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ORIGIN AND DESTINATION/ VEHICLE TRAFFIC COUNT SURVEY IN CENTRAL MOZAMBIQUE

FINAL REPO

Submitted by:

AFRICON ENGINEERING IN

in association w

STANLEY CONSULTA

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LIST OF ABBREVIATIONS

USAID	- United States Agency for International Development
DNEP	- National Directorate for Roads and Bridges
RAP	- Rural Access Project
NGO	- Non-government Organisation
O-D	- Origin and Destination
AADT	- Average Annual Daily Traffic
VOCs	- Vehicle Operating Costs
EMME/2	- Multimodal transportation software programme
US$	- United States Dollar

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- Transport Operator Associations of Beira and Nampula, as well as all other operators who supplied information

EXECUTIVE SUMMARY

1. INTRODUCTION

This assignment materialised due to the fact that there is a missing link in the main South-North highway of Mozambique, between the Beira corridor and the Zambezi River (the study area). While a "sand" road does exist between Dondo (near Beira) and Caia (on the Zambezi River), it is in a poor condition and is virtually impassable during the rainy season. In addition to this, there is a road in the west of the study area, between the Beira corridor and Tete. However, it is considered too remote for a central Mozambique link between the north and the south of the country.

At present, the United States Agency for International Development (USAID) is assisting the National Directorate of Roads and Bridges (DNEP) in improving the road conditions in certain areas of Mozambique. USAID therefore appointed Africon Engineering International and Stanley Consultants to:

- Determine existing vehicle movements between central and northern Mozambique
- Project future vehicle movement between central and northern Mozambique
- Recommend the preferred routing between the Beira corridor and the Zambezi River, based on an economic cost-benefit analysis and
- Determine the appropriate level of improvement, or construction for the highway.

2. METHODOLOGY

To fulfill these objectives, it was necessary to first assess the volume and nature of the traffic through central Mozambique. Vehicle surveys were consequently performed at five survey locations in the study area, while transport operators were interviewed at their premises in five cities in Mozambique, Zimbabwe and Malawi. Demographic and economic data were gathered from USAID and DNEP, as well as from other organisations and Government departments.

With this information available, it was possible to forecast future vehicle movements and to assess the relative costs and benefits of alternative routes. This process culminated in the identification of

the most appropriate routing for the proposed road link. State-of-the-art software was used to compile a transportation model of the study area, to simulate the existing road network in the study area, and to analyse the impact of alternative road links.

3. DESCRIPTION OF THE TRANSPORTATION NETWORK

Two South-North routes exist through the study area, namely Bandula-Tete (in the west) and Dondo-Caia (in the east). The Bandula-Tete route is in a good condition, but is viewed as a detour, as it does not lead directly to northern Mozambique. The road between Dondo and Caia passes through very sandy terrain and is in a poor condition. In the dry season, the 180 km trip between Dondo and Caia normally takes approximately seven hours, but during the rainy season, it takes much longer. Portions of a third South-North route through the study area also exist, namely Inchope-Gorongosa-Caia . This route was planned many years ago, but was never completed.

There are only three points at which to cross the Zambezi River in Mozambique:

- Just north of Tete
- The ferry at Caia
- The bridge linking Vila de Sena and Mutarara.

The crossing at Tete does not lead directly to northern Mozambique. The existing ferry at Caia can only accommodate one articulated vehicle and two non-articulated vehicles at a time. It is also rather unreliable, as it is often out of order. Further problems relate to the fact that the river embankment is not protected in any way and is very steep on the northern side, as well as the existence of a large sandbank close to the southern bank of the Zambezi which prevents the ferry from crossing the river when the water level is low. The bridge at Sena was initially a railway bridge which was damaged during the war. In rehabilitating the bridge, it was converted to carry vehicular traffic only. It is a few kilometres long and can only accommodate traffic in one direction at a time.

Despite the existing poor condition of the road network through the study area, road transport is still the major mode for transporting goods between southern and northern Mozambique. Long distance road transport experiences very little competition from the rail or sea modes of transport. The lack of competition from rail transport is due to the fact that the railway routes which are at present in operation, are generally in an east-west direction. The routes which would strongly compete with road transport through the study area are Beira-Sena-Tete and Beira-Sena-Vila Nova da Fronteira. However, these lines are now unserviceable, as large sections of the line between Dondo and Caia were totally destroyed during the period of civil unrest in the country. Sea transport relies heavily on good administration of the ports. The reason why road transport is not experiencing competition from shipping is generally the poor administration and management of the ports.

