

## **DETERMINANTS OF CYCLING IN MEDIUM AND LARGE CITIES IN SUB-SAHARAN AFRICA**

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### **Abstract**

For urban transport in developing cities cycling is a potentially important mode of transport. In many of them, particularly in Asia, it already provides a high level of personal mobility, at a low cost. In some cities in Africa cycling also plays an important role, but in most, particularly the largest cities, it does not. This paper analysis the determinants of bicycle use and ownership in the Tanzanian cities of Dar es Salaam and Morogoro. In Morogoro cycling is a well-established mode of transport, with a market share of 20% (98% males), whereas in Dar es Salaam it is less than 3%.

## **INTRODUCTION**

Urban transport in most large cities in Sub-Saharan Africa is characterised by a low level of personal mobility. One of the major reasons for low mobility is that a large number of residents cannot afford the bus fare (e.g. the bus fare in Dar es Salaam:  $\pm$  0.045 USD/ passenger kilometre; price level 1997), irrespective of trip length (Rwebangira and Nguma, 1994). Pedestrian trips are pervasive in all Sub-Saharan cities (typically, more than half of all urban travel is made on foot). In most African countries the bicycle is not acknowledged by road authorities as a means of urban transport (Howe and Dennis, 1993). Consequently, facilities and road reserves for cycling have not been provided, and bicycles play an insignificant role. However, the use of bicycles differs strongly between medium and large sized cities. This paper documents the reasons behind this difference, based on two household surveys in the Tanzanian cities of Dar es Salaam (almost no cycling) and Morogoro (substantial cycling). Cycling raises the mobility of cyclists by more than 50% compared to non-cyclists.

## **BACKGROUND**

The research for this paper is part of the work in two pilot projects on Urban Mobility and Non-Motorized Transport, that have been carried out from 1995 up to 1998 under the urban component of the World Bank's Sub-Saharan Africa Transport Programme (SSATP) by a multinational team, including the authors. Two other pilot cities within the same project are Eldoret and Nairobi in Kenya.

### **Urban transportation in Tanzania**

Urban areas in Tanzania offer numerous constraints for non-motorized transport. The chaotic behaviour of buses, cars and trucks, due to the lack of proper traffic management, absence of enforcement of traffic rules and poor road conditions, and high velocities of motor traffic create unsafe conditions for pedestrians and cyclists. For example, of all fatal accidents in Dar es Salaam between 1985 and 1994, 65% of the victims were pedestrians, and 4% cyclists. About 55% of the traffic accidents were attributed to reckless driving (Ministry of Works, 1996). The lack of separate facilities for cyclists (lanes, signal phases, parking) and dangerous traffic conditions repeatedly appear as explanations for why bicycle use has decreased, or why they are not in greater use (Howe & Dennis, 1993). Average mobility, in Dar es Salaam, is about 1.9-2.0 trips/person/day, which is low compared to mobility in most developed countries. In the Netherlands, for example, the average mobility in 1996 for all modes was almost double at 3.5 trips/person/day (CBS, 1997).

To investigate the use of bicycles in urban areas a household survey was conducted in Dar es Salaam (1994) and Morogoro (1995). Cycling has a marginal market share (2-3% of personal trips) in Dar es Salaam, with a population of 2.5 million people, whereas it is significant (20%) in Morogoro, with a population of 150,000 people. The survey area in Dar es Salaam was Temeke (ward 14, with approximately 150,000 inhabitants), which is a typical low and middle-income residential area. The data from this area can be used to give a reliable picture of transport problems in Dar es Salaam as a whole. The survey in Morogoro covered the entire city, which is also a typical low and middle-income area.

Private passenger car ownership is very low in both cities. Since public transport is not affordable for many urban dwellers, walking results in very low mobility. It would therefore be logical if bicycles were used to increase mobility. However, cycling faces a number of constraints. It is the objective of

