact that bearings are often very crude in vehicles in the developing world, and that careful selection of suitable materials and a little more initial expense could give good returns in reducing vehicle 'down times' (i.e. the times when a vehicle is out of action), lengthening the life of vehicles and improving ease of vehicle use. These ultimately save money in terms of repair costs and length of service.

From the field

Much of the fieldwork raised issues relating to wheels, and many of the wheels and tyres observed during fieldwork were identified as a weak point on the vehicles. Wheels were often reported by users to be too weak and small so unsuitable for rough terrain, to have poor tyres / outer coverings leading to frequent failure, and to have poor bearings making them difficult to turn. Wheel selection is an area for considerable attention, as breakdowns cause inconvenience and expense both in terms of time and money for repairs. Box 13 shows some of the wheel arrangements encountered in the fieldwork.

Box 13. Types of wheels in use

Reinforced bicycle wheel on a cycle cart in Delhi. Note the smaller tangentially arranged spokes.

Locally made in Delhi. Strengthened wheel using iron tubing as spokes. Note the radial arrangement of spokes, and flat tyre.

Three wheels (described 1-3 left to right) in the workshop of Virdi Industries, a vehicle manufacturer in Delhi.

1. All plastic
2. Rubber outer, iron centre for use as a plain bearing (see following section on bearings)
3. Rubber outer, steel centre forming a housing for steel ball bearings

An iron wheel on a handcart in Delhi. The combination of solid wheel and poor bearings would make this a difficult cart to use.

Wheels

Generally larger wheels are preferable because they are easier to push over uneven surfaces. Simple mechanics shows that with a forward force (as applied to a handcart or cycle cart) a larger wheel can 'climb' out of potholes much more easily than a smaller wheel, which will frequently become stuck. Wheel size is even more important for a wheelbarrow because of the way the force is delivered to the wheels; downwards as well as forwards. In Ankara collectors found that the small wheels on their vehicles made their handcarts unstable and difficult to push over uneven roads (Kazi 2001).

The centre: materials and strength

Waste collectors in India, Bangladesh and Turkey complained that the wheels on their vehicles were of poor quality and frequently broke (Ali 2001, Kazi 2001 and Rouse 2001a6). The photographs in Box 13 bear testimony to the importance of strength in wheel design: all the wheels have either been strengthened or are solid plastic or metal. A normal bicycle wheel (designed to carry loads of up to ~100kg) is not appropriate for use on carts carrying hundreds of kilograms of waste. Box 14 introduces some principles of wheel design, drawn from the studies of rickshaws in Bangladesh by Gallagher (1992).

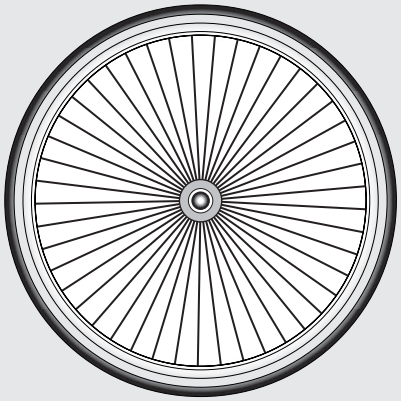
Box 14. Making wheels stronger

There are several ways in which wheel strength can be improved: thicker spokes, stronger wheel rims and thicker tyres. All of these can be seen on Chinese cycle rickshaws which have heavy-duty wheels similar to those on mopeds.

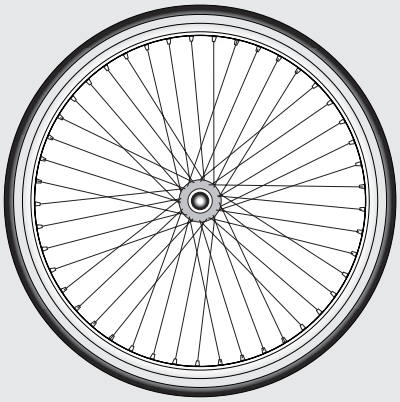
The most commonly used wheel rim in use in Bangladesh is the old 'Westwood F' pattern, which was designed for a bicycle and single cyclist, not a cycle cart / rickshaw with a heavy load and/ or many passengers. It has a very flat cross-section which doesn't allow the tyre to resist heavy loads effectively. A much better arrangement would be to have a deeper rim with deep flat sides. This would orientate more of the tyre material in the direction required to resist the loads applied.

One such example prevalent in Bangladesh is the Endric, which can also be used with the tyres already in use in Bangladesh. The Endric wheel also has thicker, radial rather than tangential spokes, which also make it stronger.

(Gallagher 1992)



"Jessore" Wheel
Thicker, stronger radial spokes



Ordinary bicycle wheel with
thinner tangential spokes

Keeping wheels round and securely mounted perpendicular to the direction of motion is also important.

Box 15. Keeping wheels round and true

Loss of roundness also causes energy loss. If the wheel becomes slightly egg-shaped, the effect is like riding on a bumpy road and energy is lost lifting the vehicle each time the wheel goes round and compressing the tyre. Fred Wilkie calculated that on a heavily loaded rickshaw, a wheel which was 3mm out-of-round could add 5 per cent to the effort required for pedalling. This was equivalent to asking the puller to do 15 press-ups every mile that he travelled. In addition, if the wheel is not properly aligned (i.e. parallel to the direction of travel) then as it rotates the tyre is pushed sideways across its tread. The result is high friction and wastage of energy.

(Gallagher 1992)

The outer: tyres

The interface between wheel and road is critical in determining the ease with which any vehicle moves, particularly over uneven ground. The worst situation is a wheel with no covering where bare metal comes into direct contact with the ground. The best situation is a firm pneumatic tyre, where vertical shocks are absorbed, making cart operation more efficient, quiet and comfortable. Box 16 describes why this is so.

Box 16. Pneumatic versus solid wheels

Imagine a vehicle with solid rubber tyres (such as old bicycles used to have) moving on a rough road. Each time the wheel hits a bump it bounces vertically and energy is lost lifting the vehicle off the ground. The wheel also loses contact with the ground for an instant so propulsion is weakened too. Pneumatic tyres, which were developed at the end of the 19th century, help to reduce these losses, at least for small-scale roughness. Instead of the whole vehicle being lifted, the tyre's tread is compressed, so energy is lost only in compressing the air inside the tube (not lifting the entire vehicle). Moreover, the air pressure keeps the tyre in constant contact with the road, so propulsion is maintained.

(Gallagher 1992)

Many wheels on the handcarts and wheelbarrows used in Delhi were designed to have no tyre so bare metal comes into direct contact with the ground. The most basic form of covering is rubber strips, often cut from car tyres, attached to the wheel rim. This reduces noise and makes pushing the cart over uneven ground somewhat easier but Coffey (2001) suggests that in most cases the covering is too

thin to make a significant difference. In India local authority sweepers complained that the crude rubber outer on their wheelbarrows wheels frequently rolled off, exposing the bare steel of the inner and requiring repair (Rouse 2001a6). Coffey (2001) describes a tyre made from truck tyre bead, where the thick base of a tyre is trimmed into a tyre shape and fitted onto a wheel the same diameter as the original truck wheel rim.

Solid rubber tyres are a step better, but good quality and appropriate specification inflatable tyres are best. Many animal carts use old car wheels (and often the original axle) but these are rather heavy for cycle and handcarts. One advantage of them, however, is their width, which makes them more suitable for wet areas because wider wheels sink less easily into mud. Certain carts in Lusaka used old car wheels – though women found them too heavy to push, and asked for old motorbike wheels to be used instead (Rouse 2001b). These were a strong and appropriate alternative.

Many cycle carts observed during fieldwork had inflatable tyres, but an alarming number were punctured. The main problem with pneumatic tyres is punctures, and quality is an important investment. In Dhaka users found that low-cost, low-quality inflatable rubber tyres required replacement every two to nine months depending on quality (Kazi 2001). While pneumatic tyres are the preferable option, it is important that they are chosen appropriately, and, once again investing at the outset in better quality pays dividends in terms of lifetime and reliability.

