Can technology save us?

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Asks the reader to: assume there is incredible technological progress in endeavours to solve problems of energy scarcity, pollution and congestion; imagine a super Super Car powered by a pollution-free perpetual motion engine; imagine a super Internet which provides free and efficient access to all the databases and libraries in the world. The result would be a social and environmental disaster – unless at the same time humankind manages to curb the appetites which are driving the steeply rising growth curves of material consumption and physical and electronic mobility. Argues that the technological enterprises that are currently consuming the lion's share of resources directed to the solution of transport problems are relaxing important constraints on these appetites. Concludes that the principal barrier to a morally and politically sustainable transport policy is the belief that there are technical solutions for these problems.

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Aspirations

> My working class constituents…want cars, and the freedom they give on weekends and holidays. And they want package tour holidays to Majorca, even if this means more noise of night flights and eating fish and chips on previously secluded beaches.
>
> They [the affluent middle classes] want to kick the ladder down behind them. (Crosland, 1970).

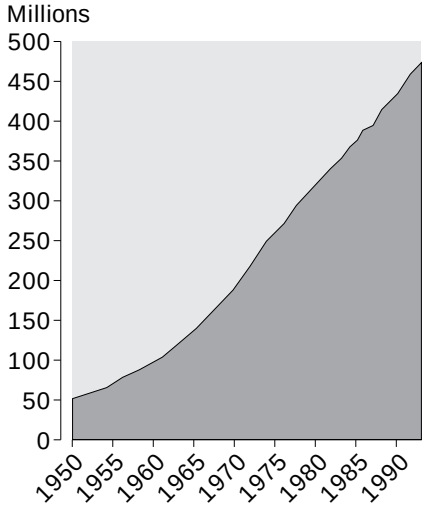
Crosland had a strong moral point which translates readily into a political imperative. All around the world most people who do not have cars would like to have them and governments everywhere applaud this aspiration and seek to help people realize it. In Britain both the main political parties have made this support explicit in official statements that remain party policy to this day:

> The [Conservative] government welcomes the continuing widening of car ownership as an important aspect of personal freedom and choice (DoE, 1991).
>
> We would like to see more people owning cars (Labour Party Policy Commission on the Environment, 1994).
>
> It would be electoral suicide to go into an election advocating reduced car ownership.

This last view, expressed in an editorial in *Common Ground* – the journal of the environmentalist wing of Britain's Labour party – appears to be common ground for almost all politicians everywhere in the world. Figure 1, showing the ten-fold increase in the world's car population since 1950, shows the success that they have had in meeting their electorates' aspirations.

During the last ten years in highly motorized countries from Denmark to the USA, through all the green rhetoric and lip service paid to traffic restraint, dependence on the car has continued to increase. In the countries included in Figure 2 there has, on average, been a 33 per cent increase in car ownership in the past ten years. Growth has been fastest in those countries – Greece (85 per cent) and Portugal (158 per cent) – in which levels of car ownership per capita are lowest. However even densely populated and congested Japan experienced a 55 per cent increase, to 326 cars per 1,000 population;

Figure 1
World car population

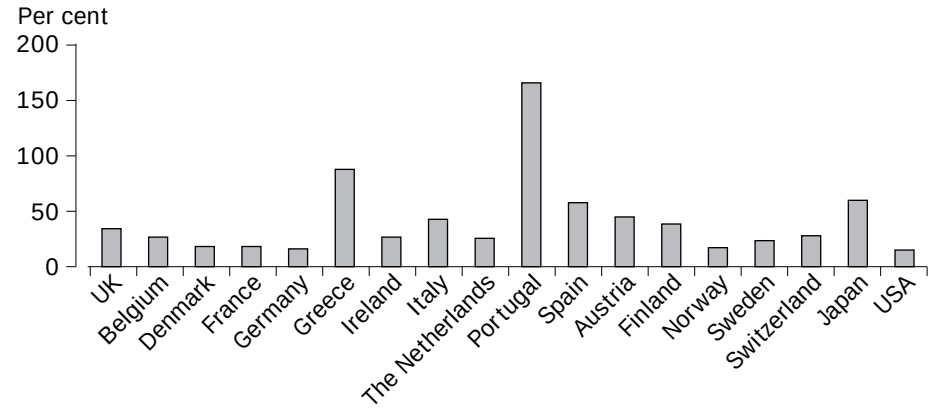


Source: Worldwatch Institute (1995)

and although growth has been slower in countries closer to the "saturation" level of car ownership, even the USA with 568 cars per 1,000 population (or 651 if light vans are included) experienced an increase of 15.5 per cent.

Although some countries have adopted policies that seek to *slow* the rate of growth in car dependence, nowhere are *national* policies being pursued, the objective of which is to pull the ladder up. There are numerous cities now implementing traffic restraint policies in their congested centres, but everywhere the effect of these policies has been to encourage ex-urban sprawl and yet more car dependence. Copenhagen, for example, is frequently held up as an exemplar of environmentally progressive transport planning, and since 1970 the city, with about one-tenth of Denmark's population, has reduced car traffic by 10 per cent. However, in the rest of the country over the same period car traffic has increased by more than 100 per cent. In eastern Europe and the former Soviet Union the loosening of the grip of the central planners has been followed by a surge in car numbers. Everywhere – with the exception of a few urban islands of traffic restraint – the tide of

Figure 2
Increase in cars – 1983-1993



Source: Transport Statistics Great Britain (1995)

car dependence, impelled by Crosland's moral and political imperatives, is rising.

China

The fastest growth rates are now being experienced in the world's poorest countries. Chinese aspirations to own cars appear remarkably similar to those of people in Europe and North America. In 1991 Beijing's transport planners paid a visit to London. They proudly presented their plans for "modernizing" their city's transport system. Their principal spokesman, Zhang Guowu (1991), contributed two papers to an Anglo-Chinese meeting in London. The meeting was told about BUTS, the Beijing Urban Transport System, and their government's proposals for improving it.

The meeting was also told that since 1949 the number of bicycles in Beijing had increased from 140,000 to 8 million. However before smiles had time to form on the faces of the environmentalists present, Zhang proceeded to denounce the bicycle as "vicious". He explained:

> In recent years the amount of bicycles in Beijing is sharply increasing by 500,000 more each year, which is a mark of urban transport being vicious…it [the bicycle] is seriously conflicting with motor vehicles and reducing road accessibility.

One of the main priorities of Beijing's transport policy is now "properly controlling the development of the bicycle;" Zhang's presentation of his city's transport plans, and the conviction with which he described them, was reminiscent of the optimism that inspired transport planning in Europe and North America over 30 years ago. A major shortcoming of Beijing, he explained, is that "there is still no continuous transport express road system in Beijing." "It has been made clear," he continued, "that the inner city is the primary investing area of road facility construction." He described plans for the construction of an express ring road and radial road system. In the discussion that followed it became clear that China's transport planners are convinced, like most western politicians, that the car expands personal freedom and choice: the "car can supply an almost 'door to door' service, it is expected to play a more important part in the future."

The connection between road building and "development" was made explicit: "compared with developed countries, these figures [the proportion of land in Chinese cities occupied by roads] show a big gap." "The backwardness of the traffic control system, the great shortage of parking lots, and the undue amount of grade crossing" are further aspects of China's transport system in which Zhang described China as lagging behind "developed" countries.

Like many of his transport planning counterparts in western countries Zhang insists on the importance of public transport: "we should also develop urban highspeed railway (subway and overhead railway) and light rail transport systems…with buses and trolleybuses as supplementary modes." However, also in common with most of his western counterparts he fails to note the inherent conflict created by attempts to promote private motoring and public transport simultaneously (see discussion of Britain below).

Also in common with his western counterparts he displayed a remarkable faith in the ability of China's transport planners to find technical solutions to the capacity problems they are facing:

> In order to solve urban transportation problems, we should take the views of systems analysis…there exists the universal gap between the volume and transportation

> capacity…The capacity of a grade crossing…can increase by 5 per cent by using optimization technique. By using line traffic control technique the number of vehicle stops can decrease by 10 per cent to 39 per cent. By using district traffic control techniques, the capacity can increase by 18 per cent…the number of traffic accidents can reduce by 20 per cent…The eye-catching and perfect road traffic sign systems will be finally established.

At the time of the London meeting to which Zhang presented his papers the most recent statistics then available indicated that in 1990 in the whole of China there were half as many cars as there were in London. Such is the current pace of change in China today that trustworthy statistics about the country's car population are difficult to find, but numerous accounts are unanimous that it is growing quickly – with a doubling time of perhaps three or four years. So now China probably has more cars than London. It is now official policy that every family in China should have a car.

Progress up the global ladder?

By road

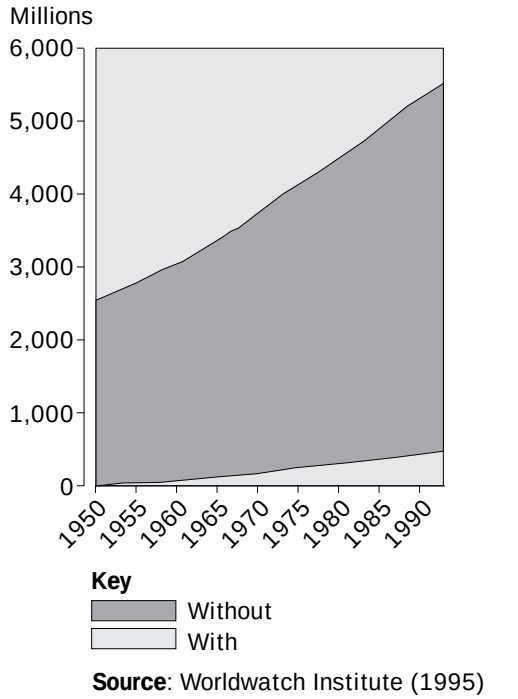
Figure 3 places the growth in the world's car population illustrated by Figure 1 in the context of global population growth. While the car population has increased ten-fold, the human population has doubled. The number of people who do not own cars has increased from 2.5 billion to 5 billion.

What would be the result should China, and the rest of the third world, sustain their growth rates in motorization, and succeed in their aspirations to catch up with the developed world? It is possible to answer this question with some simple calculations.

The UN medium projection for the world population in 2025 is 8.5 billion. The USA now (1993) has 194.6 million motor vehicles of all descriptions (755 per 1,000 population). Should the whole world succeed in catching up with the USA, by 2025 there would be 6.4 billion motor vehicles. London parking meters are 6 metres apart, allowing 167 vehicles per kilometre parked end to end. Thus 6.4 billion vehicles parked end-to-end would stretch 40 million kilometres. If stationary they could be accommodated on a motorway around the equator 1,000 lanes wide. This scenario does not of course represent the global upper limit to the growth of car dependence; the motor vehicle population of the USA is still growing.

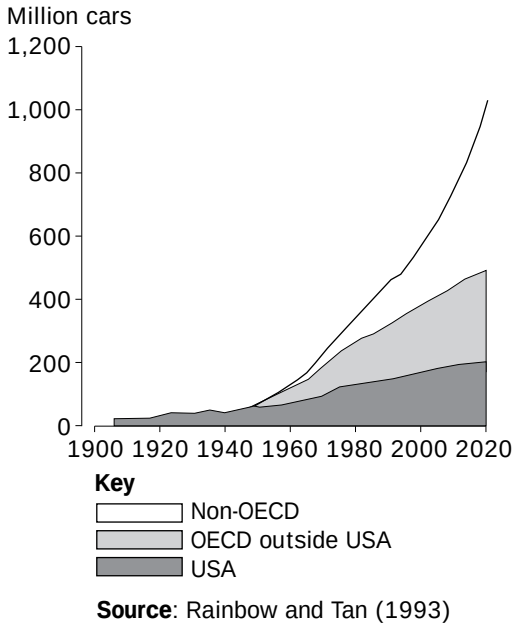
Figure 4 presents the assumptions about future growth on which the Shell Oil Company plans its future activities. It highlights the early lead enjoyed by the USA; as recently as 1965 every second car in the world was American. It shows the present dominance of OECD countries. Finally it shows that while OECD growth is expected to slow as it approaches saturation, the rest of the world is expected to rush to catch up. The Shell

Figure 3
People with and without cars



Source: Worldwatch Institute (1995)

Figure 4
Shell forecasts



Source: Rainbow and Tan (1993)

forecast ends in the year 2020, at which point the graph is still rising steeply.

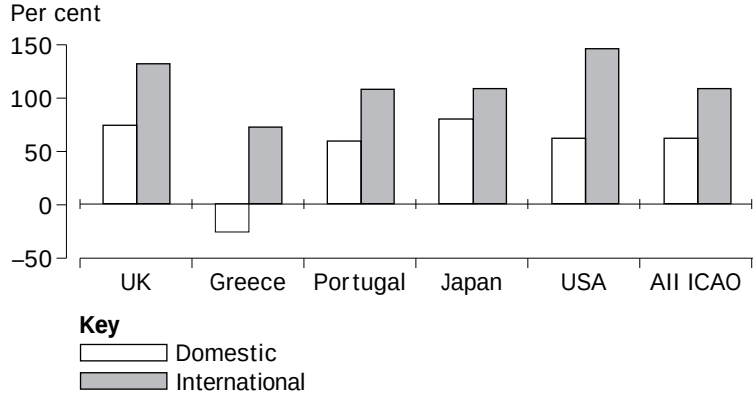
Shell's forecasts envisage buoyant growth for the automotive and energy supply industries well into the next century. Shell's forecasts, in common with similar forecasts by others in these industries, are a mixture of extrapolation and wishful thinking. The historic trends have enormous economic and political momentum, and are supported by powerful vested interests who wish to see them continue.

By air

Increases in mobility have been greatest for journeys over the greatest distances. Short distance journeys, such as the daily trip on foot to school or the local shops, have decreased. Travel by surface public transport has decreased as travel by car has increased. But even faster growth rates have been experienced by air travel and the fastest growth rates within this sector have taken place at the greatest distances.

Most air journeys cross international boundaries, and international growth rates are considerably higher than those for domestic air travel (see Figure 5). Reliable statistics on the number of people in the world who have ever flown are not available, but most people in the world have never flown and, despite the rapid growth of air traffic, the numbers who have never flown, like the number of non-car owners, have almost certainly increased since 1950. The USA, accounting for 42 per cent of all scheduled air traffic flown by ICAO airlines, has enjoyed one of the highest growth rates in international traffic over the past ten years, suggesting that the country is still a long way from saturation.

Figure 5
Increase in air travel: 1983-1993



Source: Department of Transport (1995)

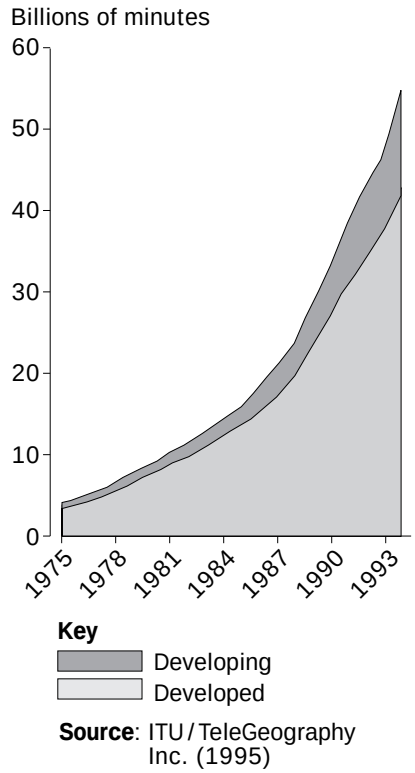
The promise of electronic mobility

The physical transport of information is increasingly being replaced by electronic mobility.