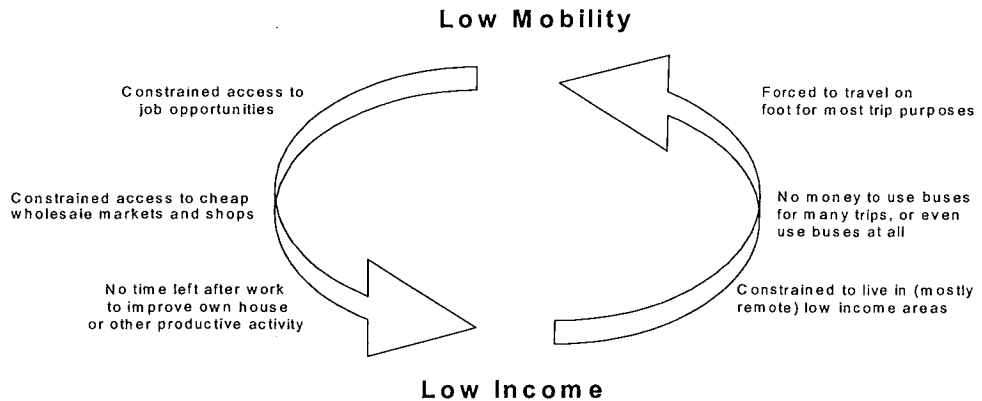
this paper to outline the constraints that limit the cycling market share to its current (low or modest) level in large and medium sized cities in Tanzania.

### Modal choice and mobility

The mode of transport used to get to a destination depends on a lot of different reasons, or constraints. Being able (or being forced) to use a certain mode influences a persons mobility.

#### *Mobility versus income*

Cycling as a mode of urban transport enables people to travel at relatively low costs (approximately 0.5-1 USD cent per passenger kilometre, depending on bicycle utilisation). With a bicycle one is able to travel longer distances and to carry more weight than in the case of walking. Because with a bicycle longer distances can be covered and travel speeds are much higher than on foot, individual mobility increases. This often means that one is able to earn or save money, through better access to job opportunities and the ability to buy products at cheaper markets or shops. A vicious circle exists linking low mobility and low income. Cycling, which is roughly 3 times cheaper than a bus and 3 times faster than walking, has the potential to break this vicious circle of personal immobility, which is illustrated in figure 1.



**Figure 1 - Vicious circle of mobility**

Different factors determine people's ability to make trips. For example:

- (1) availability of private means of transport;
- (2) affordability of public modes of transport;
- (3) traffic safety and security of intended trips.

In analysing the market penetration of a certain mode of transport, in this case cycling, it is useful to explore the existence of "critical constraints" which dictate modal choice.

#### *The critical constraint concept*

The most common model in modal split analysis tries to explain the choice of an individual in favour of a particular mode of transport on the basis of the combined impact of a number of "explanatory" variables (for example travel time, expected delay during interchanges, etc.). The step preceding

application of such a model is to determine what is the range of choices that a particular individual traveller has (does she or he have a car available, or a bicycle, does a public transport connection exist between the origin and destination of the trip? etc.).

In practice, this first step already explains a substantial part of the modal split, particularly if it includes an estimate of the number of people that reject a certain alternative on psychological grounds. This may relate to his/her personality and general perceptions of alternative modes of transport rather than to objectively quantifiable aspects of the different alternatives. For example, car owners rejecting the public transport alternative a-priori.

Through this step-wise choice mechanism the number of travellers that realistically make a regular choice between different modes of transport is already fairly limited in most urban areas in Europe, where availability of the personal car as an option is high and the cost of transport does not constrain choice for an important number of travellers. In urban areas in most of Africa, Asia and Latin America a choice model based on the simultaneous and joint influences of a number of explanatory variables, such as travel time, cost, comfort etc., is probably less important as a means of explaining the use of personal modes of transport (car, bicycle), than in developed countries.

It may be more useful to use another model concept to analyse the shares that different modes of transport have in the urban traffic, i.e. the *critical* - or *active constraint model*. An easy way to explain the "critical", or "active" constraint model is to take an example from crop growing, and analyse the growth or decline of the market share of a mode of transport in a similar manner. The growth of maize depends on a large number of factors, nutrients in the soil, water, temperature etc. However, at any given moment in time there is only one (or sometimes two interrelated) factor that is actively constraining the growth of the plant. And to enhance the plants growth the only thing that is immediately important is to do something about that limiting ("active") constraint. At a later moment other factors will come into play, and in their turn become the active constraint, but not immediately. If a lack of phosphor in the soil is the active constraint, adding more nitrogen fertiliser is just a waste of money and time, even though the measured nitrogen content of the soil is far below the optimal value that one would aspire to have to get a bumper crop. Maybe after the phosphor problem has been addressed nitrogen fertiliser is important, but it could equally well be that another factor is at that moment the active constraint, e.g. water. The bottom-line is thus to identify the active constraint(s) and act upon it (them).