4. FINDINGS

Existing traffic patterns indicate that the major traffic flows in the study area occur along the Beira corridor, and that a second, but smaller demand exists between Zimbabwe and Malawi/Northern Mozambique (the Tete corridor). However, the important item to emerge from the vehicle surveys is the fact that there is a much larger demand for regional traffic flow between Beira and Malawi (approximately 40 vehicles per day), than a national demand between southern and northern Mozambique (approximately 15 vehicles per day).

Three alternative routes between the Beira corridor and the Zambezi River were analysed namely:

- Dondo-Caia
- Inchope-Vila de Sena
- Inchope-Caia.

For the second and third alternatives, two possible routes exist just north of Gorongosa, either east or west around the Gorongosa mountain. While the eastern routing is more environmentally sensitive, it is shorter than the western routing. However, for the purposes of this analysis, only the eastern route around the mountain was considered.

As it is very difficult to predict the pace of future economic development in the country or even in Sofala province, it was decided to make projections for the year 2010, i.e. approximately 15 years from now. The projections provided estimated traffic flows in future, that were than allocated to the network for analysis.

The major findings of the study were that:

- The first-order estimated costs of implementing the Dondo-Caia alternative is approximately similar to the Inchope-Caia alternative, and significantly less than the Inchope-Vila de Sena alternative. The extent and condition of existing infrastructure on the Inchope-Caia route could have the impact of lowering the cost of this alternative.
- None of the alternatives have significantly lower vehicle operating costs than any of the others. This is mainly due to the low traffic volumes, now and in future, on the existing and planned road network, excluding of course the Beira and Tete corridors.
- There is no significant traffic flow through the area where the three alternatives are located, nor any evidence that the construction of any of the alternatives would attract a significant number of vehicles if constructed.

These findings were augmented by a first order, unweighted application of factors considered relevant and that could influence the decision. From this evaluation matrix, based on nine criteria, it is evident that the Dondo-Caia alternative and the Inchope-Caia alternative obtained a fairly similar ranking. The key finding is therefore that cost is the determining factor, and should be investigated in more detail.

5. RECOMMENDATION

From the data collected and the subsequent analysis thereof, our conclusion is that either the Dondo-Caia route or the Inchope-Caia route can be upgraded to a paved, two-lane road. This selection should be based on a detailed cost investigation of the two routes. Our recommendation is that the route with the subsequent lowest cost be upgraded.

RESUMO EXECUTIVO

1. INTRODUÇÃO

Este projecto nasceu devido ao facto de existir uma falta de ligação rodoviária na principal estrada nacional Sul-Norte em Moçambique entre o corridor da Beira e o Rio Zambeze (a area do estudo conduzido). Não obstante a existência de uma estrada rudimentar entre Dondo e Caia, esta mesma encontra-se em estado pobre rodoviário e durante a época das chuvas intransitável. Existe ainda uma estrada situada a oeste da area do estudo entre o corridor da Beira e Tete. Esta última é num entanto afastada demais do eixo central entre o norte e sul do país.

A Agência Internacional Para o Desenvolvimento (USAID) encontra-se a prestar assistência a Direcção Nacional de Estradas e Pontes (DNEP) no que diz respeito a reabilitação das estradas em certas regiões de Moçambique. A USAID por sua vez nomeou a Africon Engineering International juntamente com os Consultores Stanley para:

- Determinação do volume veicular entre a região central e o norte de Moçambique
- Projecção de futuros volumes de movimento veicular entre a região central e o norte de Moçambique
- Recomendar a rota de preferência entre o corridor da Beira e o Rio Zambeze, baseado numa análise económica do custo benéfico
- Determinação do nível de reabilitação ou construção da estrada nacional.

2. METODOLOGIA

Para fims de execução dos objectivos aqui mencionados foi necessário em primeiro lugar avaliar o volume e tipo de tráfico que se conduz pela região central de Moçambique. Estudos do tráfico veicular foram conduzidos em cinco localizações da area do estudo. Empresas transportadoras foram entrevistadas, dentro das cinco principais cidades de Moçambique, Zimbabwe e Malawi. Dados económicos e demográficos foram recolhidos da USAID e a DNEP, bem como de outras agências e departamentos governamentais.