Bearings

Wheels cannot be treated in isolation as they need to be securely attached to vehicles in a way that allows free rotation. This is the job of bearings. There are two main types of bearings: plain and ball bearings.

Plain bearings

Plain bearings are simple and comparatively cheap, consisting of two smooth surfaces moving against each other. These are more suitable for lighter loads and the materials used to make them need to be selected with care to ensure smooth operation. The sketch below shows the principle.

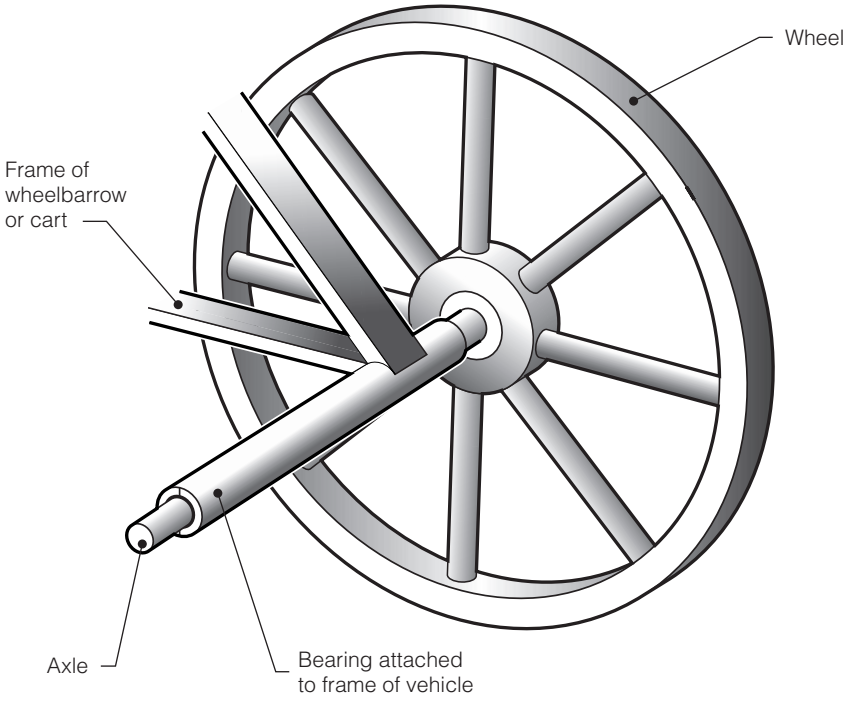


Figure 4.1. Plain bearing sketch

Plain bearings can be made from many materials including plastics, cast iron, bronze and even wood. In each case it should be decided whether it is easiest to replace the bearing or the shaft on which it is running after excessive wear has taken place. General practice is to use a soft bearing material on a relatively hard shaft meaning the bearing would have to be replaced more frequently than the shaft.

Most waste vehicles operate under dusty and gritty conditions, meaning there will be severe wear problems unless the bearings are sealed to prevent dirt from entering and wearing surfaces. Greasing unsealed plain bearings can cause more problems than running them dry (which is also not ideal!) because the grease holds onto particles of dust and grit, forming a grinding paste which increases the rate of wear. Where greasing is used for plain bearings it should be introduced through a nipple (as in a motor vehicle) into the space between the two surfaces, thus pushing out used, dirty grease (Coffey 2001).

Most handcarts and wheelbarrows studied had plain bearings, many of which were very badly manufactured and very worn. Kazi (2001) describes how the failure of bearings is the most common fault with carts. He attributes their failure to poor road surfaces and overloading, and says that wear 'is exacerbated by wet conditions'.

The photograph below shows a crude 'metal–metal' plain bearing on a handcart with iron wheels in Delhi. In this instance the outer part of the bearing is formed by the wheel-hub and the axle is secured to the bottom of the cart. The surface is not greased and they do not fit properly. This is a very inefficient bearing. Indeed, some may be reluctant to actually classify this as a bearing.

Plain bearing on a handcart in Delhi

Ball bearings

Ball bearings are slightly more complex than plain bearings, where the shaft and bearing are arranged in such a way as to accommodate a set of freely moving, usually steel, balls. Ball bearings make pushing much easier and if well chosen, installed and maintained are very suitable for many small waste vehicles. Most bicycles and cycle carts use ball bearings.

It is important that the correct bearing is chosen for a SWCV. Expensive, high-quality, heavy-duty bearings are not necessary in slow-moving lighter vehicles. Often the standard sizes manufactured locally are of sufficient quality.

Ball bearings are particularly vulnerable to grit, which will quickly cause serious damage to the bearing. This is the cause of the misconception about ball bearings in many countries. Non-sealed ball bearings (of high or low quality) have been installed and simply do not last, as grit quickly damages them, making the carts difficult or even impossible to push. They are thus disliked by users, and considered expensive by local authorities who need to replace them frequently. A low-cost, locally made sealed ball bearing unit can, however, last many years.

Brakes

Brakes on SWCVs are needed for two reasons. Parking brakes are required to prevent vehicles from rolling down inclines when left unattended. Brakes are also required to bring larger, or heavily laden vehicles to a halt when they are being pushed or cycled.

Parking brakes

In flat areas SWCVs do not need brakes, but in areas with even a slight incline cycle carts and many handcarts will roll. In waste collection, workers have to move their vehicles short distances and then leave them to collect waste from houses. In a residential area of Delhi, one waste collector had to place a brick under one of the cart wheels outside every house to prevent his cart from rolling down the street. Installing effective and easily engaged brakes can make the collector's work much easier (Rouse 2001a2).

In very hilly areas brakes on SWCVs are vital, not only for convenience but also for safety to users, pedestrians and traffic.

A parking brake could be very simple – perhaps just a piece of wood arranged to press against a tyre when the vehicle is parked. Wheelbarrows and certain handcarts with only two wheels and fixed rear supports are exceptions – the contact between supports and the ground is usually sufficient to prevent movement.

Stopping moving vehicles

Most airport luggage trolleys – carrying just 30kg – are equipped with brakes which prove essential for preventing collisions in the crowded lounges of airports. Many collectors' handcarts move in crowded streets, carry considerably more than this, but have no brakes.

Smaller vehicles such as wheelbarrows do not need brakes as their inertia is sufficiently small that the user can bring the vehicle to a halt using his or her own force. Larger and heavier vehicles, particularly free-wheeling vehicles (i.e. those fully supported by wheels), can have considerable inertia and brakes are essential. In Delhi, Dhaka and Karachi waste vehicles move amongst heavy traffic and it requires great effort to bring vehicles to a stop when inevitable obstructions appear.

Cycle carts were the only vehicles observed during fieldwork that were equipped with brakes. Gallagher (1992) describes the brakes on cycle rickshaws in some detail. Many have just one front brake, so although when laden they are many times heavier than bicycles, they have less than half the braking ability. Some cycle carts have 'Sylhet brakes'. Gallagher writes:

> *'In Sylhet's hilly areas the single brake found on most rickshaws is inadequate, so local people developed a crude form of brake for the rear wheels. A solid metal bar is pressed onto the tyres whenever a puller presses a chain with his foot. The brake stops the rickshaw alright, but in a rather crude and dangerous way: the metal bar wears away the tyres, and there is a high risk of the wheels locking and skidding, and the rickshaw toppling over.'*

Coad (2001) describes a crude braking system in Jerusalem. A piece of tyre is tied to the back of the cart and drags on the ground. When the operator wishes to brake, he or she steps on the piece of tyre. This is probably fairly effective and very cheap, but not very easy or quick to use. Innovative designs are required for better brakes for SWCVs, in particular cycle rickshaws.

4.5 Construction, wear and maintenance

This section looks at the technical aspects of construction, wear and maintenance. Note: given that these processes are often the responsibility of organisations or local authorities, there are a number of related institutional issues. These are described separately in Chapter 5.

Construction materials and components

The design of SWCVs usually involves finding a compromise between cost and the quality of components, materials and workmanship. For local authorities and the poor in low-income countries, resources are often limited and decisions are often made according to price alone.