Applied to modal split in the cities described in this paper, the logic of the proposed model can be explained as follows. All households that can afford a private car will buy one as soon as the opportunity occurs. At the same time all other alternatives will be considered much less seriously by the head of the household (unless the car is out of order), and are perceived psychologically as a past from which they have just escaped. With a small number of exceptions all other alternatives, in particular public transport and cycling, are rejected a-priori. So, for the modal share of cars the limiting constraint is ownership (income). Walking short distances will remain, from home as well as at the destination of the trip made by car. However, in view of the existing and expected future income situation, this mechanism does not have a very big impact on modal shares in many cities, in Sub-Saharan Africa and South Asia, because the number of people in this category is very limited. Moreover, a severe imbalance between female and male private car-use exists; the number of female drivers is very small, and car trips by female members of the household occur almost entirely to the extent that they can be combined with trips by male members of the household. The survey data indicate that car use remains cost-sensitive. For many short trips car owners walk rather than use their car, particularly in Morogoro

The modal share for cycling is more complicated, because the number of successive constraints that determine the decision to buy a bicycle is larger (not income only), while at the same time it is less precisely defined. For example, with only one or two bicycles in the household, which household

member 'owns' and will use the bicycle? Once a bicycle is actively available for a traveller, there may or may not be remaining constraints that decide the actual use. That is an area that requires careful analysis.

## BICYCLE OWNERSHIP AND USE

Travel behaviour, and in particular the modal split, was studied by means of household surveys in Dar es Salaam and Morogoro. The questionnaire had two parts with a total of 29 questions, which required a total of 200 possible responses from each person interviewed. Part one consisted of questions on general household characteristics including sex, age, income and vehicle ownership. The information on age and gender are useful in determining the composition and characteristics of the survey population. The income data gives an indication of the ability to afford the various transport services. Part two of the questionnaire consisted of questions on trip-making on the previous day and attitudes towards cycling in general for each member of the household above 15 years of age. In Dar es Salaam 1246 respondents from 298 households were interviewed, whereas in Morogoro the respective figures were 1469 respondents from 436 households. The results are reported in (Sambali, 1995a, 1995b).

### Vehicle ownership

The majority of the households in Morogoro belong to a very low-income group (87%), whereas in Dar es Salaam that proportion is slightly lower (75%). The 25% from a higher income group in Dar es Salaam may be the contributing factor towards a larger percentage of cars being owned by the households as compared to Morogoro, which can be seen in tables 1 and 2.

**Table 1 - Percentage of HH's owning one or more vehicles (non-motorized or motorized)\***

	Car (%)	Moped (%)	Bicycle (%)	No means (%)
Dar es Salaam	12	6	21	61
Morogoro	5	9	52	34

\* 165 vehicles (non-motorized and motorized) are owned by 298 HH in Dar es Salaam, 377 vehicles (non-motorized and motorized) are owned by 436 HH in Morogoro.

**Table 2 - Average number of vehicles (non-motorized or motorized) per 100 adults\***

	Car (#)	Moped (#)	Bicycle (#)	Carts (#)
Dar es Salaam	4	1	5	3
Morogoro	2	2	15	3

\* age ≥ 15 years. The average household size is 4.4 adults per HH in Dar es Salaam and 3.4 adults in Morogoro.

In Dar es Salaam the average car ownership is 0.16 cars/HH, whereas in Morogoro the figure is 0.06 cars/HH. For bicycle ownership the situation is reversed, with the ownership in Morogoro exceeding that in Dar es Salaam, i.e. 0.2 bicycles/HH and Morogoro 0.7 bicycles/HH.

### *Determinants of bicycle ownership*

*Affordability.* In the survey questions were asked to determine the proportion of people that can afford to buy a bicycle. The proportion is almost the same in both cities. In Dar es Salaam only 12% state that they could afford a bicycle, whereas in Morogoro the corresponding figure was 10% if adult respondents without a bicycle, which can be seen in table 3.