Telecommunications traffic is increasing much more rapidly than air travel. As with air travel, the increases have been greatest for connections over the greatest distances: international traffic is increasing faster than domestic traffic, and inter-continental traffic is increasing fastest of all – a 17-fold increase in the last 20 years. As with physical mobility, growth rates have been fastest in the poorest countries; over the period covered by Figure 6 traffic in the developed countries has increased 12-fold, while that in the developing countries has increased 33-fold. Yet the absolute differences between rich and poor in levels of use are still growing. In 1994 the average person in the UK spent over an hour on the telephone internationally; the vast majority in the developing countries have never made an international call.

Figure 6 understates, by an unknown amount, both the growth in traffic and the growth in the disparity of telecommunications use between those who are well-connected and those who are not. The development of private commercial networks – over 700,000 are estimated to exist in the USA – and

Figure 6
Trends in international telephone traffic



Source: ITU/TeleGeography Inc. (1995)

the increased use of leased lines is fostering the growth of traffic that is not systematically recorded (*The Economist*, 1995). The advent of the Internet and the explosive growth in its use is now rendering the old ways of keeping track of information flows obsolete. Users now connect to the Net via local calls and exchange vast numbers of bits or bytes of information – increasingly in the form of high-resolution graphics – with other users all around the world, commonly without knowing where in the world the other users are. Data compression techniques are altering the relationship that used to be assumed to exist between information flows and "connect time". Therefore although it would, in principle, be possible to measure the number of bits and bytes exchanged around the world in a year, or the number of hours of connect time, such crude quantitative measures would tell us little about the amount of meaningful information that had been conveyed.

Does electronic mobility reduce physical mobility?

However it might be measured, the growth of electronic mobility has far exceeded growth rates for all forms of physical mobility. This growth has not, however, reduced the amount of physical mobility in the world. Telecommunications may substitute for physical mobility in many instances – including teleconferencing – and it is possible that it may have slowed the rate of growth of physical mobility below what it would otherwise have been. But it is much more likely that it has served as a stimulus to physical mobility for the following reasons:

- The travel industry is one of the most important customers of the telecommunications industry. Advances in telecommunications have enormously reduced the transaction costs of travel and thereby reduced the cost of travel itself. For making reservations, booking hotels, planning meetings, for the quick call to say "Are you there? Good, I'll come round" – in so many ways telecommunications facilitate physical travel. For all those journeys whose purpose is not exclusively the transfer of information, cheaper electronic travel means cheaper, more convenient, less problematical travel, and hence more physical travel.
- Cellular telephones and tele-working have relaxed constraints on where people live and work. But the ability of employers to contact their employees, and the ability of salespersons and customers to contact each other, wherever they are, has freed many workers to spend more time on the road or in the air.
- Tele-working is not only liberating people from the daily commuting journey to work, but also freeing them from the necessity of living within commuting distance of their work, thereby augmenting the already existing pressures that are emptying cities and producing ex-urban sprawl. Within this sprawl, although there might be a decrease in commuter traffic, all other journeys – to shops, schools, doctors, theme parks, friends – are longer.
- As the costs of both physical and electronic travel decrease, people acquire increasing numbers of friends, customers and business associates at ever-greater distances from home or office. These relationships are supported and strengthened by the ability to keep in touch inexpensively by phone, fax and e-mail. However, most of them, ultimately, will foster a desire to get in touch physically. The following account by Gates (1995), in his book *The Road Ahead*, of his electronic relationship with a girlfriend in another city, featured in many of the reviews of his book:

  > The new communications capabilities will make it far easier than it is today to stay in touch with friends and relatives who are geographically distant. Many of us have struggled to keep alive a friendship with someone far away. I used to date a woman who lived in a different city. We spent a lot of time together on e-mail. And we figured out a way we could sort of go to the movies together. We'd find a film that was playing at about the same time in both our cities. We'd drive to our respective theatres, chatting on our cellular phones. We'd watch the movie, and on the way home we'd use our cellular phones again to discuss the show. In the future this sort of "virtual dating" will be better because the movie watching will be combined with a videoconference.

Most reviewers found this passage weird and worrying and quoted it in tones of dismay. Such virtual socializing struck most of them as sad and unlikely to blossom into real friendship or love without real physical sustenance. The nations that are highly mobile electronically are highly mobile physically. The ability to sustain relationships at a distance creates an incentive to travel.

Be a techno-optimist

Most histories of transport are told as stories of Man's triumph over distance. Airlines boast of their "earth-shrinking" prowess, and point to the fact that most people in the world have never flown as evidence of the enormous growth potential of their industry. Car makers trumpet the liberating power of their products. Politicians claim credit for their

role in expanding personal freedom and choice by smoothing the regulatory path for the transport industries.

It is increasingly acknowledged that there are external costs associated with mobility, but the assumption that the access that it provides is a benefit is rarely challenged. Wherever cost-benefit analysis is applied to a transport project the principal "benefit" claimed for the proposed scheme is time saving for travellers.

Last September (1995) *The Economist* published a 40-page survey of prospects of the world's telecommunications industry. Its gushing enthusiasm for the industry's growth potential was encapsulated by the survey's title – "The death of distance". The conventional wisdom of the transport and telecommunications industries, and their fellow travellers, is that the eradication of distance, like the eradication of small pox, would be a good thing; although a complete triumph over distance may not be possible, it is a goal worth striving for; technological progress is far from finished.

In addressing the question "Can technology save us?" there are a number of debates that I propose to bypass. It is unlikely, I believe, that the global environment could cope with the vast increases in physical mobility that would result should the whole world succeed in reaching the top of the ladder of car ownership and air travel. Probable constraints on the growth processes surveyed above include the shortages of resources to build billions more vehicles, the energy to run them, the space and energy to scrap or recycle them, and sinks for all the pollution that they would produce. One can however find techno-optimists who will argue with all these doubts:

> Global warming is not happening; or it would be a good thing if it were; or it can be prevented by the development of non-carbon forms of energy. The car and airplane of the future will be quieter and vastly cleaner and more efficient. The environment is far more robust than environmentalists believe. There is no evidence that species are being lost. The world's human population has never been wealthier, healthier, longer lived or more numerous. Increases in mobility and material prosperity are inseparable; progress lies in promoting more of both. Fairness demands the promotion of both. How can we with our three-garage houses (or aspiring to same) possibly face all those in China, India and Africa and tell them that they must not aspire to the same?

And so on (see Adams, 1995, chapter 10 for further elaboration of this perspective on environmental problems). The future does not exist except in the imagination. The various debates between environmentalists and techno-optimists are long-running because they are scientifically unresolvable. In the absence of conclusive proof about what science and technology will be capable of in the future, both sides argue from belief and conviction. For the purpose of this paper I shall concede – with some scepticism – the transport techno-optimist's wildest dreams. I shall invite the reader to imagine cars powered by pollution-free perpetual motion engines, and built with materials that are cheap, and recyclable without imposing any burden on the environment; wide-bodied supersonic passenger aircraft with science fiction engines that make no noise and consume negligible amounts of energy; high-speed maglev trains powered by pollution-free electricity; and a super-Internet which connects everyone, free, to everyone else and every library and database in the world via portable computerphones.

Let us ask with Gates (1995) "What if communicating were almost free?" – for everyone in the world. Let us further ask "What if everyone in the world who is old enough and fit enough to drive were to own a car?", and "What if everyone were to fly even more than today's frequent fliers?" Let us, in brief, pursue the implications of getting the whole world to the top of Crosland's ladder.

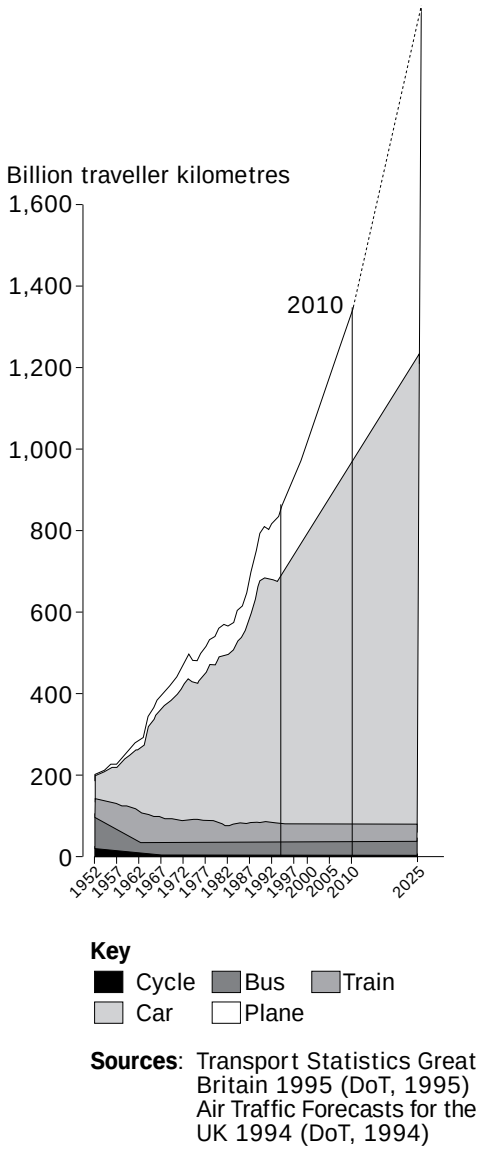
Britain

I will begin the pursuit with Britain because it is the country whose transport statistics I know best, because it is still less than halfway up Crosland's ladder, and because the main features of its dilemma can be found in all countries attempting to climb the ladder.

Figure 7 describes the changes that have taken place since 1952 in the main modes of transport and the Department of Transport's forecasts to the year 2025. Travel by bicycle has declined by 80 per cent and by bus by 50 per cent. Rail has held fairly constant in terms of passenger kilometres, but far less of the country is now accessible by rail; there has been a shift of traffic from the abandoned branch lines to the main inter-city lines. Walking has also declined but comparable statistics have not been collected to permit it to be displayed on the graph. Car travel has increased ten-fold and air travel 30-fold.

In brief, the democratic and environmentally benign modes of travel – the "green" modes – are in retreat and the élitist and environmentally damaging modes are in the ascendant. These trends are still running strong, and are strengthening the motives of those who do not yet own cars to get them. The forecasts indicate what the Department of Transport expects to happen up to the year 2025.

Figure 7
Travel by Britons: by cycle; bus; train; car and plane



Sources: Transport Statistics Great Britain 1995 (DoT, 1995)
Air Traffic Forecasts for the UK 1994 (DoT, 1994)

For air and car travel I have used the high, or "optimistic", forecasts, because they represent what will happen if the economy grows as fast as the Government hopes it will. The air forecasts stop in 2010; I have extrapolated to 2025 at the prevailing growth rates because air traffic forecasters frequently enthuse about the enormous growth potential of their industry – often adducing as evidence the fact that most people in the world have never flown. The Government's bus forecasts, showing a constant level of traffic in the future, are clearly disingenuous; the Department's own research has established that every extra car that joins the nation's car population takes over 300 passenger journeys a year from the bus services. If car use increases as forecast, the decline in bus use will continue. The Government provides no forecasts of travel by rail, bicycle or foot. Travel by rail and bicycle have been held constant at the present low levels for the sake of graphic completeness, but are likely to decline if car and air traffic grow as forecast.

Figure 7 offers little hope to those environmentalists who advocate policies to get people out of their cars and back on to public transport. It shows that most journeys now made by car were never on public transport. When people acquired cars their activity patterns were transformed. They began going places previously unreachable by public transport, and travelling at times when public transport did not run. With a time lag, as more people acquired cars, land use patterns responded. Retailers began locating out of town for the convenience of motorists. Residential developments moved to the suburbs where there was room for garages and off-street parking. Offices moved to out-of-town business parks surrounded by car parks, and hospitals, cinemas, post offices, warehouses all became bigger and fewer in number, and more difficult to reach by foot, bicycle or bus.

It is sometimes argued that if only public transport were improved people would use it instead of their cars. However, it used to be better, cheaper, more reliable and more pervasive, and even then, when people could afford cars they bought them, and were rarely seen on public transport again. The total amount of travel by bus and rail in 1994 is equal to about five years' growth in travel by car. If it were possible, by some political miracle, to divert sufficient car travel to buses and trains to restore public transport usage to its 1952 level, car travel would, according to the forecasts, be back at its present level in less than three years. The longer the trends in Figure 7 continue, the stronger become the pressures that drive them; the more expensive it becomes to maintain existing public transport services, as fixed overheads must be shared among a dwindling number of passengers; and the greater becomes the need to have a car to reach the shops, services and friends that used to be reachable without one.

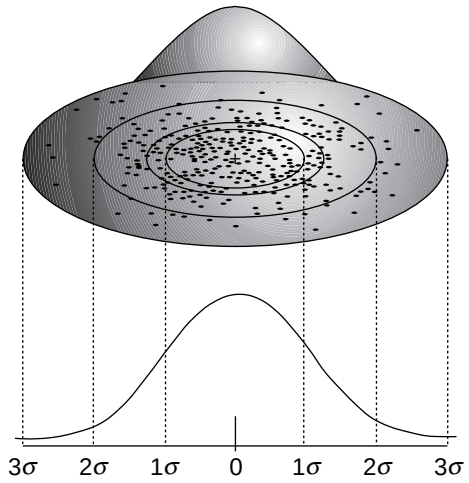
The longer the trends continue, the more the assumption of car dependence becomes built into the planning framework; Surrey, one of the most car-dependent areas of Britain, now insists, as a condition for planning approval, that new houses provide off-street parking space for three cars – thereby compelling a spread-out scale of development that discourages walking and cycling. The more dependent a country becomes on the car, the more difficult it becomes for politicians the world over to contemplate pulling up the ladder. And so the world keeps climbing.

The time-space dome

Various mathematical models have been developed over the years to describe human travel behaviour. The most popular is the "gravity model". It describes the way in which the force of attraction between any two places – and hence the frequency of travel between them – decreases with the distance separating them. This tendency for journey frequency to decrease with distance is also captured in Figure 8 which illustrates how the opportunities of which people avail themselves by travelling are typically distributed over space. It also illustrates the fact – incorporated in all models of travel behaviour – that the frequency with which people make journeys has an extremely strong tendency to decrease as journey length increases. When the journeys made by a number of people are plotted on a graph as though they had a common origin, and with the position of each dot indicating the length and compass direction of each journey, a clear distance-decay effect emerges. The density of the dots decreases with distance from the centre, permitting the generalization of the pattern as a domed "mobility surface".

Figure 8 was borrowed from an article describing the foraging behaviour of a group of rats. Inferences drawn about human behaviour from the behaviour of rats can be misleading, but in this case nothing need be assumed about the motives of the travellers involved. The figure illustrates certain inescapable principles that apply to the behaviour of all species of traveller, including homo sapiens.

Figure 8
A centred interaction field



Source: Adams (1981)

For the purpose of appreciating some of the consequences of the mobility trends discussed above we can think of the mobility surface as a "time-space dome" within which people spend their lives. The height of the mobility surface at any particular point is proportionate to the amount of time that is spent at that point. The volume of the dome corresponds to the total amount of "interaction time" that people have to spend – the number of waking hours in a day that are available for interacting with others. People can alter the shape of the dome, but not its volume; for both rats and people there are the same number of hours in a day. People and societies that do not travel much inhabit high, rigid, confining domes; those who travel a lot live in low, flexible, spread-out domes, but they all live in domes that have the same volume because they all have the same number of hours a day at their disposal.

Figure 9 gives an indication of the dramatic transformation that takes place in the time-space dome of a society as its level of mobility doubles and redoubles. The high peaked dome represents the spatial activity pattern of an individual, or a group, with an average trip length of 1.25 kilometres. The other domes represent the effect of doubling and then doubling again the average trip length. The new, more remote, opportunities of which people avail themselves as they become more mobile are generally not additional to those previously enjoyed, but substitutes for opportunities previously taken closer to home, and now forgone. Figure 9 illustrates the obvious fact that if people, in spending the time at their disposal, distribute themselves more widely over space, the amount of time they spend closer to home, and perhaps at home, must be substantially reduced.