Com esta informação, foi possível projectar volumes futuros veiculares bem como avaliar os custos relativos e benéficos de vias alternativas. Este processo culminou com a identificação da rota mais própria e eficiente para a estrada que virá servir de ligação entre o corridor da Beira e o Rio Zambeze. Métodos tecnológicamente avançados foram utilizados na compilação de um modelo de transportação referente a area do estudo. Isto para criar uma simulação da rede existente das estradas na area do estudo e para analisar o impacto de vias de ligação alternativas.

3. DESCRIÇÃO DA REDE DE TRANSPORTAÇÃO

Existem duas rotas Sul-Norte na area do estudo, nomeadamente, Bandula-Tete (no oeste) e Dondo-Tete (no este). A rota de Bandula-Tete encontra-se em bom estado rodoviário. Esta rota é, num entanto, um desvio tendo em conta que não ofereçe uma rota directa ao norte de Moçambique.

A estrada enter Dondo e Caia atravessa um trajecto muito arenoso e não se encontra em bom estado rodoviário. Na época seca o trajecto Dondo-Caia (180 Km) leva aproximadamente sete horas de viagem. Na época das chuvas o período de viagem é muito mais longo. Existem ainda partes de uma terceira rota Sul-Norte dentro da area do estudo, nomeadamente, Inchope-Gorongosa-Caia. Esta rota foi planeada em anos anteriores mas não foi completada.

Existem três pontos de travessia sobre o Rio Zambeze em Moçambique:

- Norte de Tete
- Barco de travessia em Caia
- Ponte de ligação entre Vila Do Sena o Mutarara.

A travessia em Tete não oferece acesso directo ao norte de Moçambique. O barco de travessia existente em Caia só tem espaço para acomodar um veiculo articulado e dois não articulados. Existe ainda a incerteza da operação diária do barco em si que muitas das vezes encontra-se avariado. Existe também problemas relativos a represa do rio que não é protegida e é muito precipícia na parte norte, bem como a existência de vastos depósitos de areia próximos da margem sul do Rio Zambeze que impede que o barco possa atravessar o rio quando o nível da água encontra-se baixo. A ponte em Sena, inicialmente uma ponte para caminhos-de-ferro, foi alvo da guerra civil do passado. Na ocasião da sua reabilitação a ponte foi convertida para transportação veicular. Devido a estrutura da ponte esta não tem espaço para que o tráfico possa transitar simultaneamente em direcções opostas.

Não obstante o pobre estado rodoviário da rede de estradas na area do estudo, transportação via estradas continua a ser a modalidade preferida para a transportação de mercadorias entre o sul e o norte de Moçambique. Transportação de mercadoria por via-férrea ou marítima é mínima em comparação. Pelo conseguinte os níveis de competição entre as varias modalidades de transportação são muito baixos. A falta de competição da via-férrea é derivado ao facto das linhas presentemente operacionais serem de este-oeste. Rotas potencialmente competitivas por via-férrea na area do estudo são as de Beira-Sena-Tete e Beira-Sena-Vila Nova da Fronteira. De momento estas rotas encontram-se num estado intransitável devido a destruição ocasionada pela guerra civil do passado. Quanto a transportação por rotas marítimas estas requerem uma rede de administração eficaz dos portos marítimos. Ineficácia neste sector é a principal razão ao qual este tipo de transportação não é mais competitivo.

4. CONCLUSÕES

O panorama do tráfico existente na area do estudo indica que os volumes maiores de tráfico são no Corridor da Beira e em seguida entre o Zimbabwe e Malawi-Norte de Moçambique (Corridor de Tete). Uma conclusão surpreendente do estudo foi a maior procura de tráfico na região entre a Beira e Malawi, (aproximadamente 40 veículos por dia), muito mais de que própriamente a exigência nacional entre o sul e o norte de Moçambique, (aproximadamente 15 veículos por dia).

Foram analisadas três rotas alternativas entre o Corridor da Beira e o Rio Zambeze, nomeadamente:

- Dondo-Caia
- Inchope-Vila de Sena
- Inchope-Caia

Quanto a segunda e terceira alternativas acima mencionadas existem duas rotas possíveis a norte de Gorongosa, este ou oeste da montanha de Gorongosa. Enquanto a rota do este é mais sensível devido ou impacto ao meio-ambiente, esta é num entanto mais curta do que a rota projectada no oeste. Para fims do estudo só foi analisada a rota do este.