**Table 3 - Bicycle ownership and affordability by adults**

	Dar es Salaam (%)	Morogoro (%)
has a bicycle	5	15
has no bicycle	could afford one	12
	cannot afford one	75
<b>Total</b>	<b>100</b>	<b>100</b>

From the group of respondents who had no bicycle and could not afford to buy one, the majority in both cities would want to have one, i.e. 82% in Dar es Salaam and 98% in Morogoro. Apparently the bicycle is more popular in Morogoro than in Dar es Salaam. When given the opportunity to borrow money, a credit scheme, 71% of the respondents in Dar es Salaam and 88% in Morogoro would consider buying a bicycle.

*Unsafe traffic conditions.* Respondents without a bicycle were asked why they didn't possess one, leaving aside the problem of affordability. Table 4 shows these reasons.

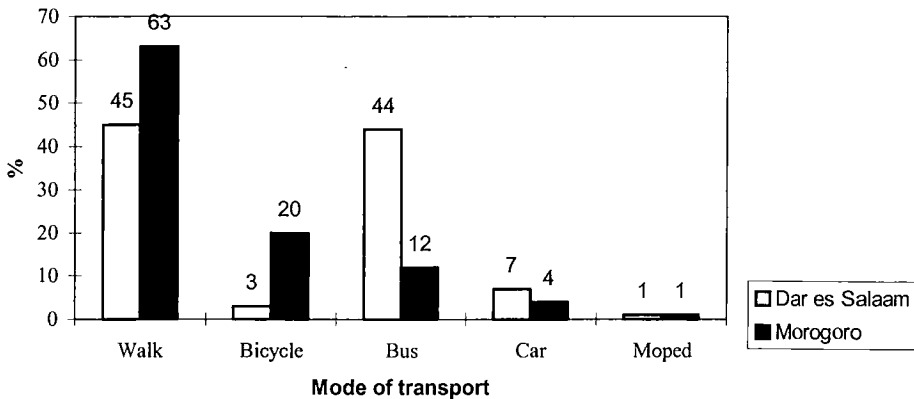
**Table 4 - Reasons for not having a bicycle [1017 respondents DSM, 960 respondents Morogoro]**

Reason	Dar es Salaam (%)	Morogoro (%)
risk of having traffic accidents	68	10
health forbids me to cycle	7	6
no safe parking places	6	3
trips are too long	2	2
women should not ride	2	1
I find riding too exhausting	2	1
other reasons	13	77
<b>Total</b>	<b>100</b>	<b>100</b>

It can be concluded that the risk of having traffic accidents (68%) is the critical constraint in Dar es Salaam. Similar results were obtained by (Immers and de Wilde, 1984) in another study for Dar es Salaam. They found that 75% of non-bicycle owners said they would not purchase a bicycle unless safety was improved.

### Modal choice and mobility

*Modal choice.* In the surveys respondents were asked to describe all the trips made during the previous day. The results concerning the most important trip of the day for both cities are as summarised in figure 2.



**Figure 2 - Mode of Transport used for most important trip**

From the figure above it can be seen that walking is the main mode of transport. In Dar es Salaam public transport is equally important. In Morogoro residents choose cycling as the second largest alternative after walking (20% on average, which is 32% for males and 4% for females; 25-30% of these trips is with a hired bicycle). It is interesting to note that the share of cycling is higher than the bicycle ownership percentage. The reason is that Morogoro has a significant bicycle hire business with over 200 locations in 1998 where it is possible to hire a bicycle for an hour or a day. It is also interesting to see that in Dar es Salaam the percentage of bicycles used in the most important trip is well below the ownership percentage.

*Mobility.* The respondents were asked the number of home based and non-home based trips the previous day. From this data the mobility of the population for both cities will be defined as the average number of trips/person/day. The actual number of trips that a person would *like* to make during a day can be much higher, and in most Sub-Saharan cities actually is (Akinyemi, 1998). So, there is a situation of suppressed demand. Table 5 gives the average mobility for the two cities. The mobility was further broken down by availability of personal means of transport.

**Table 5 - Average mobility (trips/person/day) for different mode users**

	overall	bicycle available	car available	no means
Dar es Salaam.	1.9	2.7	2.7	1.8
Morogoro	1.7	2.5	2.4	1.5

From the above table it can be seen that availability of a private means of transport strongly increases personal mobility and that bicycle ownership creates the same increase in mobility as car ownership does. For example, in Morogoro availability of the bicycle generates 2.5 trips per person per day, whereas a person with a car available generates 2.4 trips per day. People with no option but to walk show very low mobility (1.8 or 1.5 trips/person/day on average). The mobility of Dar es Salaam (DSM) residents is slightly higher. Table 6 shows the modal split by distance class.