Although the travel behaviour of people will rarely display a pattern as simple and symmetrical as that in Figures 8 and 9, the essential principle illustrated by the time-space dome is inescapable: if people in their travelling choose to spread themselves more widely, they must spread themselves more thinly. If the average trip length doubles, the area covered by the dome quadruples, and the average height of the dome decreases to a quarter its previous height.

In Britain in 1950 the average person travelled about 8 kilometres a day, now it is about 40 kilometres a day, and by 2025 according to the forecasts it will be about 100 kilometres a day. The number of trips taken every day is not increasing, and has possibly decreased slightly as the short daily shopping trips to the local high street have been replaced by the once-a-week trip by car to the out-of-town superstore, and as trips to the cinema or

theatre have been replaced by television. Thus the length of average trip made in Britain in 1996 is about five times greater than in 1950.

The amount of time that the average person spends in motion has also changed very little since 1950. People make their travel decisions within the constraints of time and money budgets. Improvements in transport technology have reduced the cost of travel, and rising real incomes have relaxed the constraint imposed by the money budget, but the number of hours in the day has not changed. The increase in average trip length is accounted for by increased speed of travel. Despite congested conditions for motorists, the huge shift from feet and bicycles to cars and planes has approximately quintupled the speed of the average journey.

Figure 10 shows what would happen on a plain with a uniform population density if the average journey speed were to double and then redouble while the time spent travelling remained constant. The number of people within the circle described by the average radius of interaction would quadruple and quadruple again. Thus, in Britain since 1950, as average journey speeds have increased five-fold, the psychological population density has increased about 25-fold; we now live in a world crowded with strangers – a world in which we have fleeting contact with far more people than we have the possibility of knowing as individuals.

Change at the centre

Most models of travel behaviour do not seek to account for the amount of time spent at home. But Figures 8-10 seek to describe changes in the way people's interaction time is distributed over space as they become more mobile. The figures suggest a very large reduction in the amount of time spent not only close to home but also at home. If the model is taken to embrace electronic mobility as well as physical mobility the impression conveyed by the figures may not be too inaccurate.

The increases noted above in telecommunications traffic suggest that whatever is happening to the amount of time people are spending physically at home, social life there is being sapped electronically. The now widespread use of the guilt-laden term "quality

Figure 9
Average trip length doubles again

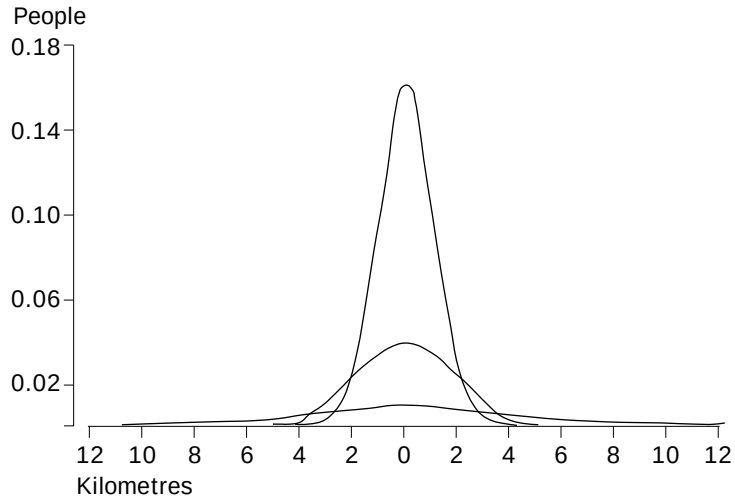
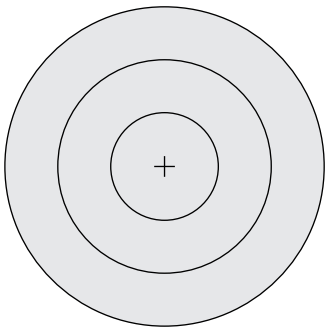
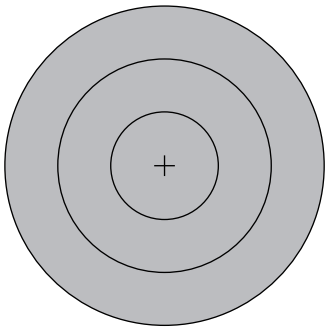


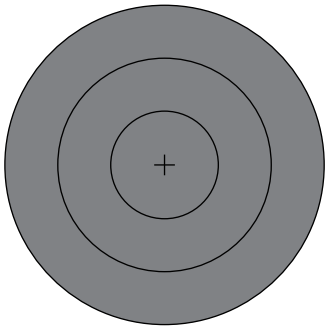
Figure 10
As journey length and speed double, psychological population density quadruples



σ = 1 kilometre



σ = 2 kilometres



σ = 3 kilometres

time", to distinguish the time during which parents are actually paying attention to their children from the time during which they are merely physically present is symptomatic of the distracting power of television, computers and telecommunications. Although interaction by telephone or Internet is a weaker form of communication than that afforded by face-to-face contact, the growth rates in these forms of interaction are much greater. The influence of television is much debated. Surveys over many years suggest that in Britain and the USA the average person spends over three hours a day watching television. Television coverage of current events now extends, depending on their "newsworthiness" to all parts of the world.

If graphs were to be drawn to describe changes in the average individual's centred information field, the spreading and flattening effects caused by the telecommunications revolution would be even more pronounced than the changes depicted by the graphs of physical interaction. If the growing amount of time spent interacting electronically is charged against time spent at the centre – that is those so interacting are counted as present in the flesh but absent in spirit – then Figures 9 and 10 can probably serve as a valid representation of the nature of change at the centre as well as at a distance.

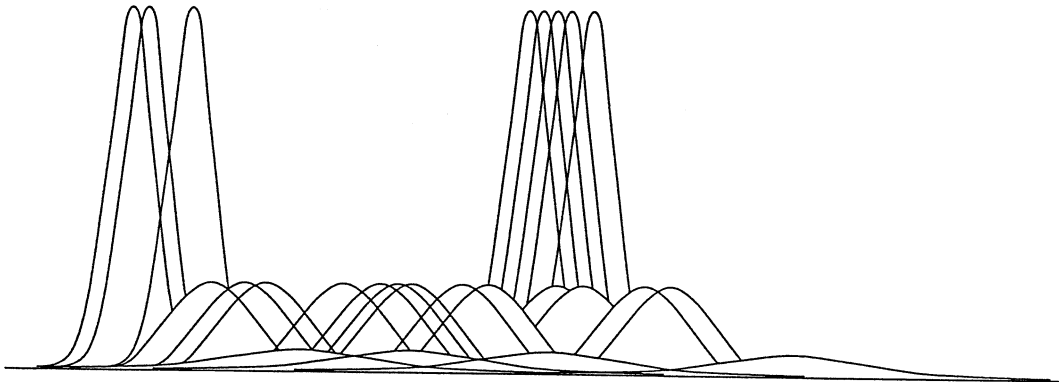
The mobility landscape

Figures 8-10 depicting centred interaction fields indicate the nature of the change that takes place in the spatial and temporal dimensions of a society's activities as it becomes more mobile. These illustrations have assumed that all members of society share equally in the increase. Figure 11 represents an attempt to describe what happens when some become less mobile while others become more mobile. It is a highly impressionistic cross section through a "mobility landscape". No scale is provided because the interaction field shown can represent a number of different levels of aggregation from the small group to the international scale. The interaction fields of the highly mobile spread and overlap, while those of the decreasingly mobile contract.

Even when they live in close physical proximity to each other, the mobile wealthy and the immobile poor live in different worlds. The high confined time-space domes inhabited by the poor may be statistical abstractions, but they have an unyielding strength. Their occupants are confined by their lack of mobility in prisons with invisible walls. They are continually tempted and taunted, in a way that prisoners confined to cells with opaque walls are not, by the freedom and conspicuous consumption of the affluent. The wealthy can be seen and heard flying overhead, or driving along motorways through the ghetto, or on television, enjoying privileges that remain tantalizingly out of reach. To the wealthy the poor are often invisible; because of the height and speed at which they travel, the wealthy tend to see the world at a lower level of resolution.

People who live in different worlds are likely to develop different group loyalties. Those who live in the least desirable worlds are prone to rationalize their resentments, and develop ethical codes that favour a redistribution of the world's goods and privileges – by whatever means. And the wealthy, in turn, rationalize their good fortune, and devise means for holding on to it. As science and technology continually improve the physical means of communication, they are at the same time undermining the conditions of shared experience essential for meaningful dialogue.

Figure 11
A cross-section through a mobility landscape



Three opinion polls

1. Would you like a car, unlimited air-miles, and all the computers and communications facilities enjoyed by Bill Gates?

At present most people in the world have never flown, and do not own cars or computers. Their answer to this question, everywhere in the world, is overwhelmingly *yes*. In answering, most people probably imagine the world as it is now but with themselves having access to the enlarged range of opportunities that they see present car and computer owners enjoying. It is this opinion poll and the *yes* replies which are driving transport policy in rich countries and poor countries alike. As we have seen above, politicians, technologists and transport and communications planners everywhere are encouraging people to believe that everyone's wish can be granted.

This suggests a second opinion poll, which so far as I am aware has never been conducted.

2. Would you like to live in the sort of world you would get if everyone's wish were granted?

For such an opinion poll to yield meaningful answers there would need to be agreement about what such a world would be like. It would probably be grossly polluted, noisy, congested and anxious about the security of its energy supplies. Let us assume, however, for the sake of our hypothetical poll, that technology will solve these problems. What else might we expect? With the help of the time-space dome, and extrapolating from the experience of Britain discussed above, we can speculate about some of its main features:

- It will be a polarized world. Not everyone's wish can be granted. About a third of the world's population will never be old enough or fit enough to drive – they will be too young, too old, too nervous, too short-sighted, too drunk or otherwise disqualified. Their disadvantage will increase as car dependence increases. They will be second-class citizens, dependent for their mobility on the withered remains of public transport or the goodwill of car owners. It will never be possible to smooth out all the peaks in Figure 11 through universal car ownership.
- The world will become one continuous suburb. The traditional city, built for people not cars, could not exist. The last unspoilt islands and wilderness areas – which travel writers incite us with a sense of urgency to visit before they are spoiled – will be spoiled. There will be no more secluded beaches, except perhaps a few owned by the very wealthy, protected by barbed wire and armed security guards.
- Geographical communities in which people know their neighbours will be replaced by aspatial communities of interest. People with similar tastes, interests and life-styles will commune on the Internet or meet at conferences and vacation resorts. More high-security enclaves of the wealthy will be developed, but because of the fragmenting force of their inhabitants' mobility, they will not function as true communities with interests and purposes in common, other than the preservation of their lives and property.
- Travel opportunities will be destroyed. The cultural and linguistic diversity in the world – the experience of which provides the motivation for much travel – will be obliterated by the rising tide of tourism, and the hegemony of English on satellites and the Internet. Our sense of place will disappear in a world obsessed with making it easier and cheaper "to get there"; when we get there we increasingly will discover there is no "there" – it will have been flooded with traffic, or bulldozed to make way for a new road or a fast-food restaurant.
- Fragile ecosystems will be destroyed; wilderness retreats with access to it. The provision of parking and road space for more than ten times as many motor vehicles will require paving much more of the world. As the world is criss-crossed with more traffic arteries the remaining wilderness areas will be chopped up into ever smaller parcels – many too small to support existing populations of rare species.
- Street life will disappear. The spread out scale will defeat pedestrians, and traffic will make cycling too dangerous. There will be no local shops to walk to. Children will become captives of the family chauffeur in a world too full of traffic and alienated strangers for them to be permitted their traditional independence. A world full of traffic and strangers will require the constant supervision of children who will no longer be allowed to play in the street. The "stranger danger" campaigns now run in primary schools in Britain are inculcating paranoia at a tender age; they are symptomatic of the mistrust that breeds in anonymity.
- Law enforcement will become Orwellian. A world full of highly mobile strangers will require ever more ingenious technology to detect and apprehend wrong doers. The use of CTV surveillance, DNA finger printing, and large computerized police databases will spread. As travel becomes easier physically it will become more difficult

bureaucratically. Wealthy countries previously protected by distance from mass invasion by the indigent will increasingly resort to restrictive prohibition and force. New barriers will be erected to contain the numbers who will take advantage of the mobility afforded by technology. Road pricing schemes will be devised to price off the road those who are on the threshold of being able to afford to travel. The poor who used to be welcomed to America by the Statue of Liberty are now dubbed "economic migrants" and denied entry to protect the living standards of those who got there earlier.

- Geographical communities will be drained of their social content and left with CTV and neighbourhood-watch to guard their possessions. The ease with which one can live one's life in a community of interest will diminish the contact that people have with their geographical neighbours. Concern for the local environment and the welfare of one's geographical neighbours will diminish as people spend more time in cyberspace.
- Political authority will become more remote. Gates observes "The day a senator receives a million pieces of e-mail on a topic or is able to have his bleeper announce the results of a real-time opinion poll from his constituents is not far away." But how a senator will read all this e-mail and resolve the conflicts of opinion contained within it is not explained. As technology deluges us in information, it leaves us less time for contemplation and reflection, and forces us to employ ever cruder perceptual filters in order to make sense of it all. It can only increase the numbers of people with whom we have relationships at the cost of diminishing the intimacy and intensity of our relationships.
- Democracy will disappear. In the whole of the literature of science fiction devoted to fantasizing about futures in which distance has been defeated, there are to be found no plausible examples of democratic government. Democracies, to function effectively, require common values, and a measure of agreement about societal goals forged out of common experience. If distance is vanquished the requisite minimum level of consensus and trust will be unattainable; the world will be filled with billions of strangers sharing the same physical space, but living in very different virtual communities of interest.

The Machine grinds on

More than 80 years ago E.M. Forster produced a minor science-fiction classic called *The Machine Stops* about a world in which technological progress had run its course. This is how it begins:

> Imagine, if you can, a small room, hexagonal in shape, like the cell of a bee. It is lighted neither by window nor by lamp, yet it is filled with a soft radiance. There are no apertures for ventilation, yet the air is fresh…An armchair is in the centre…there sits a swaddled lump of flesh – a woman, about five feet high, with a face as white as a fungus. It is to her that the little room belongs.
>
> There were buttons and switches everywhere – buttons to call for food, for music, for clothing. There was the button that produced literature…And there were of course buttons by which she communicated with her friends. The room, though it contained nothing, was in touch with all that she cared for in the world.

In the story everyone's cell was identical, and people rarely left them:

> Few travelled in those days, for, thanks to the advance of science, the earth was exactly alike all over. Rapid intercourse for which the previous civilization had hoped so much, had ended by defeating itself. What was the use of going to Peking when it was just like Shrewsbury? And why return to Shrewsbury when it would be just like Peking?

The machine provided direct, unlimited access to mankind's desired ultimate ends. It thereby rendered redundant the necessity for access to the multitude of intermediate ends with which our civilization is so preoccupied. Access to shops to obtain food and clothing, access to training to acquire employable skills, access to recreational facilities to obtain respite from work, and access to work to obtain the money with which to purchase access to these things – all such concerns had lost any significance. Technology had set humanity free, within mortal limits, to devote itself exclusively to its ultimate ends.

The result was a civilization of intellectuals in pursuit of abstraction, and despite its facilities for instant communication and gratification of material wants, it was always irritably pressed for time; the almost infinite disproportion between what was accessible and what was possible to digest either physically or mentally, created an endemic frustration that could not be appeased. There was also a pervasive, though rarely articulated, anxiety about the purpose of it all:

> No one confessed the machine was out of hand. Year by year it was served with increased efficiency and decreased intelligence. The better a man knew his own duties upon it, the less he understood the duties of his neighbour, and in all the world there was not one who understood the monster as a whole. Those master brains had perished. They had left full instructions it is

> true, and their successor had each of them mastered a proportion of those directions.