The build quality of many of the vehicles encountered during this research was very poor. Some examples include:

- wood being used for handles of handcarts or wheelbarrows, which snap when the cart / wheelbarrow is fully loaded (Kazi 2001);
- wood being used for the main containers of the carts, which rots quickly and requires regular replacement;
- welded joints, stands and handles made too weak (Kazi 2001, Rouse 2001b) requiring frequent repair or replacement;
- cheap steel used for vehicle bodies and tools (Coffey 2001). This may be brittle (if recycled) or soft (lower cost mild steel) resulting in frequent breakage; and,
- designers and manufacturers over-engineering designs, resulting in over-heavy frames. Gallagher (1992) points out that the application of engineering principles can lead to much stronger but lighter designs, using the same materials.

Many of the poor live hand-to-mouth and cannot afford to spend more than the bare minimum on components. As a result they buy weak wheels, low-quality tyres and inner tubes, weak chains and so on. This results in more frequent breakdown of vehicles (which can equate to loss of earnings) as well as higher long-term expenses on maintenance and repair. Poor quality vehicles can be both a symptom, and a cause, of poverty.

Box 17. Price versus durability: Rickshaw manufacturers in Dhaka

This box illustrates the process of component selection for rickshaw manufacturers in Bangladesh.

Bicycle components are available in Bangladesh from many different countries, but they vary greatly in quality and cost. Bangladeshi cycle components are usually the cheapest, but they are also the lowest quality. Indian components are also quite cheap, but their quality is not as good as Chinese or Japanese parts which are more expensive.

Rickshaw-makers are well aware of these differences, and when they build a rickshaw they carefully select each component to obtain the best compromise between cheapness and durability. For example, Bangladesh-made tyres are the cheapest available: at Tk70 in1988 they were only one quarter the price of Chinese-made tyres. But rickshaw [makers] say that locally made tyres do not last two months on a rickshaw, whereas Chinese-made tyres last nine months or more.

Hence the cheapest is not necessarily the best, and wherever quality is needed (for example, where precise alignment is needed, or severe wear and tear is experienced), the makers usually prefer the better quality components, even though they are much more expensive.

For example, front wheel rims are usually Chinese or Japanese-made, while rear wheel rims are usually Indian. The Japanese rims cost three times as much, but the front wheel is more highly stressed, so quality is essential.

(Gallagher 1992:382)

Even when the poor are aware of the benefits of using better quality components, it may be that available cash restricts their choice. Let us take the tyre example from Box 17. It may be relatively easy for a rickshaw driver to find Tk70 every two months to buy a Bangladesh-made tyre but difficult to raise Tk280 at one time for an imported, higher quality tyre.

Two further considerations in the selection of components and materials are local availability, which will inevitably influence decisions, but also who is purchasing them. Coffey (2001) points out that for local authorities, purchasing is often undertaken by a central store without adequate specifications, quality control or communication with workshops. This increases the scope for inappropriate purchases.

Corrosion, wear and maintenance

The components of SWCVs will always corrode and wear through normal use. Reducing the rate of wear is a question of careful selection of components and materials as well as preventative maintenance. Even with adequate maintenance, components require replacement from time to time. According to Kazi (2001) many components on carts and cycles need replacement every eight to twelve months (e.g. corroded panels, tyres, spokes and bearings).

Corrosion

Throughout the city case studies corrosion was raised as a problem with waste vehicles. Solid waste – particularly that in the developing world – has high organic content and begins to decay quickly. As decomposition proceeds the waste becomes acidic and hence corrosive. Wood-framed vehicles are particularly susceptible, though the mild steel of many vehicle bodies also corrodes quickly (Rouse 2001a, Kazi 2001, Ali 2001). It is common to see vehicles on the streets in South Asia with large parts of body corroded and patched temporarily with wood or even cardboard. Kazi (2001) reports that users in Dhaka clean their vehicles daily using bleach to counter corrosion. To combat corrosion in Ankara the metal bodies of carts are painted to form a protective layer between corrosive waste and the metal. Another means by which this can be achieved is by collecting waste in plastic bags so that it does not come into direct contact with the cart (Ali 2001).

Wear

The components which wear most quickly on SWCVs are the bearings. Section 4.4 described how sealed bearings last much longer than unsealed bearings, and the importance of careful greasing. When bearings become severely worn the wheels will no longer rotate easily or keep a straight path (Ali 2001). Findings in most of the city studies indicate that operators do oil bearings, mostly in order to reduce wear and make vehicles easier to push, but sometimes simply to reduce noise (Ali 2001). Tyres also wear out. In addition to shorter lifetimes (see Box 17), poor quality tyres are more susceptible to punctures than higher quality, stronger tyres.

In Ankara, the kapici are provided with old wheelbarrows or carts often bought from builders who can no longer use them. This is likely to be similar for other poor users in South Asia who cannot afford new vehicles. This disadvantages users from the outset, as the vehicles are already heavily worn (Ali 2001).

Maintenance

Various aspects of maintenance are described in literature, including Coffey (2001) and UNCHS (1988). They stress the importance of preventative maintenance (e.g. greasing bearings and painting the bodies) rather than just curative maintenance (e.g. patching rust holes or replacing worn bearings). SWCVs do not require considerable maintenance. For informal, private owners of vehicles, all maintenance is the responsibility of the individual. Those who are provided with vehicles by their employers (e.g. municipal sweepers) are usually responsible for smaller repairs (e.g. puncture repair) and routine maintenance (e.g. greasing bearings), but often have a formal arrangement with their employers for major repairs (e.g. replacing wheels and mending containers).

Other maintenance requirements include ad-hoc jobs such as fixing broken support legs, re-welding joints, repairing spokes, replacing the cart body materials, and changing the chain. In the light of this, Kazi (2001) describes the importance of vehicle designs being simple and 'known to the local people' as this enables people to undertake repairs themselves, or at least get them done locally. He also mentions the false economy of poor quality repairs.

There is a seasonal element to some maintenance. Oiling is required more when vehicles are used in wet and muddy conditions, and punctures need fixing more frequently during the hot season in Dhaka when rubber is softer (Ali 2001 and Kazi 2001).

Chapter 5

Organisational & institutional issues

In many cases the design, procurement, ownership, maintenance, storage and operation of SWCVs are affected or dictated by community groups, local authorities and private employers.

This section describes examples from fieldwork of how the attitudes, practices and, in some cases, inactivity of organisations and institutions affect waste collectors and their vehicles.

5.1 Local authorities

The design, repair and maintenance of SWCVs seemed a low priority to a number of local authorities. The condition of vehicles found on streets, coupled with testimonies of employees serves to confirm this. Health and safety issues are also rarely considered, likewise the possible benefits of a healthy happy workforce. In some instances it was difficult to get information from local authorities on this subject, and sometimes it was clear that individuals managing vehicles felt unwilling to share information, or simply knew very little (Rouse 2001a and b).

Priorities

Local authorities and other employers often lack the awareness, concern or resources to provide better quality vehicles to employees. Corruption may also contribute to the selection of inferior low-priced materials and vehicles over more suitable high-quality alternatives by providing opportunities for embezzlement. Field studies made it clear that local authorities lacked concern for, and awareness of, health and safety issues. In Delhi no protective clothing was issued, while in Ankara Ali (2001) reports that no eye protection was offered, though footwear and gloves were provided.

The priorities of local authorities often lie with the wealthier people and areas of cities. This is justified in terms of where revenue is generated – the higher income people and areas pay more tax and are entitled to better services. This was the case in Lusaka and Delhi and possibly elsewhere. In Lusaka the waste collection system has been privatised but a few companies are monopolising the work. Their incentive is to work where there is profit, and as a result most collection takes place in wealthy suburbs and there is no collection from low-income areas.

In Delhi there are two main municipal organisations responsible for waste management; MCD (Municipal Corporation of Delhi) and NDMC (New Delhi Municipal Corporation). Their responsibilities are summarised below.