**Table 6 - Modal split of transport by distance class**

	0 - 4.9 km		5.0 > km	
	DSM (%)	Morogoro (%)	DSM (%)	Morogoro (%)
Walk	73	83	7	14
Bicycle	2	11	5	41
Bus	23	6	72	28
Car/Moped	2	0	16	17
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

From the table above, for longer distances of more than 5.0 kilometres in Dar es Salaam only 12% are covered by non-motorized transport, whereas in Morogoro this proportion is 55%.

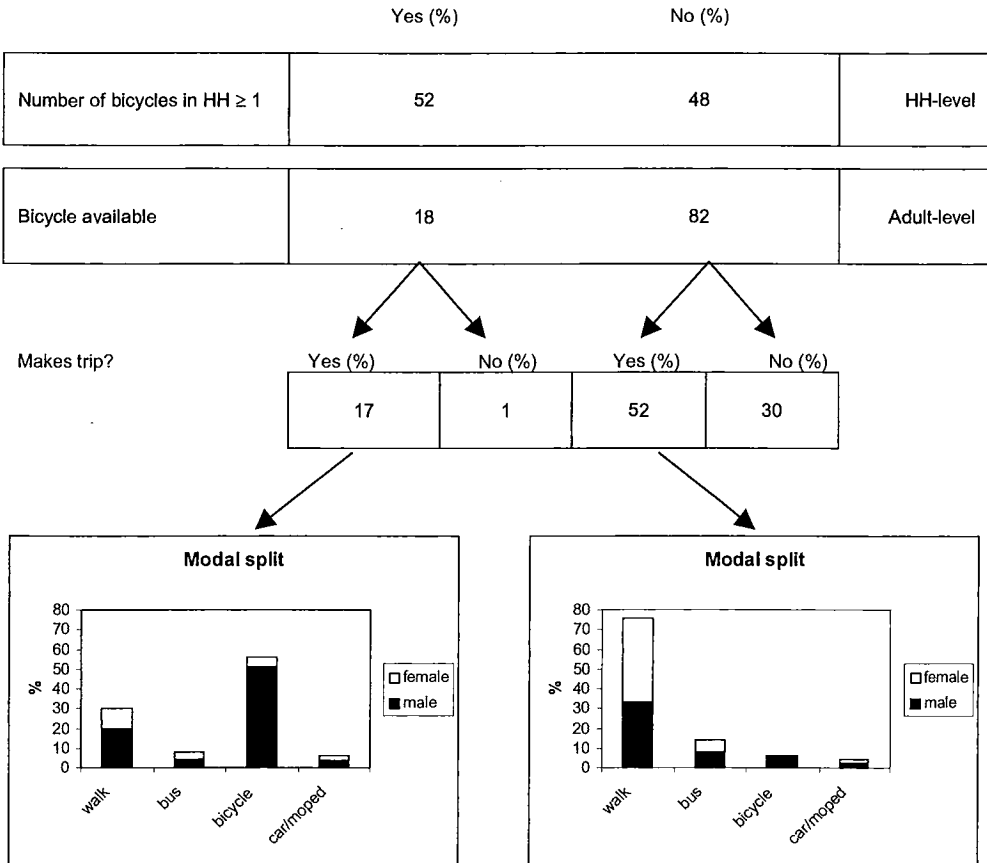
The difference between these figures derives from the completely different role of cycling in both cities. In Morogoro cycling is the dominant mode of transport for longer distance urban trips, while in Dar es Salaam the cycling option is almost unavailable. Another factor is that in Morogoro the availability of buses (in practice: share-taxi, minibuses) is lower than it is in Dar es Salaam. Whether the lower availability of buses in Morogoro reflects a demand – supply equilibrium or a shortage of buses cannot be concluded from the survey. During 1994 – 1996 the number of minibuses in Morogoro has gone up substantially, primarily an overflow from Dar es Salaam, where the competition was so strong that a number of small operators decided to try their luck elsewhere. Casual inquiries indicate that this has also created a situation of over-supply of buses in Morogoro, and also suggests that the increased supply had little influence on bicycle use by bicycle owners, but may have affected the bicycle hire business. This will be the subject of further research.