It is a bleak and dreary tale. Judging by the neglect it has suffered it is not reckoned in critical circles to be great literature. It manages no tension or excitement. The hero's attempt to escape is obviously futile. Its characters are made of dull, grey cardboard. It grinds its doom-laden way to its predestined end. The medium is the message – technical progress is soul-destroying. It is what critical circles might call a dismal read.

The house on Lake Washington

Forster's depressing tone contrasts starkly with the cheerful optimism of Bill Gates when describing the computer facilities in the house he is building for himself on Lake Washington – but Forster's machine and Gates' house have much in common. Gates can play bridge on-line – with the computer helping to find him other players with the right skill level. It helps him to stay in touch with friends who are geographically distant, and soon will permit him to "meet" them in "real places" such as Kensington Gardens. It will put him in touch with all the world's great libraries, museums and art galleries. It will give him direct access to "the ultimate market" – "the world's central department store". It will have "news and entertainment, all at a touch." It will, like Forster's Machine, have a perfectly controlled environment, and put him in touch with all that he cares for in the world.

Gates and other techno-optimists, understandably, stress the benefits of their activities – in the form of the enormous increase in mobility and access that their technologies are capable of providing. They have little to say about their inability to create more time for reflection and contemplation, more time to get to know all the people they have placed within easy reach, more time to build trust and confidence, more time to understand opposing points of view, and more time for the discussion and debate necessary for the forging of consensus. At only one point does Gates betray an awareness of such problems. Discussing the potential of the Internet to become the world's central casino, Gates observes:

> Although I play blackjack some times when I'm in Las Vegas, the gambling games that are mostly luck don't have a strong appeal for me. Perhaps it's because I am so much more limited by time than money. If they had a form of gambling that would award winners a few more hours in the day, I might be drawn in.

For a great many people Bill Gates epitomizes the top of the ladder. He encourages us to believe that with continued technological progress we can all get there; we can all gain entrance to the world's central department store with unlimited digital money to spend. But we can never gain access to the casino that awards winners more hours in the day.

If, as I suspect, the answer to opinion poll 2 is a resounding *no*, our political leaders might consider commissioning a third opinion poll.

3. Would you like to live in a cleaner, quieter, more convivial world in which you know your neighbours, it is safe to walk and cycle, and children are allowed to play in the street?

Transport and communications planning is in the grip of a linear, backward-looking vision which extrapolates past "progress" indefinitely into the future. The vision is being sold on a false prospectus that invites individuals to imagine the world as it now is but with themselves having access to the enlarged range of opportunities currently enjoyed by a small élite – an impossible world in which everyone is richer and more mobile than average.

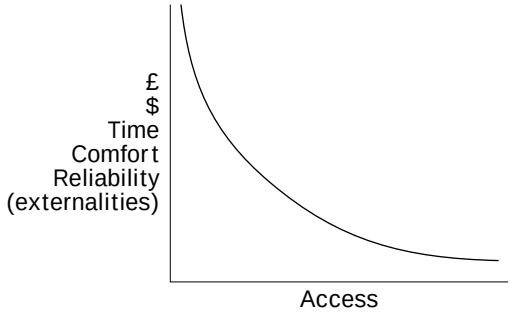
Transport and communications planners alone cannot, of course, create the world described in opinion poll 3. But they can create conditions which will make such a world impossible. In a congested, polluted world short of energy their efforts to make transport cleaner and more efficient should, of course, be welcomed, but only if they are pursued in the context of policies that give absolute priority to those forms of land use and modes of transport – walking, cycling and local bus services – that promote a human scale of living. Present priorities, measured by spending on research, development and construction, by actively promoting developments that are relaxing constraints on access and mobility, are fast creating a bleak, dangerous, alienated, selfish, polarized dehumanized world.

Technology has an important, but subservient, role to play in getting us out of the mess we are making for ourselves. Technology cannot save us. It can help, but it is currently being deployed in a way that is making things worse.

Conference postscript

Figure 12 is a demand curve taken from an introductory economics textbook. As the cost of a good (access) decreases, consumption increases. Over time technological progress has reduced the cost of travel – measured in money, journey time, discomfort and unreliability. If Figure 12 is rotated anti-clockwise

Figure 12
Demand curve



through 90° it produces a growth pattern similar to those for physical and electronic travel discussed above.

There was much discussion at the conference of "externalities" – those costs of travel for which the traveller is not directly charged – and much discussion also of ways of making the traveller pay for these costs. Electronic road pricing, carbon taxes and other schemes to make the polluter pay would have the effect of increasing the cost of travel and decreasing its amount. The conference, however, was also presented with reasons for believing that such schemes need not seriously impede progress towards yet more access.

Amory Lovins, in his paper to the conference "Hypercars and Negatrips: the next transport revolution", insisted very persuasively that it would soon be possible to produce cars that would travel more than 300 miles to the gallon while producing negligible emissions. His conclusion was somewhat ambiguous:

> Hypercars, however, cannot solve the problem of too many people driving too many km in too many cars, and could make it worse by making driving even cheaper and more attractive…Hypercars therefore both buy time for and increase the need for fundamental reforms in urban form and land-use. …Hypercars are thus part of a web of technical innovations and market imperatives whose largely beneficial effects will soon become far-reaching and irreversible.

Today's cars are a product of past technical innovations and market imperatives. By making motoring cheaper they have encouraged more of it. Lovin's hypercar is a plausible consequence of an extrapolation of these imperatives. The trends and forecasts examined above suggest that these imperatives are all aspects of a larger imperative – the conquest of distance.

Almost everywhere in the world governments in concert with the world's principal industrial enterprises are devoting most of the resources available for transport to the two modes of transport – the car and the plane – that are the most environmentally and socially destructive and the least democratic. The more time that is bought for these modes of travel, the more locked in we become to our dependence on them, and the more difficult the trends become to reverse. Their effects appear far from beneficial. The hypercar is a classic case of treating symptoms in a way likely to make the underlying disease worse.

The conference was also given an opportunity to experience another technical solution – video-conferencing. A man in Brussels appeared on a large screen to argue that in future the need to travel physically would be reduced by improvements in our ability to travel electronically.

At the conference I met an energy expert who told me that a trip from London to Vancouver and back would consume a tonne of aviation fuel. Just one such trip more than wipes out the energy saved by not using a car for a year. Waiting in Vancouver airport for my plane back to London I got chatting to a man who was waiting to fly to Toronto. He was going to play bridge with people he had met, and played bridge with, on the Internet.

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Subverting sustainability? Infrastructural and cultural barriers to cycle use in Accra

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Reports on in-depth qualitative interviews with bicycle owners and non-bicycle owners in Nima and Jamestown, Accra, Ghana. Also draws on two other surveys of transport patterns and travel behaviour in Accra. Finds a negative attitude towards cyclists. Argues that the implementation of dedicated infrastructure for bicycles may require a significant level of enforcement for success.

This research was conducted as part of the research programme of the Overseas Centre (Programme Director; Dr J. Rolt) of the Transport Research Laboratory on behalf of the Overseas Development Administration. The research was conducted in collaboration with the Ministry of Transport and Communications, Ghana, The authors also wish to thank the interviewing team from the Department of Sociology, University of Ghana.

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Introduction

Economic liberalization programmes have been implemented in countries across the developing world to encourage the efficient operation of markets and the reform of public sector enterprises. The resulting changes in the ownership of urban public transport often results in an increase in fares. This has a direct effect on the urban poor who have to absorb such increases into their meagre household budgets if they are to continue to carry out employment, educational pursuits and other essential activities (Mbara and Maunder, 1994). In Asia, cycling is more commonplace among the urban poor. The widespread use of this mode allows sudden changes in transport costs to be better absorbed. In an effort to improve the ability of the African urban poor to travel and to improve the urban transport system, the World Bank through its Sub Saharan Africa Transport Policy (SSATP) programme has initiated research into urban non-motorized transport. This research, focusing on East Africa and Francophone West Africa, has looked at ways of increasing the use of bicycles by Africa's urban poor. In parallel, the Overseas Centre of the UK Transport Research Laboratory has conducted, on behalf of the Overseas Development Administration, a collaborative study with the Ghana Ministry of Transport and Communications and the University of Ghana, on attitudes to cycle use in Accra, Ghana.

This paper reports on in-depth qualitative interviews with bicycle owners and non-bicycle owners in Nima and Jamestown in Accra, Ghana (Figure 1). Observation indicated a difference in cycling level within the two communities. A total of 46 individuals were interviewed and these reported on the ownership/non-ownership experiences of 260 people. The paper also draws on two other surveys of the transport patterns and travel behaviour in Accra. The first is a survey of portering in Accra where 81 interviews with porters were conducted in respect of the gender divisions in access to wheeled technology, access to credit within the urban poor and the role of non-motorized modes within mixed traffic. The second survey conducted 275 interviews with female and male traders on their transport needs, the importance of their economic role within the household and the use of family, especially girl child, labour within their enterprises.

The cycling study found that ownership of a bicycle, even a second-hand bicycle, represents a large capital item for a low-income household. Its use is decided as part of household survival strategy and its importance within that strategy differs according to the cultural attitude towards cycling. Grieco *et al.* (1995) demonstrated that attitudes to cycling differ between ethnic communities in Accra. Where cycling is perceived as being of economic value, then its use will be constrained to those in the household who can show the most likely economic benefit. Where cycling is not seen as being of economic value, its practice will be constrained by the community at every opportunity.

Accra has a very mixed road use. There is a negative attitude in the urban area as a whole towards cyclists. This leads to a dangerous environment for anyone cycling: they put themselves at considerable risk of death or injury. The provision of dedicated bicycle infrastructure is often seen as the way to reduce the risk for cyclists. This paper argues that the implementation of dedicated infrastructure for bicycles may require a significant level of enforcement for success, as a result of the negative community attitude towards cycling and the prevalence of the invasion of road space by the informal trading sector.

Counteracting the cost barrier: a culture of purposeful cycle use

There is clear evidence in Accra of different levels of cycle ridership between different low income areas (Grieco *et al.*, 1995). It is the differences in "transport cultures" that exist among different ethnic communities which

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Figure 1
The Accra road network

produce widely varying ridership levels in low-income areas. There are highly divergent socialization practices around cycling in a community composed of Northern Ghanaians or those of Northern extraction (Nima) as compared with those of a community composed primarily of coastal indigenous people (Jamestown). In the North, cycling is a widespread practice among adults; in coastal Ghana, cycling is rare as an adult activity. Whereas the parents of children in Jamestown frequently beat their children for cycling, the parents of Nima encouraged cycling as an activity.

Urban poor households have implicit principles that guide family members when seeking the family good in the survival of the household (Moch *et al.*, 1987, Ross, 1987). These are termed "household survival strategies". All resources available to the household (monetary, time-based, physical and human) are guided by these strategies. Assessing attitudes towards cycling in terms of survival behaviour points to the differential effect of high cycling cost on different communities within Accra. In those communities that have learned that ownership and use of a bicycle can be economically beneficial, who owns a bicycle and who gets to use a bicycle will depend on the survival strategy adopted and power relations within the household. In those communities that have not yet learned the benefit of its use, cycle ownership is seen as an unnecessary expense and bicycle use may prove very expensive by posing a significant risk of death or disabling injury to the principal resources the household has control over; its human resources.

Even communities which have already learned the economic utility of cycling are likely to be affected by high costs which will limit the number of bicycles a household can afford to buy. This leads to family-imposed restrictions on ownership thus preventing use becoming widespread. Household decisions are made to restrict ownership to those, within the household, who have greater control over household resources, either by being able to demonstrate possible higher earnings or by having greater power. Communities which have not yet learned to accept cycle use are unlikely to experiment while the cost of ownership puts bicycles out of reach. Lack of community knowledge about the economic utility of purchase will mean it is not adopted by households trying to reduce risks in order

to survive. Households will, instead, adopt community views on the use of bicycles which make cycling unacceptable.

Households only allow cycle ownership to those who can show that there will be some economic and occupational use for it and that ownership will generate greater income than would otherwise be the case without it (by carrying greater loads or allowing travel to work and job search over greater distances). Adaptations to improve load-carrying capability of the respondents' bicycles serve to strengthen the case for ownership and cycle use within the household. However, while household strategies may guide household behaviour, these strategies may often not be consensual, rather, those who can command most power and resources within the household may have greater say over what is and is not beneficial economic use. Qualitative evidence indicates that use of bicycles within households is determined by the ability of the "best off" member to secure sufficient resources, with other household members only gaining access for specific and "emergency" uses. Many respondents, both in Jamestown and Nima, frequently lent out their bicycle though often only under the strictest conditions. Often only close family members were able to borrow it and then only in emergencies:

> My elder brother uses it, when I am in the house not going anywhere. Conditions given to him is that, to be very careful and repair anything that should get spoilt while using it. No one else uses it (male carpenter, bicycle owner, 21, Jamestown).

Some respondents did, however, use the bicycle in a revenue earning capacity, by hiring out the bicycle to those in the local neighbourhood willing to pay the hiring fee. Revenue from hiring offset the purchasing costs of the bicycle. Furthermore, once purchased a bicycle had use-value that people would pay for.

> The elder brother bought the first bicycle for him at 12,000.00 cedis but this present Raleigh was bought from his own personally accumulated savings from the hiring of the first one for one month (unemployed male, 18, Jamestown).

Nearly all respondents who owned a bicycle reported that they purchased it through their savings or the resources of some close family member. The use of traditional group saving and rotating credit systems, such as "susu", was also commonly cited (see Steel and Aryeetey, 1994):

> Mallam Adams saved money with Susu collector to buy his bicycle. He plans to purchase next bicycle through "Group Susu" under the Group Susu system, a number of people contribute a stated amount each month or week, etc. The money is then given to one member at a time. This continues till the last person gets and the process is repeated. Other people he knows also used the Susu method to finance the purchase of their bicycles (male watch repairer, 45, Nima).

Table I shows that the purchase of a bicycle is a major capital expenditure. The average respondent reported saving for between six and nine months before purchase and this was very much dependent on a stable financial base in the household. During this time the ever-present pressures of other, equally pressing, household expenditures must be overcome. This is particularly difficult for women who often spend most of their income on the household. Access to credit was limited and fraught with difficulties, such as legal implications if repayments are in arrears; their credit worthiness is weak in the eyes of formal institutions as a result and a low social status and the high interest rates payable to moneylenders reduce the viability of this option. Steel and Aryeetey (1994) claim that interest rates can be as high as 100 per cent over 9-12 months:

> Q: If given the choice between saving and obtaining credit, which would you prefer?
> A: Credit, since it is difficult to save in our type of economy and considering the size of my family and dependants (male security guard, 42, Nima).

Table I
Costs of bicycle ownership in two communities in Accra

	Jamestown	Nima
Number of owners who bought new bicycles	5	11
Average new bicycle purchase price	33,000 cedis	20,700 cedis
Purchase price as a percentage of GNP per capita (US$450)	10 per cent	7 per cent
Average time saving for new bicycle	2.9 years	5.6 years
Number of owners who bought a second-hand bicycle	10	9
Average second-hand bicycle price	17,900 cedis	23,800 cedis
Purchase price as a percentage of GNP per capita(US$450)	6 per cent	8 per cent
Average time saving for a second-hand bicycle	9 months	14 months

The lack of low-income access to formal credit facilities results in people diverting sums from their meagre income to informal savings collectors such as the susu (Gabianu, 1990), with the risk of losing the accumulated capital and the devastating effect that that could have on household survival:

> No because I am fairly old and need not involve myself in the social activities of the youth. I always keep my monies in the room that I stay in with some relations. I have no trust for susmen because they have twice absconded with my savings (Ewe Kayayoo, 45, working at the Timber Market).