MCD and NDMC areas of responsibility

Organisation	Area of responsibility	Budget	Budget per unit area
MCD	~ 95% of Delhi, mostly low-income areas	Twice that of NDMC	
NDMC	~ 5% of Delhi, mostly high-income / commercial areas		Approximately ten times that of MCD

The fact that NDMC effectively has ten times as much money as MCD to spend on higher income and commercial areas points strongly to a disregard for the needs of the poor. This is reflected in the contrast between the cleanliness of the wealthier and poorer areas in Delhi (Rouse 2001a3).

Funds

Ali (2001) reports that for local authorities in Ankara, the availability of funds is the main factor in vehicle design. He describes how there is a big problem with the narrow, steep streets but that these factors do not affect the type of vehicle that is bought by, or supplied to, the collectors. Trucks for waste collection are acquired using a bidding system for which, again, the only significant criteria is availability of funds.

Box 18 provides an example of how the responsibility for vehicle design stops ultimately not with the designer, but with the local authority.

Box 18. Virdi Industries: Delhi vehicle manufacturer

Amarjeet Singh is a manufacturer of small vehicles and is based in a large market in Delhi. He supplies individuals, building contractors and local authorities across India with wheelbarrows, handcarts and specialist vehicles such as ice-cream vendor carts. He was able to describe the common problems with the vehicles he manufactured, and said that quality was mainly restricted by the budget restrictions enforced by customers– particularly local authorities.

He said 'If they paid me enough I could make a handcart with sealed bearings, a strong container with a lid, and handles which would never snap'. (Rouse 2001a5)

Short term versus long term

'Most of the municipalities try to overcome the problem at hand rather than planning for the future. Only remedies to the immediate problems are being sought.' (Ali 2001)

In the design and construction of small waste vehicles, quality of construction and components are juggled with cost implications. Often spending more on high quality components proves to be a prudent investment over the lifetime of vehicles because of increased durability and reliability. However, lack of funds, coupled in some cases with the indifference of local authorities or ignorance of alternatives means that very poor construction quality and components are common. Supply is not to blame: high-quality components are available, albeit at higher prices, in most countries.

In Lusaka, the provision of cheap 'local' wheelbarrows resulted in short lifetimes and incurred frequent repair costs (e.g. replacing handles and repairing corrosion). Better-quality imported vehicles were available but these cost twice as much. This was a problem in terms of funds, but also the local manufacturer would have lost out on this business (Rouse 2001b). Perhaps in this instance the

local manufacturer should have been encouraged to make better vehicles for the same cost as the imports.

Less directly, better vehicles may be prudent because they would produce a healthier, happier, more effective workforce. Coffey (2001) states that many local authorities do buy cheap materials with no regard for users or long-term costs, and this was backed up by much of the research.

The institutional aspects of repair and maintenance

Private collectors are responsible for all repairs and maintenance to their vehicles, while those in the employment of community organisations or local authorities rely (in part or whole) on their employers. The technical side of repair and maintenance was discussed in Section 4.5. This chapter takes a brief look at the institutional aspects.

Box 19. Repair and maintenance arrangements in Dhaka

Officially, DCC (Dhaka City Corporation) carry out the major repairs on SWCVs, while everyday maintenance and smaller repair work is the responsibility of the users. There are a number of issues around this arrangement.

When major repair or maintenance work is required, the vehicle user informs the Conservancy Inspector. This Inspector then arranges to send the vehicle to the DCC workshop for repair, but this process takes a long time. Down times (i.e. inoperative periods) of vehicles prevent a collector from undertaking his or her work, so often they just get the repair done themselves, particularly if the work is minor. It is not clear whether they would be reimbursed for these expenses. It is basically not worth their while waiting for the authorities to repair the vehicle.

Although routine maintenance is the responsibility of users, it is reported that no facilities (e.g. space, oil, tools) are made available for this. Kazi reports that when collectors want tools (e.g. shovels) they often buy their own simply because, again, authorities take so long to deal with requests and issue them.

(Kazi 2001)

Similar problems exist in Delhi. NDMC state that repairs are undertaken immediately, but it was clear from looking at the condition of municipal vehicles on the streets that either the standards were very low, or that vehicles were simply not being repaired. One sweeper's wheelbarrow in an NDMC area had had a broken handle for over a month, according to the woman who used it (Rouse 2001a6). During a meeting with the NDMC the ubiquitous broken handles were mentioned

and they were adamant that they never broke. Many handles are broken on carts around Delhi, but the representatives did not know about these and still denied that 'anything made of steel' could snap. It was clear that they did not know what was happening on the ground in this respect. Given their position in the organisation, this may be quite reasonable, as repairs are probably the direct responsibility of supervisors or inspectors. It may be an indication of the gap between management and workforce, however (Rouse 2001b3).

In the UK, when a car is taken for repair, the mechanics will sometimes provide a 'courtesy car' for the duration of the repair, resulting in minimum inconvenience to the customer. One possible solution to the problem of long, costly, down times for waste collectors might be a 'courtesy cart' arrangement.

Authorities in Ankara have a policy of replacing vehicles every five years (Ali 2001). This is positive and simple to manage but is not very responsive to needs – a vehicle with heavy usage may deteriorate much faster than another with light usage.

Legislation

There are many ways in which national policy and legislation can affect waste collectors and vehicle choice. Fieldwork, particularly in Delhi, raised a number of good examples. For example, in India legislation is being introduced to make separation at source a legal requirement. This might necessitate a vehicle with compartments to enable carriage of different types of waste.

Legislation is pending relating to the use of cycle rickshaws and carts on the Delhi roads. One of the cycle cart manufacturers in GKII mentioned that this threatened to put him out of business, as demand would drop. It would obviously also have an effect on the collectors themselves, may limit the places from which they can collect waste, and could restrict their access to markets for selling waste (Rouse 2001a2).

Other legislation affects collectors and their work less directly. Legislation has recently been introduced in south Delhi that is forcing out the informal polluting industries based in residential areas and moving them to dedicated industrial areas. This is said to be having an adverse effect on the market for recyclable materials, because the local recycling industries in central slum areas have been forced to shut down or relocate to demarcated industrial areas (Rouse 2001a2). This may mean collectors have to travel further to sell their recyclable waste.

Box 20 describes the situation for the semi-formalised *kapicis* in Ankara.

Box 20. *Kapicis* in Ankara

It is a legal requirement in Ankara that blocks of flats over five stories in height employ a *kapici* to manage their waste. This system is an example of a semi-formalised waste collection system operated by independently employed individuals.

Ali (2001) describes two *kapicis* working for 240 apartments in five blocks of flats. They are protected under the government health insurance system and live rent-free in a house, with free utilities. Their salary is respectable compared with informal sector workers and it is paid directly into the bank. Many are able to pay for their children's education.

Perhaps because of their recognition by local authorities as important workers, *kapicis* appear to have a good bargaining position with householders. In one instance, *kapicis* were unhappy with how waste was being collected and complained to residents. As a result, residents began using larger, stronger plastic bags for waste, they stopped disposing of liquids with the waste, and began wrapping sharp articles before placing them in bags. These changes have meant fewer injuries and cleaner, safer working conditions for collectors.

The *kapici* system might be seen as an example of how progressive legislation and attitudes towards waste workers can improve their relationship with householders as well as their living and working conditions. It is interesting to note that informal sector activities (e.g. waste picking) are illegal in Turkey (Ali 2001).

Relying on local authorities

In response to poor waste management services provided by local authorities, many community groups have formed to organise door-to-door waste collection for their areas. Waste removal is very important to people, and householders in Karachi, Ankara and Dhaka all said they considered the punctuality of their collector to be very important. This was particularly the case in hotter climates, where waste would begin to smell after short time, and householders wanted it removed from their property. People also reported that they did not mind how collectors looked or what vehicle they used (Kazi 2001, Shakaib 2001).