It is also interesting to note from table 6 that cycling is primarily a relatively 'long' distance mode of transport within the city.

*Bicycle ownership and modal split*

From table 1 the car and bicycle *ownership* in both cities can be obtained. The respondents were also asked to indicate whether their car or bicycle was *available* to them (for their most important trip the previous day), because they might be out of order or being used by someone else. Thus, it is also possible to derive the modal split based on availability and ownership of that particular mode of transport.

Figure 2 showed the share of cycling in Dar es Salaam and Morogoro, i.e. 3% and 20% respectively. Because of the sample size and the small number of cyclists in Dar es Salaam too little data was obtained to analyse cyclists systematically. For that reason the analysis will concentrate on the Morogoro situation.



**Figure 3 - Bicycle ownership, availability and actual use in Morogoro**

From figure 3 it can be seen that of the people with a bicycle available for their most important trip of the day almost everyone (93%) makes a trip. 56% of the persons with a bicycle available actually use it for their most important trip. Distinguishing between sexes, it can be observed that only one in ten of these cyclists is a woman. Apparently, women are not used to (or allowed to) use a bicycle,



which is available in the household. A tailor made bicycle promotion campaign could be useful in lowering this barrier. The males using a bicycle without having a bicycle available to them use the possibility of bicycle hire (bottom, right hand part of figure 3). People not having a bicycle available largely walk as their most important mode.

The mobility needs of women have been particularly overlooked in Sub-Saharan Africa especially in relation to actual non-motorized transport adoption (Bryceson and Howe, 1992). Bicycle use is constrained both by culture and the bicycle models available. Absence of ladies' models and simple provisions to carry small children pose severe impediments to female usage (Nyasulu *et al*, 1991).

### *Bicycle utilisation*

From figure 3 it could be seen that 18% of the adults in Morogoro have a bicycle available to them (18,000 bicycles). Estimating the total number of trips made in Morogoro per day on a bicycle from the survey and subtracting the estimated share of hired bicycles, the estimated bicycle utilisation of private bicycles in Morogoro is 1.9 trips per bicycle per day. This indicates that on average all bicycles are used once a day. This utilisation is high compared to e.g. the Netherlands (0.9 trips per bicycle per day). In the Netherlands bicycles are more often used by women than by men. Women make 1.08 trips per day on a bicycle and men 0.87 trips (CBS, 1997).

However, expressed in terms of the effective driving hours per day 2 trips is no more than approximately 1 hour at most, which means that most bicycles are idle during most of the day. Taking into account the very low income levels and the problem of affordability of trips other than on foot, the actual utilisation of the available stock of bicycles should be considered as low. It is important to analyse what factors constrain a higher utilisation, in particular more shared use by different household members. This will be the subject of further research, with the aim to identify interventions that could increase bicycle utilisation above its current level.

### **Bicycle use**

Once a bicycle is available it can be chosen for a trip. As can be seen from paragraph 3.2. This is actually done in most cases. However, not always. This paragraph documents the reasons given by the respondents in Morogoro and Dar es Salaam for not choosing other alternative modes that were available to them. The main factors appear to be very straight forward: time and money. Other factors that are mentioned are flexibility (combination of more trips) as a disincentive to cycle and fear for bicycle theft as an argument not to cycle. According to the survey answers, a negative attitude towards cycling (or a negative perception of factors such as status, weather, fatigue) play no role of any significance in relation to the use of bicycles.

Since our main objective is to analyse the determinants of cycling, the discussion will focus on the decision to use a bicycle as opposed to other modes and vice versa.

### *Decision to cycle rather than using a bus*

The next table shows the reasons given by respondents for cycling, while they had a bus alternative available for the same trip.

**Table 7 - You made the trip by bicycle: Why not use a bus? [20 respondents DSM, 53 respondents Morogoro]**

Reason	Dar es Salaam (%)	Morogoro (%)
save money	50	34
needed bicycle for another trip	20	18
trip is quicker by bicycle	0	15
takes long waiting for a bus	0	6
carried a big load	5	0
buses are unreliable	0	6
other reasons/no answer	25	21
<b>Total</b>	<b>100</b>	<b>100</b>

From table 7 it can be seen that saving money is the most critical reason for deciding to cycle rather than taking a bus.