Women cyclists, who were not owners and who rode, only provided leisure, enjoyment and exercise as reasons for riding. These are not sufficiently pressing reasons to warrant large capital outlay in an income-scarce environment. Few of the respondents who did own bicycles cited such leisure use as justification for purchase. Of the male cycle owners, a large number have occupations (e.g. tradesmen, farmers) that require the carrying of goods during the working day or the need to travel to their workplace outside of the most convenient time for the use of public transport (e.g. night watchmen).

Playing with the traffic! Effect of community attitudes on responses to road safety

The continuing perception of most urban Accra dwellers is that cycling is a dangerous activity. The cultural values and attitudes of the urban communities within Accra influence the reaction which develops over time to the increasing level of cycle accidents. These community values and attitudes are explored to assess what effect possible policies and measures may have in altering the level of cycling safety.

For households living in constant threat of dire poverty, access to resources (financial, time-based, physical and human) and the wellbeing of those resources are of importance. The key role that children, especially girls, play in acting as labour resources for the household from a very early age must be considered here (Grieco *et al.*, 1994; Joekes, 1994). Within communities which do not recognize the economic benefit of riding a bicycle, attempting to learn to ride as a child is not seen as acquiring life-skills but as merely putting important household resources in danger, for no economic benefit, in a risky traffic environment. In those communities where riding bicycles is seen as having a clear economic benefit, learning to ride as a child becomes a useful life skill. Accidents with other road users in this context do not deter the community from endorsing children learning to ride but rather produce adaptive behaviour to reduce the risk, such as only encouraging ridership by those who will go on as adults to cycle for economic purposes. Women in neither community were perceived as having a need to use bicycles for economic purposes. In Jamestown, girls learning to ride were discouraged and in Nima, girls cycling after puberty were discouraged. Equally, parental opposition to cycling feeds a "dare-devil" cycling culture where accidents are more likely (Grieco *et al.*, 1995). There were many respondents, both in Jamestown and Nima, who told of aggressive driving behaviour and pedestrian movements which led either to accidents or near-misses. This aggressive behaviour was an outcome of the negative attitude towards cycling formed within the greater urban community.

In the North there is good cycle/other traffic interaction. By contrast, indigenous ethnic groups of Accra are used to living in areas where this interaction is dangerous. The Northern communities are more likely to ignore the risks, i.e. evidence of accident frequency is about the same but the "lessons learned" are different. Salifu (1993), studying the cycle accident statistics of Tamale, Northern Ghana, points out that the increase in motorization in this bicycle-using area of the Northern Region is having a significant effect on the level of cycle accidents. While at present, cycle use remains high, compared with other areas of Ghana, with time, this cycle-friendly area may too experience a change in attitude by the community against cycling. This will have detrimental financial, environmental and safety effects on the urban poor unless steps are taken to protect the existing cycle population.

Improving the safety of cycling is a fundamental step in increasing the demand for cycle use among the urban population. As recognized by the World Bank (Pankaj and Coulthart, 1993), the segregation of non-motorized modes from motorized modes is fundamental. However, how to enforce a right of way for bicycles within an environment of mixed road use needs consideration. The problem of who has priority within a mixed road use environment is of significance when determining how to promote non-motorized modes in the developing context: consider the context and culture of the cycle/other transport interaction in Accra:

> Q: What journeys around Accra can you not use your bikes for and why?
> A: Very long journeys and on busy streets because of dense vehicles and human traffic

(male construction worker, bicycle owner, 24, Nima).

I don't take it to Circle area because of the nature of the traffic and the way the taxi drivers drive around (male Pretty Trader, 38, Jamestown).

Mixed road use in a Ghanaian context is characterized by conflicts between motorized and non-motorized modes and conflicts among non-motorized modes (Agarwal *et al.*, 1994 and Apt *et al.*, 1994). In Ghana, human transport (e.g. head load porters) and roadside vendors fulfil a significant economic role. Correspondingly, within the transport hierarchy, human transport and vendors have more status than cyclists. Many respondents recounted incidents where pedestrians deliberately stepped out in front of the cyclist or where the cyclist was verbally or physically abused for travelling in crowded pedestrian areas or for colliding with street vendors. These experiences were paralleled by abuse from motor vehicle road users, especially taxi drivers. Other forms of non-motorized transport such as barrows and trolleys experienced the same disregard (Apt *et al.*, 1994). Attitudes of junior officials are unfavourable towards non-motorized modes; respondents reported occurrences where bicycles or trolleys were confiscated for being in places of high human or vehicular traffic density. The transport environment of Accra is not friendly towards cyclists.

There are cultural aspects involved in rendering cycling safe. In China and much of South East Asia, there is mass cycling behaviour and safe roadspace for cyclists is determined by sheer weight of numbers (Ghuo, 1994). In the UK the pressure group "Critical Mass" organizes mass cycling events to "claim back the road". In The Netherlands and Germany, cycling is a respected means of behaviour and is provided for within the transport system (Tolley, 1990). Positive measures for the provision of bicycle infrastructure and its efficient enforcement may effect some change in the Accra transport culture towards cyclists. As people perceive that, as a result of these official actions, there is no longer an official endorsement for their own negative attitudes, cycling may become more acceptable.

Given existing community values and the mixed road use characteristics within Accra, simply providing infrastructure for cycling does not guarantee that it will be used for this purpose. Respondents painted a picture of conflictual interaction of pedestrians with cyclists, motor vehicles, pedestrian street-sellers, kerbside vendors and people living on the street. Cultural attitudes currently favour vendors' rights against cyclists' rights where there is a collision over use of road space. There is significant potential for invasion of dedicated cycle infrastructure by vendors and other non-motorized road users. Motor vehicles have the natural advantage of being able to enforce their share of road-space; solitary bicycles do not!

If there is, as yet, not enough cycle demand in Accra for the bicycle to be able to maintain a right-of-way in competition with other human activity by sheer weight of numbers, how are the cycle lanes which are currently planned for Accra going to be protected from becoming yet more space for street-sellers and pedestrians? If cycling were safer then there would be more bicycles to use the dedicated infrastructure, but if the risk of constant interaction with other road users is seen as a safety problem, then, clearly, there is a need for some form of enforcement of any newly-constructed cycle lanes. Extra enforcement needs to be introduced and paid for. Conspicuous signing indicating bicycle priority needs to be put in place. In the most congested locations, such as the central market areas, where all forms of human transport are competing for limited space, only the construction of alternative provision for pedestrians and street vendors will begin to ensure cyclists have priority.

Cycle paths, suppressed demand and substantial variations in low income attitudes towards cycling: the imperative for cultural sensitivity

Ownership of a bicycle represents a significant investment for an urban poor household. Reduction of the purchase price of bicycles makes it easier for household members to justify ownership. There is a need not simply to accommodate a suppressed demand, by reducing bicycle costs, as this will merely replicate the gender and cultural divisions within cycle use at present. There are significant variations between communities within Accra towards bicycle ownership and these will not be overcome through purchase price reductions alone. Within those communities that accept cycle use, the cost to the households of earmarking valuable resources for bicycle ownership should be made easier; the lack of access to credit for the urban poor hinders efficient organization in transport provision. Demand must also be induced within other communities and sections of the population. Explicit consideration must be given on how to render the bicycle more economically and occupationally useful, in order

that people can justify the large call on resources necessary within a household to purchase a bicycle. There is a need to promote cycle use within communities with limited acquaintance of the bicycle and to promote its use by women: sustainability should be accompanied by equity.

Household members are major economic resources within an urban poor household and as motorization increases, even in those communities that accept cycle use, it will become increasingly difficult to justify the risk that cycling places on such human capital. Segregated infrastructure is required to preserve the existing levels of cycle use and allow its promotion in other communities. The special features of mixed road use in Ghana and the overall negative attitudes towards cycling require consideration in the designing of infrastructure. The potential for vendor and pedestrian invasion of cycle facilities, the costs of enforcement and role of signing require explicit consideration in any scheme. It is not sufficient to build cyclepaths or to persuade a substantial section of the public to use cycles on the main arteries of the city. Other road users need to be educated on their behaviour towards cyclists. In the absence of an appropriate infrastructural policy that considers behavioural as well as engineering factors, the admirable goal of sustainability will inevitably be subverted.

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The future of public transport: the dangers of viewing policy through rose-tinted spectacles

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Improved public transport services are generally viewed as the most effective means of encouraging transfer from the car, especially on urban journeys. Accordingly, substantial public funds are being invested to this end. Demonstrates that such an approach achieves little of this transfer. By comparing patterns of travel in Britain and The Netherlands, shows that the prioritizing of walking and cycling is not only far more effective and cost-effective in achieving the transfer, but also is likely to deliver a wide range of social, health and environmental objectives of public policy additional to those related to transport. There must therefore be a presumption in favour of investment in networks for walking and cycling and in other measures enabling journeys to be made by these non-motorized modes well in advance of investment in public transport.

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It is the conventional view that the key element of a package to deal with the adverse effects of the growth in car-based geographically-dispersed patterns of activity is much improved bus and rail services in order to provide equivalent levels of convenience, speed and comfort to the car. In this way, car users can be more easily encouraged to transfer back to public transport.

These judgements about public transport as by far the most important substitute for the car are apparent in documents produced by the European Commission, notably in its recent Citizens Network, professional papers by academics and from transport institutions and transport-related commercial bodies, in party political agenda-setting statements, local and central government reports, in most spheres of information gathering and dissemination, and in the media. They are reflected too in attitudinal surveys revealing that the public, including most motorists, agree.

One of the primary explanations for this outcome, additional to the obvious one of the relative power and influence of both the private and public motor lobbies, is the fact that published statistics on patterns of travel are focused on a modal split that usually excludes journeys over short distances and by non-motorized means, thereby resulting in an exaggeration of the significance of longer journeys and of the importance of public transport. This then encourages solutions to be seen to lie in the area of investment in transport infrastructure – road building, rail electrification, and other improvements in public transport services to reduce travel times on these journeys.

So influential has been the support for substantial investment in public transport that it is rarely questioned, with the sole problem lying with budgetary limitations. Many cities have invested in or are proposing new high quality systems in spite of their capital costs per kilometre being not dissimilar to those for road building largely because of the expensive rolling stock and, in some instances, tunnelling.

Current patterns of travel

Any examination of the current role of public transport must differentiate between bus and rail. Their characteristics vary significantly in terms of meeting the demand for travel over shorter and longer distances. Table I shows that, in Great Britain, the near-exclusive use of buses at present is for journeys of between one and ten miles, but accounting for only 1 in 10 within this distance band, though for eight times as many as by rail. Indeed, only 1.6 per cent of journeys of any length are made by rail which is rarely used to travel less than 10 miles (16 kilometres) – 86 per cent of all journeys. Rail comes into its own on longer journeys over 10 miles in length but then caters for only 1 in 15 of them. However, it can be seen that most journeys are still sufficiently short that they can be made by non-motorized means. A third of all journeys is made within one mile, a distance fairly well suited to walking. A further third is made over distances of between one and four miles, which would involve a cycle ride of between five and 20 minutes. The fact that few of these journeys are made by bicycle in Great Britain may be explained by the lack of provision of safe networks for it, rather than its unsuitability for journeys within this distance band.

The bottom two lines of Table I show the ratio of walking and cycling journeys to those by bus, and the ratio of car journeys to those by rail, both ratios being recorded within each distance band. It can be seen that walking and cycling cater for five times as many journeys as do buses – in urban areas, the proportion is still higher – and 35 times as many journeys are made by car as by rail. Although it is clear that many issues other than travel time influence personal decisions on modal choice, even on journeys of up to 2 miles, journeys on foot do not take much longer than journeys involving use of a bus. Cycling is almost twice as fast: on journeys of up to 10 miles, it takes less time than bus or rail. On longer journeys, that is over 25 miles, accounting for only 4 per cent of all journeys – the car is used seven times more than is rail.

On work journeys in Great Britain, where public transport comes into its own, albeit

largely owing to parking control, road congestion and other deterrents to car use, the number of journeys on foot is very similar to that by all public transport modes combined; the number by cycle is very similar to that by rail in spite of the very limited provision for cyclists. In general, buses are rarely used for most types of journey. In the case of shopping, walking accounts for nearly four times the number made by bus – a similar ratio to that for school journeys and for most leisure journeys. Bus and rail are rarely used for day trips or holidays.

Table I
Modal split on journeys, by distance band, Great Britain

	Distance band in miles							Trips per
	<1	1<2	2<5	5<10	10<25	25+	All	week
Walk	236	45	10	–	–	–	292	5.9
Cycle	5	6	5	1	–	–	18	0.4
Car	43	99	190	114	82	29	560	11.4
Public transport	5	14	33	17	8	4	79	1.6
Bus[a]	5	14	30	12	3	–	63	1.2
Rail[b]	–	–	3	4	5	4	16	0.3
Other	3	9	16	10	8	7	51	1.0
Total	290	173	254	143	100	40	1,000	20.3
Walk and cycle: bus	51	3.6	0.5	0.1	–	–	4.9	
Car: rail			63	28	16	7	35	

Notes: base = 1,000
[a] London Transport bus and other stage bus
[b] British Rail and London Underground
Source: derived from Department of Transport (1994)

It would seem that the prospect of buses playing a significantly larger role for most types of journey under 4 miles currently made by car is small. For journeys of 4 miles or more, the prospect of much substitution of journeys from car to coach or rail without considerable limitations on car use is also small. Neither improvements in urban services, recently introduced or under consideration (such as light rail, more comprehensive networks of bus lanes, computer-controlled traffic lights favouring buses, electronic indicators showing expected time of arrival, or even lower fares), welcome though these are or would be for bus users, nor improvements for longer inter-city journeys (such as faster trains, seat-back videos, and concessionary fares) bring about more than a modest transfer of people with the choice of travelling by these services rather than by car.

Indeed, in Great Britain, for every passenger kilometre "lost" to bus travel, 13 car passenger kilometres have been added over the 30-year period to 1993. Growth in car use has not come about from transfer from public transport but from walking and cycling – in Great Britain in 1949, cycle mileage exceeded car mileage whereas it is now exceeded by a factor of 75! It has stemmed from more journeys newly-generated by the ownership of a car; and increasingly from travel to and from more distant destinations in new developments of low density – housing, shopping, commerce and leisure centres, convenient access to which is realistically only possible by car. In general, door-to-door travel time by car is far lower than by bus or rail, from which it can again be observed that it is wholly unrealistic to anticipate that improved public transport could result in it competing with the car on journeys up to 50 miles, accounting for over 98 per cent of all journeys. The expectation that, given sufficient improvement in public transport, especially rail, people will return to it from the car, overlooks the fact that, in the main, these journeys were neither previously made by public transport nor do they lend themselves to being matched by it.

Lessons from The Netherlands

The appropriateness of the bicycle as a far more appropriate substitute for many car journeys (as has been seen, over half of these journeys even today are over distances of less than 4 miles) is apparent by comparing patterns of travel in Great Britain and The Netherlands. The travel surveys for the two countries reveal similar levels of household car ownership, and a considerable degree of congruence within each distance band both in the overall distribution of journeys and in car use. However, one particular difference stands out, namely the much higher proportion of journeys made by cycle, a lower proportion on foot, and a lower proportion by public transport. In The Netherlands, over a quarter of all journeys are made by cycle – including over half of school journeys (only 1 per cent in Great Britain) – and journeys by cycle and on foot exceed those by public transport by a factor of 10. The ratio of car journeys to cycle journeys is about 2 to 1 whereas, in Great Britain, the ratio is 32 to 1. Moreover, the number of cycle journeys there easily outstrips those made by public transport on journeys in all distance bands up to 15 km.