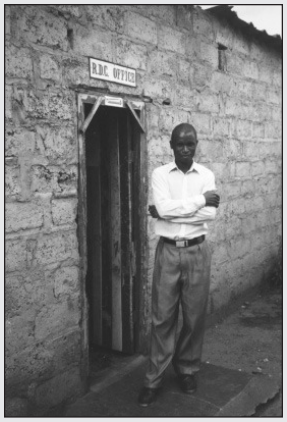
In many cases, door-to-door collection systems rely on support from local authorities, particularly for the removal of waste from transfer points. Box 21 describes how such support was not forthcoming in Lusaka.

Box 21. The Residents Development Committee in Ngombe

This photograph shows a member of the Residents Development Committee (RDC) standing outside RDC's office in the low-income Ngombe compound, Lusaka. This group have set up various elements of infrastructure in the compound, including water and sanitation, and most recently a solid waste collection service. Within the compound these people are responsible for payment to workers, design, provision and maintenance of vehicles and for the overall running of the collection system. The success of this waste collection service relied heavily upon the co-operation of the local authorities. The RDC had planned to collect waste from households and deposit it into a concrete transfer point from which the authorities had promised to collect it. After some months, however, this collection was still not undertaken and so the RDC had to hire a vehicle to remove the waste themselves. The group said,

'we need money to buy a truck for secondary removal, as we cannot rely on the council.'

(Rouse 2001b)



Resident Welfare Committee Office in Ngombe compound, Lusaka.

Transfer points are usually the responsibility of local authorities, so again collectors are reliant upon them for the provision of appropriate facilities. Transfer points have been discussed in some detail in Section 4.3, which also described the importance of compatibility with vehicles to minimise health and safety risks to collectors.

5.2 Purchase, ownership and storage of vehicles

Purchase and ownership of vehicles

Most vehicles on the streets in the study countries were owned by businesses, NGOs, CBOs or local authorities, although a large number were owned privately. The cost of a vehicle is too high for most individual waste collectors to consider buying outright. It has been found that in some cases a waste dealer will lend money to a collector to purchase a vehicle, the loan being repaid over time in valuable recyclable materials (Rouse and Ali 2001 and Kazi 2001). The provision of other appropriate lending schemes may improve poor people's access to better vehicles.

For small businesses it is important that the cost of vehicles can be realistically repaid from income over time, particularly where credit has being used. In Lusaka, the UNDP lent money to CBOs for purchase of vehicles. The vehicles were relatively expensive, however, and simple calculations suggest that the loan can never be repaid.

It is likely that ownership plays a part in determining the way people care for and use their vehicles. In Delhi, ACORD *gave* a number of waste collectors vehicles. A year or so later, very little maintenance was being carried out; the wheel bearings and chain were un-lubricated, the tyres were flat and the vehicles very dirty. The only exception to this poor record of maintenance was a cart given to a woman (the other recipients were all men) by ACORD in the same area who kept her cart well maintained and clean. It may be that the other collectors felt no sense of ownership or responsibility for their carts. If they had to pay for even part of the vehicle, or had to contribute to maintenance costs, it is likely they would have taken greater care to extend the life of the vehicles. The woman who was taking care to maintain her cart may be an exception, or it may be that she felt that the appearance and condition of her cart was important in terms of her relationship with householders, particularly as a female collector.

Coad (2001) suggests that in situations where vehicles are not owned by users, it may be worth at least ensuring that workers use the same vehicle each day, so there is some sense of responsibility for a particular vehicle and incentive to keep it in working order.

Night storage of vehicles

Vehicles need to be secured overnight to prevent theft, and in some climates stored under cover to protect them from rain which causes them to rust.

Ideally employers provide storage space for vehicles, but in reality the responsibility often lies with individual employees. It is important to consider that most waste collectors live in tightly packed slum areas where there is little spare space, so storing a vehicle can be a problem (Kazi 2001). This may be the reason that many vehicles around Delhi, for example, can be seen chained to railings on roadsides. Elsewhere in Delhi, groups of waste collectors gather vehicles together at the end of each day in an area where they are guarded by night (Rouse 2001a2). This relies on the social capital of collectors. This is also practiced in Dhaka where ‘neighbourhoods’ are said to guard vehicles. Kazi (2001) reports that theft is, however, commonplace. This must be catastrophic for a waste collector, both in terms of financial loss, continuity of work, and the prospect of replacement.

Storage area for handcarts in Delhi

Kazi (ibid) reports that some collectors store their vehicles overnight in government premises but also suggests that these are not necessarily secure. Another option available in Dhaka for those with no secure place of their own is to pay for a secure parking space. This is available for Tk50 (US$.70) per month, which is equivalent to one full day's wages for a waste collector.

If vehicles are continually wet, they will corrode faster and the bearings will require more maintenance and not last as long. In Ankara the *kapicis* (who store their vehicles inside each night) oil their wheels mainly to cut down the noise. In the same town, waste pickers (who store their vehicles outside, exposed to the rain) are reported to have to oil their bearings much more frequently (Ali 2001). This has implications for costs (in terms of time and money) to collectors because of the more frequent repairs and shorter lives of vehicles exposed to overnight rain. Ideally vehicles should be stored under cover.





Chapter 6

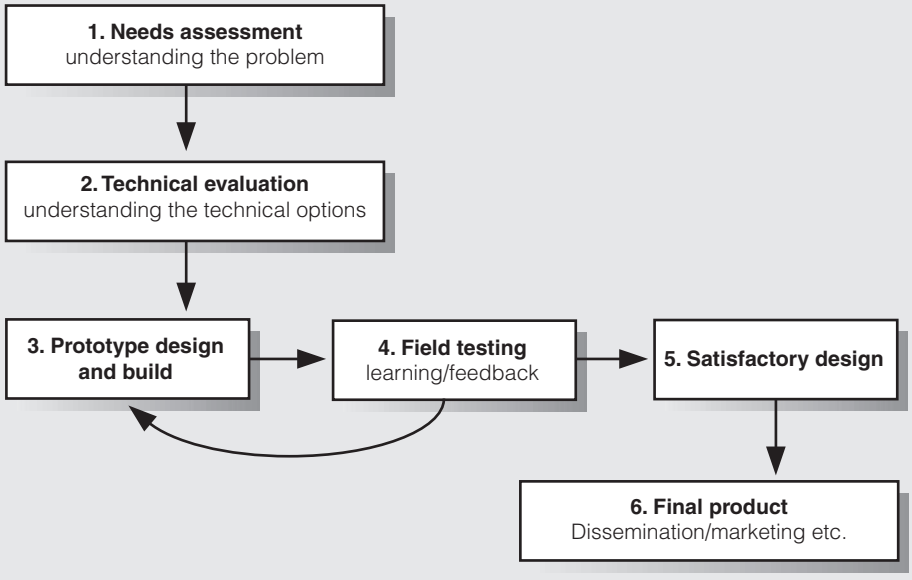
Vehicle design and participation

This chapter considers the process of designing vehicles, and how user participation in this process can most usefully be achieved.

6.1 The design process

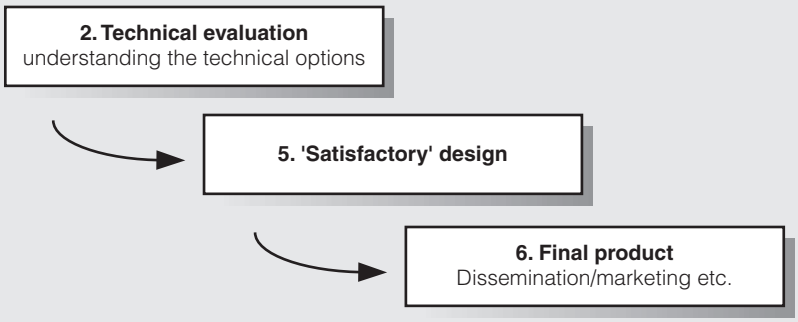
Box 22 illustrates the basic cycle of learning, design and feedback required for effective design.

Box 22. Process of design



The feedback cycle at field testing stage (step 4 to 3) is a vital part of the design process, but is often omitted. In many cases designers pay lip service to needs assessment, undertake a brief technical evaluation, skip the prototype and feedback stages altogether, and then distribute a final product that is not the result of careful research or testing. This is shown in Box 23.