*Decision to cycle rather than walking*

Table 8 below shows the reasons given by cycling respondents for not walking, while the walking alternative was available for the same trip.

**Table 8 - You made the trip by bicycle: Why didn't you walk? [21 respondents DSM, 149 respondents Morogoro]**

Reason	Dar es Salaam (%)	Morogoro (%)
trip is quicker by bicycle	43	59
bicycle needed for another trip	14	12
carried a big load	5	2
like cycling better than walking	5	10
no tree shade	0	1
bad pavement	0	1
unsafe road crossing on foot	0	1
health forbids to walk	0	0
risk of being harassed	0	2
visited shops	0	3
other reasons/ no answer	33	9
<b>Total</b>	<b>100</b>	<b>100</b>

The table indicates that the main reason to cycle rather than walk is to make the trip quicker. In Dar es Salaam about 40% of the cyclists find cycling quicker than walking, but the number in Morogoro is higher (about 60%). The implication may be that besides walking the next best option for one in Morogoro is to cycle. Whereas in Dar es Salaam one could alternatively take a bus for the same trip, hence the slightly lower percentage finding cycling quicker.

*Decision to walk rather than cycling*

Table 9 shows the reasons given by a group of people who walked but had a cycling alternative; their reason to walk instead is given below.

**Table 9 - You made the trip on foot: Why didn't you cycle? [73 respondents Morogoro]**

Reason	Morogoro (%)
parking problems with bicycle	13
trip is quicker on foot	5
health forbids cycling	5
bad pavement	1
like walking	4
took baby	4
unsafe traffic for cycling	4
risk of being harassed	1
no important reason/ no answer	63
<b>Total</b>	<b>100</b>

Table 9 indicates that most respondents in Morogoro have no strong reason for not taking a bicycle. For many shorter trips they just prefer to walk. On the other hand 13% of the people in Morogoro find parking as one of the constraints encouraging them to leave the bicycle at home.

*Decision to use a bus rather than cycling*

The decision to take a bus while having a bicycle available for the same trip depends upon a number of factors.

**Table 10 - You made the trip by bus: Why didn't you cycle? [20 respondents Morogoro]**

<i>Reason</i>	<i>Morogoro (%)</i>
trip is quicker by bus	60
parking problem with bicycle	0
health forbids cycling	5
bad pavement	0
unsafe traffic for cycling	0
no important reason/ no answer	35
<b>Total</b>	<b>100</b>

From table 10, it is clear that one decides to take a bus rather than using the available bicycle in order to travel more quickly. From the trip distance distribution it appears that this applies specifically to the longest distance trips in the city. This occurs only when it is really necessary, probably due to longer travel distances, especially in Morogoro.

**CONCLUSIONS**

Based on the household survey findings, it can be concluded that the reasons for bicycle ownership and use differ between the two cities. For bicycle ownership in Dar es Salaam it appears that the critical constraint is the unsafe traffic conditions that a cyclist is perceived to be exposed to. This perception is also objectively true, as traffic accident data for Dar es Salaam, clearly show. Once a person owns a bicycle, he is not so deterred by the unsafe traffic that he will not use it. This group of persons appears to be either (and predominantly) those that use a bicycle as a business tool (petty trading), or young male adults that judge their ability to avoid accidents optimistically.

Should the unsafe traffic constraint in Dar es Salaam be addressed so well that it would no longer hold back most people, it can be expected that the modal share of cycling could go up from the present 2-3%, to the next constraint limit. Probably, affordability of a bicycle (or rather the ability to save enough cash for the investment, or to borrow money at an acceptable cost) is the next constraint, and the share of cycling could under safe traffic conditions go up to approximately 10-15%.

Unsafe traffic conditions do not play an important role (yet?) as a constraint for bicycle ownership in Morogoro. Based on income data, the number of households owning a bicycle roughly equals the expected number in view of affordability. Accordingly, the critical constraint is the ability to afford a bicycle.

If it were possible to overcome the affordability constraint (e.g. via credit schemes), the modal share of cycling would probably grow. The greatest potential in this respect probably lies in women in households that already own one bicycle, adults entering secondary school, and newly formed households. A similar development took place in many Chinese towns in the 1970's and 1980's (with the side-remark that in that period traffic safety was not a problem in China, because the amount of private vehicles was almost nil). Once the affordability constraint is overcome it is expected that other constraints will become visible, such as bicycle theft.

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