Given the fact that most urban settlements in Europe are topographically not "cycle-unfriendly", it is clear that the explanation for the high level of cycle use in The Netherlands has much to do with its transport policy over the last 25 years which has led to cycling playing such a significant role in spite of a

continuing rise in car ownership. Nor can the relatively low use of public transport there, much lower than in Great Britain, be explained by a poorer service, for the reverse is true: 12 times as much money is spent on that mode as on cycling. Indeed, higher densities of population which in turn promote public transport use are more commonplace in The Netherlands. This again points to the limited role of public transport in attracting people who currently use cars.

Investment decisions in transport

Repeated calls are made in transport circles for a "level playing field" in road and rail investment. "Balance", "least-cost planning" and an "integrated approach" in policy decisions, are recommended. All travel methods are claimed to incur environmental costs. That is true for motorized travel: like private transport, all forms of public transport are the source of noise, pollution, danger to other road users, severance, and so on. It is untrue for walking and cycling.

What sort of sensible balance, however, can be struck when the transport modes incurring high economic, social and environmental costs are given preferential treatment to those incurring low costs; when investment in all the modes is not evaluated according to common criteria; and when the benign non-motorized modes are largely left out of consideration other than in the context of road safety?

Even when large investment has been made in high quality public services, the outcome has been disappointing. On average, the best of new public transport systems cost far more than budgeted and then carry far fewer passengers than predicted. In spite of their high capital costs, rapid transit systems add no more than a few per cent to public transport patronage for a whole city and have relatively little effect in terms of the objective of relieving road congestion by attracting car users, and the benefit of the small transfer to public transport tends to be overtaken within a year or two by the continuing rise in the use of the car.

Even discounting criteria other than direct economic ones, comparison between investment in walking and cycling networks rather than public transport, points overwhelmingly to one decision based on achieving the best rate of return: the capital costs per kilometre for the new type of public transport systems currently under construction or being reviewed are hundreds of times higher than those for cycling provision and are likely to be much more effective in meeting travel demand. Indeed, the total 2,000 kilometre cycle network for London would cost the equivalent of two kilometres of the Leeds Supertram system or 0.4 kilometres of the Jubilee Line Extension!

Discussion

At this juncture, it must be acknowledged that, of course, public transport does have an important role to play. First, it is needed to cater for the journeys of people without access to a car, and for those who, for whatever reason, prefer to travel by it rather than use their car on particular journeys. Second, it is required for commuting where it may be especially necessary to oblige motorists to use public transport owing to the shortage of parking space and problems of congestion in central urban areas – though thereby rendering its services extremely uneconomic as vehicle occupancy, and therefore revenue, are low outside the rush hour. Its third role is for long distance inter-city travel but, as has been seen, door-to-door travel time and convenience – and overall cost where several people are travelling together – can easily tip the balance in favour of the car even when rail journeys are on fast electrified routes or coach journeys are largely on motorways. Unless the real and perceived costs of car travel are dramatically increased, holding down fares is likely to have only a minor effect on this particular modal choice.

At the heart of the debate about the future role of public transport lie three questionable and dubious, albeit unspoken, assumptions. The first is that people's appetite for travel – "further and faster" – is insatiable and that longer journeys at higher speeds are somehow more significant. This is certainly true as far as environmental impacts and other costs are concerned! The second is that current and future demand must be met, though perhaps in less environmentally-damaging ways, because people have an inalienable right to have their wish to travel met, if not by car, then by some alternative form of motorized transport to which they can be won over because it largely matches the car's attractions. The third, and perhaps most worrying, is that the accumulation of greenhouse gases from all sectors of the economy, especially transport, can continue to rise without putting at risk the ecological balance of the planet.

It may be through our response to the urgent need to curtail dramatically our use of fossil fuels that the inappropriateness of bus and rail as substitutes for car and air travel will be recognized. Not only do all these

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modes rely completely on the use of fossil fuels but, taking account of typical vehicle occupancies, public transport's fuel consumption per passenger kilometre is only a third to a half lower than that of the car, whereas, of course, for walking and cycling, none is required.

Two recent reports of the Intergovernmental Panel on Climate Change have called for a global 60 to 80 per cent fall in carbon dioxide emissions to stabilize the world's climate. With the moral imperative as stewards of the planet to modify our lifestyles to meet this objective, and political realism to reflect the fact that developing countries cannot realistically be called on at this stage in their development to reduce their low levels of fuel consumption, the author of this article has calculated that for Western European countries, the reduction determined on an equitable per capita basis is over 90 per cent. Without action to this end, the overriding message of the Brundtland Report, the 1992 Rio Conference, and European Union States' response to it including a commitment to sustainable development, that we must hand on to future generations an environment no worse and preferably better than the one we inherited, will prove to be just pious and unfulfilled expressions of intent.

Conclusions

A consensus is being reached that, in the light of all its adverse consequences, demand for car travel must be reduced. Restrictions will have to be progressively but speedily phased in during the next two decades – for instance, through private and public parking control, much lower and properly enforced speed limits, traffic calming, much heavier taxation of fuel and possibly fuel rationing. However, while investment in public transport is justified for the motorized travel of all adults without access to a car or who prefer not to use a car, and of course for all children who can be allowed to travel on their own, buses are generally a far less satisfactory alternative to the car than the door-to-door convenience of walking on short journeys or the door-to-door convenience of cycling on journeys up to four to five miles in length – in combination, representing close on 2 in 3 of all current journeys. While rail can be a better alternative to the car on long journeys, in practice these represent only a very small proportion of all journeys and opportunities for transfer from car to rail are limited.

Thus, to meet the objective of providing a realistic substitute for the car, an investment strategy would be better directed to provision first, for safe and convenient pedestrian networks for short journeys; second, for safe and attractive cycle networks for other urban journeys; and third, for the non-motorized modes in combination with public transport for longer journeys. Any evaluation of the costs and benefits of each form of transport, taking account of social, health, economic and local and global environmental criteria, is likely to reveal the non-motorized modes as by far the most cost-effective. Such a strategy must take precedence over one aimed at encouraging significant transfer from the car to public transport for that is an ephemeral goal.

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Road infrastructure investment in Bangladesh: environment under threat?

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Bangladesh's attempts to support and expand a road network are, relative to its wealth and agricultural land, far in excess of its Asian neighbours. The dubious grounds for such a policy are belied by its unsustainability from inadequate maintenance, significant environmental and social dis-benefits, namely the loss of scarce land through road construction which leads directly to increased poverty, and destruction of dwindling forest resources. Argues that prominence given to road construction should be questioned, especially in view of the country's rich endowment of waterways and non-motorized forms of transport which are less environmentally destructive.

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Introduction

The Bangladesh infrastructure experience has been presented as evidence for the leading catalytic role of roads in inducing development and thus as a model that should be copied by other similarly poor countries (Ahmed, 1990; Ahmed and Hossain, 1990; World Bank, 1990a; World Bank, 1991a). However, in Bangladesh all new road infrastructure works have environmental dis-benefits, the consumption of land being both the most evident and significant in the context of the relationship between landlessness and poverty. These dis-benefits have been glossed over by the vigorous promotion of road development. Few ask whether gross benefits are thought sufficient to compensate for negative environmental effects and still make investment worthwhile.

The fragility of Bangladesh's environment is internationally renowned and dictated by its physical geography. Deltaic, annually flooded by numerous major rivers, and located in one of the most cyclone-prone parts of the world makes the risk of disaster ever present. Risk reduction is the foundation of the proposed Flood Action Plan, an expensive ($ 5-10 billion) and controversial infrastructure investment (World Bank, 1990b). Part of the controversy is whether such massive physical infrastructure changes will affect Bangladesh's sensitive environment. This is acknowledged in the cautious sequencing of further studies, pilot projects and initial investments pending a decision to proceed with the full plan.

Road infrastructure investments in Bangladesh on the other hand, are not accorded such environmental concern.The piecemeal nature of road projects may well provide the explanation for this anomaly, since few are of such a scale that their individual effects are very significant. However, the cumulative environmental impact of whole programmes conducted over decades is another matter. It is the consumption of land and the other dis-benefits associated with rural road development, which leads this paper to challenge the prevailing assumption that more roads enhance rural welfare to such an extent that environmental considerations are not a significant issue.

Roads in Bangladesh

From only a few hundred km at the time of the country's separation from India in 1947, the length of the road network has increased rapidly. In 1970 there were 3,200 km of main roads which had increased to 12,300 km by 1990. There were also 22,000 km of rural/feeder roads and over 90,000 km of local earth roads constructed primarily under Food for Work programmes. The main and rural roads represent one of the highest density networks in Asia (World Bank, 1991b) with Bangladesh having a density of 86 km of road per 100 sq km of area as compared with 50 for Sri Lanka, 45 for India, 18 for Malaysia, and 15 for Thailand.

In terms of rural land requirements it is more meaningful to examine road densities per unit of agricultural land, and in relation to the apparent ability of the country to afford the infrastructure. Table I shows that of the poor countries with an annual GNP per capita of $430 or less only Sri Lanka has a density of roads close to that of Bangladesh. When corrected for GNP the agricultural road density of Bangladesh is double that of Sri Lanka, three times that of India and approximately 12 times that of China or Nepal. Its pre-eminent position is all the more surprising given the high cost of road construction. Because of the alluvial soil, large numbers of rivers which must be bridged or crossed by ferries, and the annual threat of flooding making roads on high (2-3 m) embankments essential, road building in Bangladesh is very expensive – 60 per cent higher per km, for example, than in India (Smillie, 1991).

Roads and the environment

The three most evident environmental effects resulting from rural road development in Bangladesh are:

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1 the loss of land;
2 land degradation through inadequate road planning and design; and
3 forest destruction.

Loss of land

A feature of many rural infrastructure investments – embankments, roads, river training works, drainage canals and ditches – is that they involve significant scale earthworks.

Table I
Road density in relation to agricultural land and GNP per capita

Country	GNP per capita $ (1990)	Road density per 100 sq. km agricultural land	Road density per 100 sq. km agricultural land per 100 $ GNP per capita
Nepal	170	9	5.3
Bangladesh	210	118	56.2
China	360	20	5.6
India	360	74	20.6
Sri Lanka	470	139	29.6
Thailand	1,420	37	2.6
Malaysia	2,320	134	5.8
Korea	5,400	230	4.3

These consume one of the country's most precious assets: land. For roads, embankments and river training works an additional and greater need for land results from the structures themselves, in the form of areas, or borrowpits, from which soil is dug for their construction since the land is uniformly flat. Such areas are not always recultivated and often remain as flooded ditches or ponds which serve mainly as watertanks, for soaking jute, or fish production.

Land degradation

Roads and embankments often lead to a further loss of land due to waterlogging resulting from poor planning, design and construction of alignments and drainage (KBN Engineering and Applied Science, Inc., 1991). Most such structures are an artificial imposition on natural drainage patterns which are very finely demarcated on an alluvial flood plain. Unless implemented with great care they obstruct flood dispersion leading to waterlogging which will lower yields or, in extreme cases, render land useless for cultivation.

Unfortunately the necessary care has rarely been the case. An apparent feature of Bangladesh's rural road network is the way roads zig-zag across the flat landscape. Right-angle turns averaging less than 50m apart are common. In other flat deltaic regions, such as Thailand or The Netherlands, this is seldom the case and lines of communication, both road and rail, are as direct as the river and canal systems will permit. The curved alignment of roads in Bangladesh is not due to elaborate provision for drainage requirements. The reverse is the case – creation of difficult-to-drain areas within the arc of the many changes in direction of the road alignment.

One explanation given for the zig-zagging of roads is that they follow the boundaries of individual land parcels to minimize the loss and inconvenience to any one farm (Associates in Rural Development, Inc., 1989). Alternative explanations are that such alignments result from deliberate actions to avoid the large land plots of the relatively wealthy and powerful and conversely take the small land plots of the poor and uninfluential (Wood, 1988). There is evidence that this is the case, and it is consistent with the mechanisms by which the poor become landless (Hartmann and Boyce, 1983; Jansen, 1987).

Whatever the real explanation the effect is the same. Such alignments offer no engineering advantages and create environmental and operational problems, including slower and longer journeys. Moreover, in following the alleged path of least social resistance, the length of road embankment and the number of drainage structures per kilometre is increased over that of a straight alignment. This unnecessarily increases the cost of construction and maintenance, and the consumption of land.

Forest destruction

Forest destruction is a direct environmental consequence of road development due to the use of burnt bricks, both as the major road surfacing material and, when broken, as aggregate for the construction of low-strength structures such as small bridges and culverts. This technology is common to the plain of the Ganges River in Bangladesh and India because of the absence of any other naturally occurring hard-surfacing material. The plain – 300 km wide in places – is composed of materials which can be baked into bricks but otherwise are structurally very weak.

Assumed benefits from investment in roads

The benefits to be expected from the lowest cost investments, i.e. maintenance, are in theory non-controversial. They comprise reductions in vehicle operating costs and can be estimated relatively easily and accurately if the roads are in a sound condition and carry reasonable volumes of motorized traffic. Techniques for estimating user benefits

when existing roads are upgraded are also reasonably well established.

The real uncertainties lie with new roads where benefits are essentially the economic and social changes which are likely to be "induced" by the investment. The difficulty which all developing countries face is that despite much research these changes have defied generalization. Sometimes they are positive, sometimes negative, and occasionally so few in number that it is difficult to discern any at all. Certainly, it has so far not been possible to develop a reliable method for predicting the outcomes of investments either quantitatively or qualitatively (Howe and Richards, 1984).

This uncertainty is clearly not shared by the Government of Bangladesh (GOB). Road investment has been, and continues to be, viewed as a key mechanism for engendering positive economic and social change, although this role was emphatically challenged by the foreign contributors to the 1977 Bangladesh Rural Transport Survey (Transport Survey Section, 1978). Under the conditions prevailing in Bangladesh they concluded that improving rural transport without complementary changes in credit, the provision of agricultural inputs and marketing arrangements would provide benefits only to the large farmers and to the traders.

A further boost to the pro-roads lobby resulted from a joint study by the Bangladesh Institute of Development Studies (BIDS) and International Food Policy Research Institute (IFPRI). Although conducted in 1982 the study has only recently received widespread international publicity, and has been considered by some commentators to hold important investment lessons for other poor countries (Ahmed, 1990; World Bank, 1990a; World Bank, 1991a). However, major issue can be taken with the structure and scope of the BIDS/IFPRI study, and especially with the interpretations which have been placed on its results[1].

In essence the BIDS/IFPRI study attempts to isolate the development impact of rural infrastructure, in particular roads, on the rural economy of Bangladesh. The 16 villages in its sample were categorized into two groups – developed and underdeveloped – based on an aggregate infrastructure index reflecting ease of access to various services such as markets, schools, and banks. Villages which had better-than-average access were classified as "developed" and these were found to be significantly better off in a number of areas – including agricultural production, household incomes, wage incomes of landless labour, health, and the participation of women in the economy – than underdeveloped villages. According to the authors:

> the most important finding is *the profound effect that infrastructure has on the incomes of the poor* (present author's emphasis). Overall, estimations based on the most and least developed villages indicate that infrastructural endowment causes household income to rise by 33 per cent: income from agriculture increases about 24 per cent, that from livestock and fisheries about 78 per cent, that from wages almost doubles, but income from business and industries only rises by 17 per cent. Most striking, however, is the distribution of these increases: the functionally landless and small farmers garner a larger share of the increases from crops, wages and livestock and fisheries, while the large landowners capture most of the smaller increase in business and industries.

The study concluded that development of rural infrastructure, with roads explicitly identified as the central component, had to play a key role in any development strategy for Bangladesh (Ahmed and Hossain, 1990). Further that past allocations to infrastructure, based on experience and judgement about current or emerging "bottlenecks", should be replaced by conscious creation of excess capacity that would induce production of agricultural and non-agricultural goods, services and employment (Ahmed, 1990).