Box 23. Common design process



Coad (2001) points out that a design is almost never right the first time, and that often the perceived needs of users are different from actual needs – reinforcing the importance of steps 1, 3 and 4.

6.2 Participation and consultation

> *'Users are generally not encouraged to comment on the tools and equipment which they are using. Little attention is paid to the ergonomics of hand tools, and a single model of handcart will be provided for people of different sexes, heights, ages and strengths without any reference to their individual needs.'*
>
> (Coffey 2001)

Participation is more than just a fashion – it is an essential part of vehicle design, and appropriate vehicles will not be designed without serious consultation with users.

Experiences from the field

Generally user participation and consultation in vehicle design is poor in the countries studied. The story Ali (2001) describes is typical of the way many authorities operate:

> *'The head of the district municipality cleansing unit in Ankara decides the required capacity of a vehicle and informs the manufacturer. The engineers at the manufacturing firm design the vehicle. Generally the lower staff like waste collectors or drivers are not consulted.'*

This is an example of a top-down design process which is not flexible. By contrast, Kazi (2001) reports that no design specifications exist within solid waste management organisations in Dhaka. He says a 'trial manufacturing process is followed in every workshop' and as a result there are many defective products. He also says there is very little creativity in design. Flexible, responsive, well informed guidance to workshops would be ideal middle ground.

There are few encouraging exceptions, though Coffey cites one from Faisalabad, Pakistan. Here, the street sweepers choose their own sweeping brushes, adjusting the length, weight and sweeping angle to suit their own preference. During fieldwork in Delhi, when a local authority representative was asked about the extent to which they involved users in design of vehicles and equipment, he also recounted a story about brooms. He said that as a result of women being involved in the design process for a broom in Delhi, its length was altered to make it more comfortable. He went on to say, however, that there was no user consultation in the writing of the Ministry of Urban Development waste guidelines manual (Ministry of Urban Development 2000). Other discussions with the municipality indicated that there was very little contact between decision-makers and the workforce (Rouse 2001a3).

An example of close partnership with manufacturers comes from Dhaka. When a community-based organisation decided to start a waste collection programme, their activists sketched a cart based on what they had seen elsewhere in the city. They marked the rough dimensions and took it to a metal workshop in the area. The artisan in the shop had manufactured similar carts in the past and suggested a few changes, and provided various quality and price options. The CBO opted for medium quality and price. There was no written agreement on design or price, but representatives from the CBO visited the workshop on a daily basis to ensure correct materials were used. The representatives were relying on a degree of trust, and good relations with, the manufacturer.

A resident welfare committee created in Ngombe Compound, Lusaka required SWCVs to use in narrow, muddy streets, that could be operated by men or women. Box 24 tells the story of how the design process started at an engineering university and ended with local artisans in the compound.

Box 24. From university engineers to local artisan

This first vehicle prototype (i) was designed by a university engineering department. It was a design resulting from poor engineering and inadequate research into user needs. There were several problems.

(i)

- A foot-operated release mechanism intended to allow the main container to tip forward and empty the cart did not work. The pivot was placed forward of the centre of gravity of the cart, so the container did not tip. The mechanism was useless.
- The cart was very heavy and the centre of gravity was behind, not over, the axle. As a result the user had to lift much of the weight.
- The wheels were too small for use on the uneven ground in the compounds.
- The cart was too costly for the community organisation to afford.

The engineering department then designed the model labelled (ii). This was field tested in the Ngombe compound but again was not accepted.

(ii)

- The wheels were made larger in diameter but were too crude – a simple 'v bar' shaped into a circle with a bicycle tyre and inner tube fitted. Tyres rolled off (as in picture) and rendered the cart useless.
- The cart was lighter, but it was not strong enough. The rear supports broke frequently.
- The main container was considered too small and had a 'lip' on the inside of the rim which made emptying it difficult.

Box 24. continued

A local metal-worker then became involved and designed the cart shown in (iii), based on comments direct from the resident welfare committee whose office was situated near his workshop. This was heavy but strong, cheap and had good sized strong pneumatic wheels which made it easy to use on the uneven, muddy ground. The same man went on to design and build the vehicle shown in (iv) based on further feedback. It has a sloping front to ease emptying. He then built (v) for a women's CBO as they wanted larger, but lighter wheels with the sloping front.

These last three vehicles built by the local artisan were being used on a daily basis for waste collection. Vehicles (i) and (ii) were not used.

(iii)

(iv)

(v)

Who should participate in design?

The example in Box 24 from Lusaka illustrates a number of key points:

1. When technical institutions do not include users in the design process they can overlook vital details – in this instance the poor road conditions and strength of users.

2. Formal technical institutions do not always get things right.

3. When communities work together with local manufacturers the results can be much better.

4. All users of vehicles, both men and women, have useful inputs to the design process. Designers need to listen.

As in Lusaka, vehicles in many countries are designed either by qualified engineers or small-scale artisans. Both have their strengths and weaknesses.

Engineers may have better resources, tools and technical knowledge but will often know very little about the work for which the vehicles are intended. This may be particularly the case in developing countries. Coffey (2001) describes how in the more industrialised countries in Europe and the United States, for example, it is quite feasible for individuals in the management of local authorities to have started their working life, perhaps as students working during vacations, street-sweeping or truck loading. When they reach management level, these people will be much more aware of the issues and requirements of equipment and vehicle design, having experienced the work first hand. The chances of engineers having had this experience in say, India or Pakistan, are very slim, because of the great socio-economic divide between management and labour forces. As a result, they have a poor understanding of the work.

Small-scale artisans will not usually have such good resources or technical knowledge as a local authority or university engineer, but they have often actually used the vehicles they design and are in much closer contact with users. These are valuable assets to the designer.

Waste collectors have the best understanding of what is required of a vehicle, and consulting them is essential. At the same time, it is important to consider the possible limits to their useful contribution, as with engineers and artisans.

Fieldwork in Delhi exposed some of the shortcomings in vehicles operators' understanding of technical issues of design. The following two examples arose during fieldwork in Delhi whilst discussing possible improvements to cycle carts with waste collectors.

- One worker was asked if he would like a lighter cycle cart. He replied 'No, because it would then be too weak'. He was then asked how he would feel about a vehicle which was both lighter and stronger. He replied 'Then it would be too expensive'.

- Another worker was asked if he would like a cart with larger wheels. He answered 'No, because that would make the cart too large' (Rouse 2001a).

These examples show how these waste collectors are seeing technical barriers to improvement which in fact do not exist. In the first case, an engineer would (hopefully) know that a lighter vehicle does not necessarily mean a weaker vehicle, and that a well-designed light vehicle need not necessarily be more expensive. In the second case, it is clear that larger wheels can be added to many vehicles without significant changes to design and often no change to overall size.

These examples raise questions about *how,* and the *level at which,* users participate, not *whether* they participate. Clearly, where one group is weak, the other is strong. This points towards a need to exploit their complimentarity.

Do people wish to participate?

In addition to *how* users participate, there are also issues about how much users actually *want* to participate in the design process. Ali (2001) describes how *kapicis* are not interested in being involved with design as they only use their vehicles for short distances, and are not bothered about the design. In other instances, he says, they simply have no ideas.

In Dhaka users are reported to be keen on participation if they believe that changes will significantly increase efficiency. The author often encountered apathy in responses from waste collectors being interviewed, particularly in India (Rouse 2001a). This may be because they had been asked questions many times before and never seen any benefits.

Box 25. Dyson's 'ballbarrow'

In 1974 whilst renovating an old farmhouse James Dyson and his wife had just bought, he found himself becoming increasingly frustrated by the limitations of his [traditional] wheelbarrow. It continually sank in the mud, was unstable, the legs gouged holes in the lawn and the contents slopped out without much encouragement.

He eventually solved all these inherent problems of a traditional barrow by coming up with the idea of what is now famously known as the 'Ballbarrow.' This wheelbarrow has a large ball instead of a wheel, which could go anywhere and even travel over mud without sinking. Its other innovative design feature was the plastic barrow body which didn't rust and to which concrete couldn't stick. This amazing looking wheelbarrow became the best selling barrow in this country in just three years.

Text and photographs from an article at: http://home.about.com/

Recipes for design

Box 25 relates how an Englishman called James Dyson came to design a new type of wheelbarrow. It is an example of how frustration with technology drove an individual with appropriate skills and resources to design something better.

Much technological innovation is driven by dissatisfaction with existing technologies, and enabled by expertise and resources. Users of waste vehicles often feel dissatisfied with (albeit resigned to) poor vehicles, but they rarely have the expertise or skills or resources (time, money, space, tools, etc.) to effect change. They do, however, have expertise in terms of knowing what is *needed* in a vehicle design.

Together, and *only* together, users, employers and vehicle designers have the necessary components of a successful design process: information, money and expertise.

Chapter 7

Final words

7.1 Summary of findings

This research has found that small vehicles are being used around the world for waste collection (and many other purposes), and that there is a need and demand for better-designed, safer, more comfortable, affordable alternatives.

The literature review undertaken at the beginning of this project revealed a wealth of information relating to the technical aspects of vehicles, but very little relating to the social and institutional aspects. Findings from fieldwork have emphasised the importance of viewing vehicles not in isolation, but in their social and institutional context. Understanding these 'softer' aspects is a vital part of the process of designing appropriate vehicles. There are, however, a number of technical issues which need to be resolved. These include balancing cost with quality, matching vehicle design with other stages of waste management (i.e. collection, transfer and disposal points) and selecting appropriate materials and design for particular situations and conditions.

The lack of long-term planning by authorities responsible for providing vehicles is in part responsible for the many low-cost, low-quality SWCVs used on the streets at present. Greater capital investment could lead to savings over the long term as well as better vehicles for workers. There are, however, various forces working against this, including short terms of government and local authorities as well as corruption.

The ownership of vehicles has been raised as an issue from a number of angles. Relative to incomes, wheelbarrows and carts constitute a large investment for waste collectors, and as a result most are owned by employers. Ownership affects users' sense of responsibility and the level of care they take of their vehicles. Ideally there would be a move towards more widespread ownership of vehicles by those who use the vehicles.

Design and consultation has been discussed in some detail. Those who design vehicles are mostly different from those who use vehicles, and fieldwork has identified examples of where users have been closely consulted in design. Where such examples were found (e.g. in Ngombe, Lusaka) the results have been very positive. Vehicles are intended for use by *people*. People need to be central to the design process.

Involvement, and concern for the welfare of users of waste vehicles will be the main driving force for the development of better vehicles for the urban poor.

Stakeholder analysis

This brief stakeholder analysis outlines some of the positive and negative effects on individuals or groups affected by the issues raised in this research project. This analysis is based on the ultimate objectives of this research, namely:

- improved small waste collection vehicle design;
- better access to small waste collection vehicles and livelihood opportunities for the poor; and
- improved solid waste management services to the public, particularly the poor.

Box 26. Stakeholder analysis of possible impacts of this research

	Positive	Negative
Users – men	■ Better health and safety conditions in work ■ Faster and easier work ■ Lower expense on maintenance ■ More awareness of health and safety issues ■ Higher perceived status of work and workers because better equipped	■ Possible competition from women for work resulting from their recognition & new opportunities.
Users – women	*All above, plus:* ■ Possible increase in opportunities for work ■ Access to vehicles and tools specifically designed for women	-
Householders	■ Better service provision ■ Smarter / cleaner neighbourhood ■ Healthier and happier workforce ■ Possible better attitude to waste workers because the better vehicles legitimise them	■ HH may be required to separate their waste
Waste dealers and recyclers	■ Better segregated waste so higher value recyclables ■ More waste through more extensive coverage	-
Employers and decision-makers	■ Healthier and more satisfied workforce ■ More efficient workforce ■ Long-term savings from lower maintenance and higher reliability ■ Greater popularity from public due to better service provision	■ Possible greater initial expenditure on better vehicles ■ May have to change the way money is spent (i.e. adopt longer term vision)
Vehicle designers	■ New work for designers ■ New skills training may make them more employable	■ May require some extra training (see positive)
Manufacturers and repairers	■ More manufacturing work ■ New skills training may make them more employable	■ May require some extra training (see positive)

7.2 Making a difference

Literature and fieldwork have shown that waste collectors and local authorities can be resistant to change and it can be difficult to convince them to try new technologies (Asnani in Rouse 2001a2). There are also practical barriers to change such as the availability of spares, lack of funds and skills of engineers and artisans.

Box 27 distils lessons from improved cycle rickshaw programmes in Bangladesh which are relevant and applicable to waste vehicles. They are based on a similar technology, social group and environment.

Box 27. Lessons from the past

The road to successful vehicle introduction:

- At the stage of wider dissemination the new vehicle should be a finished product rather than a developing prototype. The vehicle must be significantly better than that which it is to replace. This is fundamentally important.
- Target dissemination and promotion wisely. Experiences in Bangladesh suggest that the existing industry is more effective than NGOs and academic institutions. Work with established networks and industry, not against them.
- Promotional efforts require careful thought, planning and funding. A large production run (perhaps of free vehicles initially) may be necessary to raise the profile at the outset.
- Radically different designs can mean problems with cost / availability of spare parts and discourage adoption because new skills would be required for their manufacture.
- Ideally a vehicle will have the backing of the government and / or some credible body. This can be beneficial in terms of funding, reputation and support.

Gallagher 1992:362

Forthcoming publication: 'The Vehicles Toolkit'

The final output from this research will be *The Vehicles Toolkit*. This will comprise a set of guidelines on how best to design appropriate vehicles for use by the poor for solid waste collection. These will be based on, and respond to, the issues raised in this book. The *Toolkit* will tackle problems from the perspective of various groups including governments and local authorities, NGOs and donors, community organisations and vehicle designers themselves.

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Appendices

Appendix 1. Details of individual researchers

Azhar Ali, Ankara, Turkey

Mr Azhar Ali is a graduate of the Department of Environmental Engineering at the Middle East Technical University, Ankara, Turkey. He finished his BSc in February 2001. He has taken part in various onsite and online conferences and worked as online consultant on solid waste issues for various municipalities. Azhar has had ten international papers accepted or presented at various conferences in different countries, and is writing a book on the issue of NGO management. At the moment he is working in the United Nation's Volunteer programme and as Director of External Development to Unitedafrik, a US-based NGO.

Dr Noor M Kazi, Dhaka Bangladesh.

Dr Kazi is an Environmental Engineer with a PhD in Environmental Engineering from the UK. He has worked in urban environmental management for the last nineteen years and is now the Adviser of Environment and Development Associates (EDA) in Dhaka, Bangladesh.

Dr Kazi specialises in urban environmental issues for low-income countries. Some of his research areas are municipal solid waste management, hospital waste management, water supply, sanitation, and issues related to environmental impact.

Engr SM Shakaib, Karachi, Pakistan

Shakaib has been working with the Karachi Metropolitan Corporation for the last ten years. He has extensive experience in the field of solid waste systems in Pakistan, and has attended a number of training courses on solid waste management.

Appendix 2. Abstract from Terms of Reference for country studies

Developing a general understanding of waste management in the city

Before detailed investigation begins it is necessary to develop a broad understanding of the way in which solid waste is managed in the city being studied.
Some key questions:

- Which authority / authorities have overall responsibility for waste management? What is their responsibility? (i.e. primary, secondary, domestic only, etc.)
- Is work tendered out to contractors? What work, to whom and why?
- What part does the informal sector play in city waste management?
- How do the different actors work together? (e.g. does the informal sector work compliment or compromise the local authority's work?)
- What major issues emerge regarding waste management in the city? Do different actors have different issues? (e.g. capacity, competition, primary, secondary, final, etc.)
- Generally, look to develop an understanding of the issues that effect vehicle choice, waste characteristics, road widths and surfaces, gradients, storage systems at houses, housing densities and seasonal factors, etc.