It is the advocacy of road investment as a strategic "catalyst", or causative factor, of more general development which appears to be fundamentally unsound. The proposition, which adds fuel to Bangladesh's already strong propensity for investment in roads, is open to criticism on a number of grounds:

1. it contradicts the consensus of theoretical argument and empirical evidence;
2. it is based on a short-term view of the economic and social changes associated with new roads, which in Bangladesh are fundamentally unsustainable owing to the endemic lack of maintenance; and
3. it rests on an appeal to gross rather than net benefits which leaves the real effect on the poor indeterminate.

The first two of these reasons are discussed elsewhere although it is germane to note that about 40 per cent of the present network is functionally ineffective because they are physically incapable of carrying the motorized traffic for which they were designed. The main barrier to use by motorized traffic is the presence of gaps in the embanked roads: sections where major cross-drainage structures – bridges or large culverts – have either collapsed, and remain in that state due to lack of maintenance, or were never built with the

main earthworks. These obstacles usually mean that four-wheeled vehicles cannot pass, and may be a barrier to all wheeled traffic (Howe, 1994). This paper limits itself to point 3 (above) since environmental effects are the main dis-benefits associated with road investment.

Dis-benefits from investment in roads

Landlessness and poverty

Poverty is highly correlated with landlessness not just in Bangladesh, but elsewhere in Asia, Africa and South America (World Bank, 1990a). Although there is disagreement about the general strength of the connection, Begum (1986) argues that in Bangladesh, landlessness and poverty are closely linked due to the very limited opportunities for non-agricultural employment. Moreover, it has the unenviable distinction of having experienced one of the most dramatic transitions from a predominantly land-owning to a landless society of any country in the world. Hartmann and Boyce (1983) have graphically described the relentless process by which land has become concentrated in a smaller number of hands over the past few decades and the subsequent plight of the landless for whom life undoubtedly becomes more precarious. Jansen (1987) has corroborated their findings and argued that through the process of landlessness, Bangladesh is gripped in an almost inexorable impoverishment that threatens catastrophe, and which present policies and plans do little to address. More refined assessments of poverty in Bangladesh also confirm that it is generally the rural landless labourers, and their families, who are among the poorest of the poor and the most vulnerable to death from starvation (Ahmed *et al.*, 1991).

In 1978 it was predicted that by the turn of the century the majority of the population in Bangladesh would be functionally landless (USAID, 1978)[2]. Projections made a decade later confirm that this is likely to be the case, with the proportion of households without land expected to reach 60 per cent by about the year 2010 (World Bank, 1990b).

Land consumption

Given the overwhelming evidence of the negative effects caused by landlessness, then investments that actually require land – not only its transfer but also its sacrifice indefinitely – ought to be subject to rigorous scrutiny. Such programmes should not be entered into without a thorough investigation of the full costs and benefits, including the costs and methods of compensating those made landless. This is difficult for the road sector since investments take place under different programmes and are supported by a multiplicity of government and, especially, foreign agencies who have both formal and informal investment criteria. Some investments have been the subject of detailed cost-benefit analyses, but not all. It is the lower and most extensive categories of "rural roads" that have most often been omitted from consideration.

Roads have consumed at least 94,000 ha, or 1 per cent of the available cropland. This may seem small but in a densely populated and overwhelmingly agricultural country it could support in excess of 1 million people. The land required for a road is approximately 0.75 ha per km, one third right-of-way, two-thirds borrowpits (Merril *et al.*, 1990). However, a consequence of the 1987 and 1988 floods has been to increase the land required in flood-prone areas, since engineers consider embankment heights to be inadequate and the desirable level has been raised from 2 to 3m. Further increases in land-take seem certain since global warming is now accepted as irreversible and sea levels are expected to rise by between 20-80 cms in the next 100 years (European Federation for Transport and Environment, 1995). Thus a further increase in embankment heights and land-take seems inevitable.

Deforestation

Deforestation is particularly significant in Bangladesh because its forests have an important function as wind barriers to limit cyclone damage and as a source of domestic fuel. The main remaining area of forest is the coastal mangrove swamps, or "Sunderbans", which provide protection to inland areas from the endemic cyclones to which it is subject. They are also the last remaining refuge for much of the country's wildlife, including the Bengal tiger.

Bangladesh's forest area is estimated to have declined from 11,000 to 8,000 square kilometres between 1980 and 1990 (World Bank, 1994). The annual rate of deforestation, at 3.9 per cent of total forested area, was second only to Jamaica among the 72 low and lower-middle income countries for which data are available (World Bank, 1995)[3].

These figures imply that there will be no significant forested areas within 25 years.

In Bangladesh bricks for road and other contruction purposes are traditionally fired with fuelwood. Each brick needs 0.43 kg of wood, enough for two-thirds of a person's daily needs for domestic fuelwood. A typical road in Bangladesh uses 200,000 to 300,000

bricks per km – which means around 100 tons of firewood. This could supply the needs of 450 people for a year, in a country where there are already desperate shortages of this basic rural resource, shortages which over the past few years have resulted in the price of wood increasing at the rate of at least 25 per cent per year.

The GOB is attempting to switch production of bricks from wood to coal as the main fuel, but given the large number of traditional brick producers and difficulty of policing production at remote sites, this is bound to take many years. It is also not clear if the country can afford to import all the coal it needs. In the interim, building only the most essential roads, and surfacing them with bricks only when there is no alternative are the sensible ways in which Bangladesh can move towards a more sustainable use of its resources in the road sector.

Conclusions

It is difficult to understand why one of the poorest countries in the world tries to support and relentlessly enhance a road density far in excess of its neighbours when measured against the resources available for the task. This is especially the case when the environmental costs of this policy appear to be so high. The benefits claimed to result from this process can only be sustained by a very short-term view. If the demonstrable lack of sustainability of the resulting infrastructure is considered, allowance made for the permanent loss of land assets that many of the poorest incur due to road construction, and the destruction of the country's remaining forested areas taken into account then it seems likely that the conclusions would be substantially different.

Unsustainability, owing to lack of maintenance, makes large-scale road investment in many rural areas in Bangladesh a huge waste of resources accompanied by only a few measurable, but ephemeral benefits for the asset-rich population, whereas the asset-poor population are by-passed or suffer significant disbenefits. To an impoverished peasantry that walks, or whose vehicle ownership is confined to boats and bicycles, roads built for use by motor vehicles are almost irrelevant, especially when they have to be purchased at such a high personal cost.

Notes

1 It appears that after enthusiastically endorsing the study in 1991 the World Bank has also reassessed the results. In 1994 it commented that: "It is difficult…to verify whether the Bangladesh study took into account all possible intervening factors, such as unobserved differences among the communities in natural endowments" (World Bank, 1991a; 1994).

2 Generally considered to be households owning < 0.2 ha (0.5 acres) agricultural land. This provides food for a small household for about two months and makes sharecropping or employment obligatory.

3 Of these countries 12 achieved either zero loss or a net gain in forest area.

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Assessing the costs and benefits of cycle networks

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Non-motorized transport can make an important contribution to improving environmental quality and enhancing personal mobility. Too often bicycles are seen as a hindrance to other traffic and the planning and evaluation of transport proposals often focuses on this negative side and underplays the many indirect benefits. The costs that might accrue if cyclists were to transfer to motor vehicles is not assessed. Research in Pune, India demonstrates that the true benefits of a cycle network far outweigh the costs. Reviews recent approaches to bicycle planning in Europe and Asia, and examines in-depth the cycle network in Pune and assesses its costs and benefits. Analyses the process of evaluation which is used to obtain project funding and recommends an alternative approach to project appraisal.

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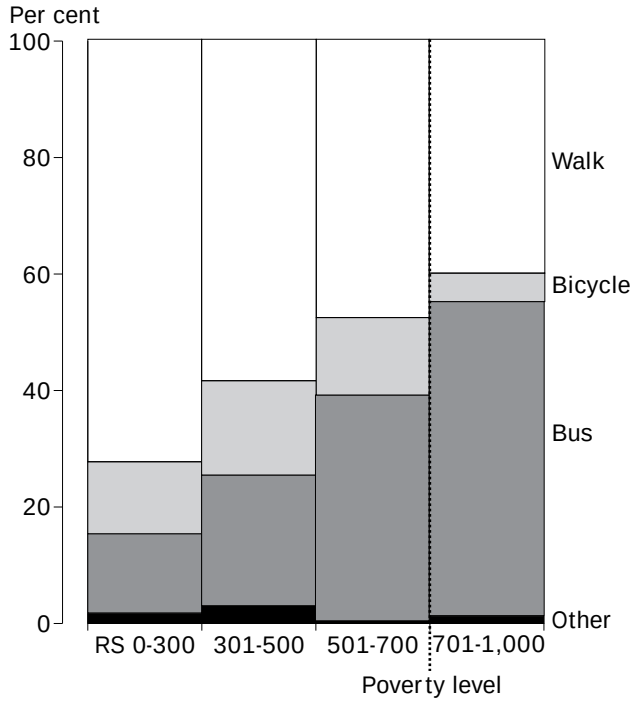
Introduction

There is growing acceptance that the headlong pursuit of personal motorization will neither improve mobility nor quality of life for the majority of the population in large cities. An alternative is to share investment between mass transit system and improving facilities for non-motorized transport. Yet both of these options face great difficulty in being accepted as sensible investments that produce a satisfactory rate of return. This is particularly strange in the case of non-motorized transport, as facilities can be cheap to implement and even cheaper to sustain. Why is it that this option is seldom implemented? This paper examines the costs and benefits of non-motorized travel and the evaluation techniques used. A case study in India is examined to clarify the benefits of non-motorized transport (NMT) and recommend an alternative approach to project appraisal.

In many developing countries the car is only available to a small, relatively wealthy section of the population. The remainder of the population rely on walking, cycling and public transport for the majority of their journeys. Research by the author into the travel behaviour of low-income households in New Delhi confirmed that the majority are dependent on walking or cycling for the journey to work (see Figure 1). The households studied represent over half the population of most large cities. Many more would like to cycle. Of bus passengers 86 per cent preferred the potential speed and low cost of cycling but were deterred by either the length of journey or fears over safety (Hathway and Dongre, 1989). Bicycles form a major component of the traffic on most roads. A Government of India study of 14 towns showed high cycle use (32-34 per cent) along many city corridors (Chandrasekhara, 1987). Detailed studies in Madras (MMDA, 1986) revealed that bicycles

Figure 1
Method of travel used by each income group



Source: Hathway and Dongre (1989)

Table I
Growth and composition of motor vehicles in India

	1980-81		1989-90	
Vehicles	**Number in 000s**	**Per cent**	**Number in 000s**	**per cent**
Two wheelers	2,528	49	10,823	65
Cars, jeeps, taxis	1,117	21	2,391	14
Buses	154	3	293	12
Goods vehicles	527	10	1,107	6
Others	874	17	2,086	13
Total	5,173	100	16,700	100

Source: CIRT (1992)

represented 40 per cent of traffic on many roads but in Pune it has been found that bicycles formed up to 59 per cent of the traffic composition during peak hours (Government of Maharashtra, 1981).

Cars and trucks form a small proportion of the total composition of vehicles in many developing countries. Even though they are increasing in number their growth is being overtaken by other forms of transport, noticeably motorized two-wheels. Table I illustrates how two wheelers have grown to represent 65 per cent of vehicles, whereas cars, jeeps and taxis have decreased their share to only 14 per cent. The bicycle industry is booming. Unconfirmed press reports suggest that bicycle ownership may have increased five-fold in ten years (*India Express*, 1993).

Despite this, demand for two-wheeled transport investment is being directed at highways for conventional motor vehicles. Experience suggests that the increased danger and intimidation experienced by riders of two-wheeled vehicles will gradually force them off the road. This will lead to more motor vehicles; congestion; environmental pollution; increased fuel consumption and further road building.

Provision for bicycles and non-motorized transport

The potential conflict between cyclists and other traffic has been studied by several researchers. There is agreement that separating the vulnerable bicycle from larger, faster-moving traffic is a valuable first step. Hillman (1990) claims that if cyclists were protected from traffic, it might release a pent-up demand for cycle use. Trevelyan and Morgan (1993) point to 21 examples in the UK, The Netherlands and Denmark where cyclists have been successfully accommodated on to other routes avoiding conflicts and accidents.

In addition to improved safety, the facilities must satisfy other needs to make it attractive to cyclists. Lester (1982) believes that it is important for cyclists to maintain a steady speed. Stopping, slowing and restarting is to be avoided. This implies a continuous rate and, as Hudson (1982) explains, for a route to be successful new cycle measures should not be introduced as a set of discreet proposals but rather as a comprehensive network providing links between various facilities. This need for comprehensive networks has been reinforced by McLintock (1992) and many others in recently published studies.

Some European towns have been investing in comprehensive networks for several years. In Copenhagen there was a dramatic drop in bicycle use when car traffic increased in the city between 1955-70. Since 1980 a network of cycle paths has been built on approach roads and within the narrow, older streets of the city centre. This has led to an increase in cycle traffic of 50 per cent over a five-year period (Rorbech, 1994). A recent EU conference identified 17 European cities where policies have been introduced to restrain motor vehicles and promote walking and cycling. For example Aachen is extending its network of 73km of cycle lanes. Bologna has built a 40 km cycle network and Granada is providing independent cycle routes to the city centre (Wijk and Bouma, 1994). It has been recognized within the EU that the unrestricted growth of motorized traffic cannot continue and that cycling provides an attractive low-cost alternative for short journeys.

A comprehensive review has been carried out on the provision of NMT facilities in Asia (Padeco, 1993) which identifies considerable potential for the bicycle, if appropriate measures are introduced. India has been reviewing the provision that it makes for bicycles. A report on Alternative Systems of Urban Transport by Chandrasekhara (1987) identifies three common mistakes:

1 cycle tracks alongside road without consideration of intersections.
2 network provided in low density areas where there is small demand.

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3 route stops in congested areas where provision becomes difficult.

It is emphasized that for a cycle network to be effective it must be comprehensive. One good example is noted in the study: the cycle network in Pune.

Pune and its traffic problems

Pune metropolitan area has a population of nearly 2 million inhabitants spread across an area of about 800 sq. km. It lies about 170 km from Bombay and has grown at the point where the main Bombay road and railway cross the Mula Mutha River. The old city is built to high density (690 ppha) on a network of narrow roads and lanes. The surrounding area is developed at a much lower density extending along the main arterial roads.

The predominant modes of travel in Pune are walking and cycling. These account for 77 per cent of all trips (see Table II). The most recent Transport Study for the Pune Area (CIRT, 1987) found that every household owned at least one bicycle. In addition, in excess of 50,000 cycles were available for hire within Pune. Traffic surveys indicate that bicycles form the majority of vehicular traffic both inside and outside the old city at both peak and off-peak times. It was also found that the average length of cycle trip was 4 km and the average cycle journey time was 19 mins (see Table III).

The main problem in Pune is the inability of the existing road and rail infrastructure to accommodate all users efficiently. The arterial roads attract an endless stream of heavy vehicles leaving cyclists and two wheelers to fight for limited road space with cars, buses and autorickshaws. The result is a high accident rate on the main highways with over 2,000 accidents in 1992 and at least five people killed every week. Congestion and low speeds are common in the city centre with some roads carrying eight times their design capacity. Most traffic travels at below 20 km ph and in the worst area, speeds drop to 5 km ph or less (*India Express*, 1993).

Table II
Method of travel

Mode	Between zones	Within zones	Overall
Walk	44	83	56
Bicycle	26	11	21
Bus and train	14	1	11
Autorickshaw	3	1	2
Motorcycle	10	3	8
Car	3	1	2

Source: Government of Maharashtra (1984)
Note: percentage by mode

Table III
Cycle journey length and time

Distance in kms	Percentage of trips	Time in minutes	Percentage of trips
Cycles on arterial roads			
1 to 4	69.00	1 to 20	66.94
5 to 8	20.63	21 to 40	23.25
9 to 12	07.26	41 to 60	07.00
13 to 16	02.42	61 to 80	02.31
Above 16	00.69	above 80	00.50
Average length:	4.85 km;	average time;	19.03 mins
Cycles within the city			
1 to 4	68.72	1 to 20	69.02
5 to 8	20.72	21 to 40	22.33
9 to 12	07.26	41 to 60	06.87
13 to 16	02.60	61 to 80	01.49
Above 16	00.70	above 80	00.29
Average length:	4.07 km;	average time;	17.84 mins

Source: Government of Maharashtra (1981)

The cycle network project

To overcome these problems the Traffic and Transport Cell of the Town Planning and Valuation Department of the Government of Maharashtra produced a study in 1981, recommending the segregation of two-wheeled vehicles from other traffic. This was to be achieved by:

- providing cycle tracks on main arterial roads.
- building cycle subways at dangerous crossings.
- creating a network of lanes in the old city for exclusive cycle use.
- constructing two new lightweight bridges across the river for pedestrians and cycles.

The project in total proposed 66 km of cycle track. 1.75 km is constructed as a completely new route whereas the remainder is achieved by adapting or widening existing roads. Implementation was proposed in three phases:

1 Phase 1 relieves congestion on existing roads by providing two new river crossings and a cycle track alongside the main Bombay highway.
2 Phase 2 provides a dedicated cycle network through the narrow roads and lands of the old city.
3 Phase 3 involves constructing additional cycletracks and subways on the other arterial highways leading into the city.

The first phase of work commenced in 1985 and was completed at the end of 1993. It concentrates on tackling those locations with the severest congestion and highest number of

Table IV
Use of new bridge (7am to 7pm)

	Pedestrians	Cycles	Two-wheelers
Towards city centre	1,428	2,371	2,970
From city centre	822	2,416	3,062
Total	2,310	4,787	6,032
Average per hour	192	399	502

Source: Pune Municipal Centre Corporation (1992)

accidents. Relief is provided for the existing congested river crossings by the construction of two new lightweight bridges. These provide a 2.4m footpath (8 ft) and a 3.6m carriageway (12 ft) in each direction. Special routes link the bridges to the main pedestrian and cycle network on either side of the river.

A cycle track of at least 3m width has been provided alongside the main Bombay highway. Serious accidents and congestion used to occur at two points on the highway where up to 4,000 cyclists crossed the busy main road at peak hours; to overcome this problem two ramped subways have been constructed under the highway to provide safe crossing points for two-wheeled vehicles. In addition the service road alongside an old storm water canal has been converted to a cycle path linking one of the major employment centres to the north west of Pune with the new river crossings.

The first bridge to open has proved very successful in attracting traffic away from the old congested bridge. Over 2,000 pedestrians and nearly 5,000 cycles use the bridge each day (see Table IV). Its success is proving somewhat counter productive as it also attracts motorized two-wheelers (6,000 per day) plus some three-wheel autorickshaws. It has recently been decided that now the second new bridge is finished, all cycles and two wheelers will be banned from using the old congested bridges.

To any casual observer the Pune network is a great success. Why is it not being applied elsewhere? The answer appears to be that the current methods of appraisal do not attach much value to the benefits achieved from this type of project.

Assessing costs and benefits

The conventional method of evaluating transport projects is to apply the technique of cost-benefit analysis. This approach has received much criticism. Whitelegg (1993) claims that the outcomes are rigged because of a cultural commitment to time saving. Atkins (1991) reporting on the COBA system adopted in the UK, explains that travel time is the overwhelming component in monetary evaluation representing an average 80 per cent of total scheme benefits. Banister (1994) identifies the difficulties of including social costs and demonstrating how conventional CBA techniques for London Victoria Lane predicted a loss of £2.14 million pa whereas by widening the appraisal this loss was transformed into a healthy rate of return of 11.3 per cent. Hook (1994) suggests that the lack of investment by Multi Lateral Development Banks into more sustainable modes of transport such as cycling, walking and public transport is because these projects are not seen to yield a sufficiently high normal rate of return. The Environmental benefits of non-motorized transport should increase the value of these projects but Wood (1993) agrees with many other researchers that environmental impacts cannot be reduced into a simple system of monetary measurement. As a consequence they are considered separately from the main financial equation.

A number of countries, e.g. France, The Netherlands and Italy, have largely abandoned the use of CBA but the major lending agencies still favour a project appraisal technique based on monetary units. A study by Rendel Planning (1992) involved a detailed review of monetary evaluation and other techniques. After extensive comparisons they concluded that an extended cost-benefit analysis approach should be adopted.

The Pune project demonstrates that it is possible to apply a modified cost-benefit approach but that many difficulties are raised in the process. The costs of the project are defined as:

- land and building acquisition costs;
- demolition and construction costs;
- maintenance costs.

The benefits that can be given a monetary value include:-

- savings in time;
- vehicle operation and fuel savings;
- reductions in accidents.

The additional benefits that are considered but not included within the monetary evaluation are:

- loss of amenity, heritage, ecological sites;
- noise;
- visual obstruction and intrusion;
- local air pollution;
- severance, impact on pedestrians and cyclists.

Further aspects which should be considered but are very difficult to quantify include:

- global environmental issues, climate change;
- displacement caused by construction and new infrastructure;

- induced trips resulting from changes to the transport network.

The costs and benefits of the Pune network

A delay of nearly ten years implementing the scheme has led to the costs of the first phase nearly doubling to US$ 2.3 million. Almost half of the construction and land acquisition costs were used for the two river bridges and their approach routes. The widening of the Bombay highway to provide the cycle track cost nearly US$ 0.5 million with the remaining money being used for cycle subways and ancillary works. The increased costs are largely due to rapid inflation which occurred during the pre-construction period. Delays were caused by difficulties in reaching agreement over the purchase of land. This has resulted in the first phase taking nearly as long to complete as was originally allocated for the entire project.

The benefits of the scheme are calculated in the conventional way. Time savings are achieved by both cyclists and motorists. Cycles using the new routes will slightly increase the length of journey (average per trip 0.02 km) but the journeys should be much quicker with an average saving in time of 1 minute 19 seconds per journey; in total this amounts to a saving of 8,400 person hours per day for inter-zonal trips.

The construction of a new bridge in Exeter shows even greater time savings with journey times being reduced by 40 per cent (Slinn and Cole, 1993). Owing to the removal of a large number of cycles from the main highways the speed of other vehicles will increase. The improvement in speed was estimated to be 5.12 kmph in the old city and 2.33 kmph for other routes, creating significant savings in time for motor vehicle occupants.

A major difficulty arises when attaching a price to the value of time saved. Most bicycle owners have very low incomes. If the cyclists' average income is used in the calculations the value attached to their time is relatively low; Chandrasekhara (1987) identifies the value of a cyclist's time as being worth one-tenth that of a car driver's time.

Savings in the running costs of bicycles will again be relatively small. The average annual cost of a bicycle in India including depreciation and parking is equivalent to 14 litres of fuel. The direct perceived costs by the owner for tyres, air and repairs is equivalent to 6 litres of fuel per year. Any significant monetary savings are achieved not by bicycles but by the improved average speeds and even running of motor vehicles. The most significant benefit is the saving in fuel which has been calculated as 9,600 litres per day.

Segregating cycles from motor vehicles should lead to a substantial improvement in safety. Accident statistics for Pune show that pedestrians, cyclists and riders of two-wheelers account for 85 per cent of all casualties (see Table V). Most of the fatal and serious accidents occur outside of the old city on the major arterial roads where heavy vehicles travel at relatively high speeds. Within the old city, travel speeds are much lower and most of the accidents are of a minor nature. It is estimated that 46 per cent of cycle trips will be diverted on to the new network leading to a substantial reduction in accidents.

A study of four towns in the UK which built continuous cycle routes into their town centres showed a significant reduction in the number of casualties on the main roads as large numbers of cyclists transferred to the new routes (Harland and Gercans, 1993). Shayler (1993) reports that new measures in Oxford have reduced bicycle accidents by one-quarter and led to a doubling of bicycle use. He also highlights the difficulty of placing a value on human life and suggests that the price of accidents (in the UK) should be increased four-fold to provide a truer indication of the real cost. Improved safety is a major contributor to attracting new cyclists on to segregated routes. Research in Sweden (Almquist and Hyden, 1994) suggests that it is the amount of conflict or number of near misses, rather than actual accidents which influence the riding of bicycles. The provision of safe segregated routes should release any suppressed demand for cycling.

Despite all these complications it is possible to apply best-fit figures in an attempt to value the Pune cycle network project. These suggest that the benefits from the scheme in

Table V
Accidents by different modes of travel in Pune

	Fatal		Serious		Total	
Mode	**No.**	**(%)**	**No.**	**(%)**	**No.**	**(%)**
Motor cycles / scooters	87	10.65	96	12.63	183	11.62
Autorickshaws / tempos	26	3.19	29	3.82	55	3.49
Cars / taxis	49	6.02	22	2.89	71	4.51
Trucks / buses	48	5.90	30	3.95	78	4.96
Pedestrians	312	38.33	268	35.26	580	36.86
Cycles	274	33.66	304	40.00	578	36.72
Bullock carts	18	2.21	11	1.45	29	1.84

Source: Government of Maharashtra (1981)

one year, are equivalent to one-fifth of the total cost.

In addition, significant environmental improvements can be demonstrated by encouraging the use of non-motorized transport. The environmental damage from NMT is negligible compared with that of motor vehicles. If international standards are to be met and harmful local effects avoided, the growth of motor vehicles must be restrained.

It is clear that cyclists and pedestrians will benefit enormously from travelling on routes away from traffic where there is less noise, clean air and a much improved environment. However, major difficulties are faced when trying to place a price on environmental impacts. The value can vary significantly from country to country. For instance, Denmark uses a price for noise units that is six times greater than that used in Norway. Air pollution in Sweden is given a value ten times greater than in Denmark (Rendel Planning, 1992). Quinet (1993) identifies that there can be significant differences in the price a person is prepared to pay for change as approved to their willingness to accept change. While it may be possible to resolve these variations and agree a standard price for local environmental effects, it is far more difficult to quantify and cost global damage. One of the key problems is assessing how future generations will value the environment and as Jacobs (1991) states "sustainability rests on an implicit rejection of discounting" whereas with the cost benefit analysis, discounting is central to the technique. A recent UK Government report (SACTRA, 1992) sums up the difficulties by stating, "It is clear that for the foreseeable future, and quite possibly in perpetuity, it will not be possible to value all elements of environmental costs and benefits in monetary terms". With the weight of evidence against extending the cost benefit approach to provide a comprehensive appraisal it is worth reviewing how NMT projects can be given a fair evaluation.

Difficulties with project appraisal

Apart from the difficulties encountered in assessing the individual costs and benefits there are added complications with the process as a whole. This is caused by:

- aggregation of values;
- changing conditions;
- displacement effects.

Aggregation of values

The trouble with the traditional assessment method is that it combines different values to provide a single simple answer. For example the value of 3,600 people each saving one second on a journey is given the same weight as one person saving one hour. Important determining factors can become lost. For instance, should the same value be attached to the travel time of a school teacher as a school pupil? It is helpful when taking decisions to understand how these individual values are aggregated. Improvements to the transport network in Pune will effect different groups of people in different ways. An example of a more explicit analytical framework is illustrated in Table VI. This framework enables a clear distinction to be made of the benefits to different types of traveller. It illustrates how a particular proposal might benefit low-income travellers at the expense of, for instance, long distance freight traffic. It also allows different values for journey time to be attached to each category of traveller. All of the individual values can still be aggregated to give an overall sum of benefits if required. The number of travellers in each category can be calculated and (if politically acceptable) different weights could be applied to each category of traveller).

This framework approach could be extended to include activities affected by the proposal, e.g. street traders or property values. Environmental issues could be treated in a similar way but agreeing the value of environmental factors causes much debate and needs to be the subject of a separate paper.

Table VI
Appraisal framework categories

Travellers	No.	(%)	Value	Type of transport
Low income				Walk, cycle, bus, mass transit
Mid-income				Scooter, motor cycle, autorickshaw, taxi
High income				Car
Local service				Deliveries, waste collection
Emergency				Fire, police, medical
National economy				Long distance freight

Changing conditions

A further disadvantage of the traditional appraisal is that it often fails to recalculate benefits over time. An initial snapshot of benefits is provided while changes in the direct costs of construction are carefully monitored. In Pune construction costs have risen substantially reducing the apparent cost/benefit ratio. However by re-examining just one element of the equation, i.e. the price of petrol, it can be demonstrated that benefits have risen faster than costs. The original study was based on a fuel price of RS 5.70 per litre. In 1993, this had risen to RS 18.25 per litre. If this price increase was applied to the original trip attractions (ignoring the recent growth in cycles and two-wheelers) the additional saving in the cost of fuel would amount to RS 288 lakh per year (1 million US dollars at 1993 exchange rates). Therefore the savings incurred on fuel alone almost balance the increased costs of construction and land acquisition.

Another factor which is difficult to predict at the outset of the study is the growth in vehicles. Cycle ownership has risen dramatically since the scheme was first planned and the use of two wheelers has also grown dramatically. This rapid rise in the use of cycles and two-wheelers has resulted in a corresponding growth in accidents. The number of minor accidents has more than doubled in Pune in the last six years (*India Express*, 1993). Is there any way in which these changes could have been accurately predicted?

Displacement effects

It is now commonly accepted that the provision of a new road generates additional traffic to fill the space available. The construction of the M25 orbital motorway around London has attracted traffic volumes 50-100 per cent greater than anticipated (SACTRA, 1994). It is conceivable that similar new trips are attracted to cycle networks. European cities have shown an increase in cycle use of up to 80 per cent following the introduction of new cycle facilities (Eir, 1994).

Traffic conditions on the main Pune highways appear unchanged. It is not clear whether this is because cyclists continue to use their old routes along the main roads while new cyclists use the new network or if additional motorized traffic has filled up the space left by some of the bicycles. If foreseen, this additional space could possibly have been used as bus lanes. The result is that traffic speeds have not increased, which brings into question the benefits to motorists from time savings.

A further aspect of displacement which needs to be assessed is the effect of relocating traders or residents as a result of road widening and construction activity. A recent study in Thailand (Immers and Biyl, 1993) found that the additional costs encountered by some of the people forced to relocate were dramatic, with rents rising by nearly 40 per cent and travel costs increasing seven fold. Overall they identify total displacement costs as:

- moving costs;
- loss of business;
- increased housing costs;
- increased travel costs;
- loss of employment income.

Conclusions

A review of the literature and my own experience of monitoring the design and implementation of NMT projects suggest that cost-benefit analysis does not favour these schemes. The major advantages of investing in NMT, i.e. the lack of environmental damage and social disruption, are difficult to quantify in monetary units. In addition the prices attached to NMT benefits that can be measured in monetary units are given much lower values than those applied to conventional highway schemes.

If current methods of appraisal are to continue in use, the only equitable method of analysis is to consider all travellers as potential highway (car or bus) users. Projections can be made of the number of NMT travellers who would transfer to the highway by using cars, buses or motorcycles and those who would travel by rail or off-road systems. An assessment of the cost of building the new highway infrastructure to accommodate the previous NMT travellers would provide an accurate indication of the value of not building NMT facilities. This technique could be developed to include projections of traffic over a 30-year period together with the social and environmental costs resulting from the scheme. Decisions could then be made on the basis of either widening the highway to accept the additional motorized traffic, or constructing new facilities for non-motorized transport.

The recommended approach would be simple to calculate and applicable in different countries and locations. Easily quantifiable costs will allow direct comparisons to be made between options. It is therefore suggested that future NMT projects should be assessed by comparing the direct cost of the NMT facilities with the cost of enlarging the highway network to accommodate those NMT travellers in motorized vehicles.

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