Detailed investigations

Detailed investigations into waste collection vehicles will be divided into two main areas: the formal and informal sectors. This section outlines some of the issues to be explored with these two groups.

Formal sector

- What do the formal-sector waste-management activities in the city comprise? How do the activities vary between high- and low-income areas of the city? Why is there this variation?
- What SWCVs are used and by whom? Why are these specific designs used? (cost, size, availability, etc.) (Refer to Section 3.6 for a research checklist.)
- What are the existing procedures for the design, supply/procurement and maintenance of SWCVs and equipment?

- Who decides what vehicles are required in certain areas?
- Who pays and who arranges the finances? Are costs recovered? How?
- Who designs the vehicles? Are users of the vehicles consulted in the design?
- Are design drawings / specifications available? How formalised are the designs?
- Who manufactures the vehicles?
- What are the arrangements for maintenance of the vehicles?
- What problems do the local authorities face in using, repairing and maintaining vehicles?
- What complaints (if any) do the local authorities receive from users of vehicles and waste collection services?

Other issues of interest

Transfer spaces (where waste is deposited after primary collection) are an important part of a waste management system. They mark the point at which community involvement and formal and informal sector activities and issues meet. Their design and location, and the level of community consultation in this, are of interest to this research. Details of their operation and maintenance are also relevant.

Transfer spaces can be designed to relieve the hardship of emptying SWCVs and loading larger ones for secondary transfer. They are often designed in a way that makes emptying difficult and hazardous. The design of transfer points in cities, and the possibility of designing them with SWCVs in mind, are of particular interest to this research.

Secondary collection can be a strong factor in the success and sustainability of primary collection schemes. The nature of secondary collection is relevant to this research.

Attitudes of local authorities. The need and willingness of local authorities to improve their practice is also of interest. This includes willingness to consult users in the design of vehicles, to change vehicle designs considered to be unsuitable, or to purchase vehicles which are more expensive but more comfortable and safer for the user.

Formal sector employees and users of SWCVs. Locate some of the users (e.g. sweepers) of the SWCVs provided by the formal sector and explore the issues outlined in Section 3.

Try to cross-check information provided by the authorities with information provided by users. Include differences in information in the report.

Informal sector

Locate individuals (or groups) working in the informal sector and use Section 3 of this document as a guide to issues to explore. Investigation need not be restricted to low-income areas as it is likely that informal-sector collectors will choose to work in higher income, industrial and commercial areas.

Some broad areas to be considered.

- What kind of people undertake this work?

- What gender issues are involved in the use of vehicles? Do these issues depend on design or type of area in which the vehicle is used? (e.g. Do women use SWCV as well as men? Do women use smaller vehicles than men?)

- What issues relate to age, race, tribe, caste or class? (e.g. Is waste collection work restricted to a particular caste? Are children unable to use the SWCVs because they are too large or heavy?)

- It may also be useful to speak to individuals engaged in similar waste collection work but who do not used vehicles. Why do they not use vehicles? (e.g. cost, supply, convenience, lack of need, etc?).

- Try and locate some of the vehicle manufacturers and repairers. They are likely to be able to tell you what dictates their design (materials availability, cost, government guidelines, etc.). Repairers will be able to say what the inherent weaknesses are with particular vehicles.

The case of NGO interventions

In certain instances NGOs may have initiated SWCV projects in the city being studied. It is likely that many useful lessons could be drawn from these, and information about their experiences could be included as case studies in the outputs of this research.

Note: general information about NGO projects is not required. Please restrict research and reporting to areas directly relevant to SWCVs.

Final notes

In the final report please detail all research undertaken, including difficulties encountered. Outline possible areas for further research and work.

Please keep details of all correspondence and contacts relating to the research and forward them with the report.

Detailed research topics

The following were investigated:

- Vehicles and collection systems in three middle-income residential areas
- Small vehicles around one of the commercial centres of Delhi
- Small vehicles / collection systems in part of the old city
- A supplier and manufacturer of small vehicles
- Waste collectors with *no* vehicle

The following sections detail the issues investigated in Delhi with a range of actors including door-to-door household waste collectors, municipal sweepers and private entrepreneurs. Many of the issues will be relevant in other cities, some will not. This list is intended to provide guidance to suitable research topics. It is not exhaustive and can be extended. References to 'he' can be read as 'he' or 'she' throughout.

General

- How long has he had this vehicle? Is it the first? Why did he get one?
- How does having a vehicle affect his livelihood?
- From where was vehicle acquired? Is it easy to get a vehicle for this work?
- How much did the vehicle cost? How was this money found – who paid and how? Credit?
- Who designed the vehicle? *Get address and visit….*
  – What involvement did the users have in this design process?

- How long is the vehicle likely to last?
  – What wears first?
  – Are there corrosion problems?

- What maintenance is undertaken on the vehicle? By whom? Frequency? Cost? etc…

- Where is the vehicle kept at night? Security a problem? Detachable parts?

- Is the vehicle used for any other purpose in the course of the day?

- What does he think of the vehicle?
  – What problems does he encounter with it and its use? E.g. comfort, cost, breakdown
  – What improvements have been / could be made?
  – Why have these improvements not been made?
  – What equipment does he use in addition to the vehicle?

The waste

- What waste is collected? (Nature / density / moisture content)

- Is the waste segregated at all? At what stage? In the vehicle?
  – What happens to different portions?

- Is there seasonal / regional variation in nature of waste?

The collection area

- How many houses / roads does he collect waste from?

- Do other people help with the round?

- What is the road surface like? Quality / inclines?

- Where is the waste taken?
  – If taken to a transfer point, what is the method of transfer? How is the transfer point designed? Note amount of direct of contact with waste / lifting of weight
  – Could this be improved – and how?

- How far is the dumping point from the round?

- How many times is the dumping point visited in a round?
- How long does the round take, and when is it undertaken?
- Who determines what roads are covered by whom?
- Could the round size be changed? Would this be desirable?
- Are there any trends? (e.g. rounds have got smaller, more waste, less pay, etc.)
- *Any details of municipal collection would be useful …*
  – *Frequency, method, possibilities of integration etc.*

Users of collection service

These may be householders or shopkeepers who pay a man / woman to collect their waste on a daily basis. Look into the following:

- What are people's general impressions of the service they receive?
- What are people's attitudes towards the waste collector? (e.g. respect, trust, distrust, friend, etc.)
- Does the waste collector's vehicle affect people's attitude towards him? (e.g. people may feel he is more official, trustworthy and permanent if he works with a vehicle).
  – Does the *type* of vehicle affect people's attitudes?

Please beware of suggesting answers to users. Try to allow people to answer open-ended questions.

Personal issues

- Where does the collector live?
- What is his salary?
  – How does he collect the money? (e.g. door-to-door, or through Residents' Welfare Association, municipality salary?)
  – Does he encounter any problems with payment – e.g. householders being unwilling to pay?
- Does he undertake other work during the day? (e.g. is he employed as a sweeper)

- How did he get into this job? (e.g. through friends, Resident welfare committee, etc.)
  - How long has he been doing this? What did he do before? Does he plan / hope to do anything else? *(don't suggest!)*
  - Is the job secure? What threats (if any) exist?
  - What alternative forms of employment exist?

Small waste collection vehicles

- Photograph the vehicle.
- What age is the vehicle?
- Make a sketch of the vehicle and mark particular features such as areas of weakness, strong / weak design points, damaged / dangerous parts, etc.

Also note:

- Dimensions and capacity
- Construction materials
- Wheel type (e.g. wood / metal / are they sealed?) and size. Are there bearings?
- Evidence of corrosion
- The approximate payload
- The kind of road surfaces it is used on
- How noisy it is during operation
- Any obvious safety issues
- How comfortable it is to use. What problems are there? (e.g. size, balance, weight, etc.)
- Ergonomic issues – with particular reference to size / gender / strength of users

Terms of reference prepared by Dr Mansoor Ali and Jonathan Rouse,
1 March 2001