É naturalmente muito difícil de predizer o passo do futuro desenvolvimento económico do país ou da província de Sofala. Foi num entanto decido projectar desenvolvimento económico até o ano 2010. Estas projecções deram estimativas que foram analisadas de volumes do tráfico no futuro.

As principais conclusões do estudo:

- Custos, de primeira ordem, estimativos na implementação da via alternativa Dondo-Caia são aproximadamente semelhantes aos da via alternativa Inchope-Caia e significamente menos do que a via alternativa Inchope-Vila de Sena. A infra-estrutura existente, da via Inchope-Caia, pode num entanto ter o impacto de reduzir o custo desta via alternativa.

- Nenhuma das alternativas tem níveis significantes de diferença nos custos operativos veiculares. Isto é em maior parte devido ao volume baixo de tráfico presente na rede de estrada existente, como também planeado para o futuro, excluindo naturalmente os corridores da Beira e Tete.

- Não existe presentemente volumes significativos de tráfico nas areas de localização das alternativas nem provas substantivas que levam a conclusão que construção de qualquer das alternativas atrairá um numero significativo de veículos.

Estas conclusões foram confirmadas por factores de igual relevância que tiveram um factor influente nas decisões por fim concluídas. Por intermédio desta matriz de avaliação, baseado em nove critérios, é evidente que as alternativas de Dondo-Caia e Inchope-Caia obtiveram um "ranking" quase igual. A conclusão definitiva é que a questão de custos é o factor determinante, e pelo conseguinte precisa de ser investigado em maior pormenor.

5. RECOMENDAÇÃO

Pelos dados recolhidos e subsequente análise a nossa conclusão é que uma ou outra das rotas Dondo-Caia e Inchope-Caia podem ser reabilitadas para uma estrada de duas faixas com pavimento asfáltico. A decisão de qual rota a selecionar para este efeito será baseada numa investigação pormenorizada e individual dos custos associados. A nossa recomendação, após esta investigação, é que a rota com os custos mais baixos seja reabilitada.

CHAPTER 1

AIMS AND GOALS

1.1 INTRODUCTION

The United States Agency for International Development (USAID) is assisting the National Directorate of Roads and Bridges (DNEP) in improving the road conditions in certain areas of Mozambique. This action is taking place through the Rural Access Project (RAP) which aims to contribute to the overall reconstruction of the transportation sector in Mozambique. The purpose is to reopen farming areas and reduce the cost of transportation in those areas.

The RAP is a US$53,0 million, seven-year long activity to rehabilitate approximately 1 000 kilometres of rural roads in Central Mozambique to an all-weather standard. Inadequate transportation and the poor condition of the existing road system prevent commodities from reaching the market place. The RAP's purpose is therefore to increase transportation efficiency and capacity in central Mozambique, while the goal of this assignment was ultimately to increase rural household incomes and decrease transportation costs.

1.2 THE BRIEF

At present, there is a missing link in the main South-North highway of Mozambique, between the Beira corridor and the Zambezi River. Under RAP, a roadway between Inchope in the south (situated midway between Beira and the Zimbabwe border) and Caia in the north (situated on the Zambezi River) is tentatively planned for improvement to an all-weather standard. Although planned many years ago, this road was never completed. While a "sand" road does exist between Dondo (near Beira) and Caia, it is in a poor condition and is virtually impassable during the rainy season.

The above mentioned Inchope-Caia and Dondo-Caia routes are merely two possible options that could be considered for upgrading, to complete the South-North road link. USAID therefore appointed Africon Engineering International and Stanley Consultants to:

- Determine existing vehicle movements between central and northern Mozambique
- Project future vehicle movement between central and northern Mozambique

- Recommend the preferred routing between the Beira corridor and the Zambezi River, based on an economic cost-benefit analysis; and
- Determine the appropriate level of improvement, or construction, for this proposed south-north link through central Mozambique.

A map showing the study area is included on the next page as Figure 1.1.

Besides the above-mentioned Inchope-Caia and Dondo-Caia routes, the Chimoio-Tete route also exists, to the west of the study area. However, to reach northern Mozambique via this route, one would need to travel through Malawi. This assignment is focussed rather on the missing link in the highway to northern Mozambique to the east of Malawi, i.e. through the Zambezia province.

A map portraying the geographic area of the study in more detail has been attached as Annexure A. The following items are indicated on the map:

- The defined cordon area (or screen line) which delimits the roads and routes which may be affected by the proposed Beira Corridor - Zambezi link, and which therefore forms the target area of the study;

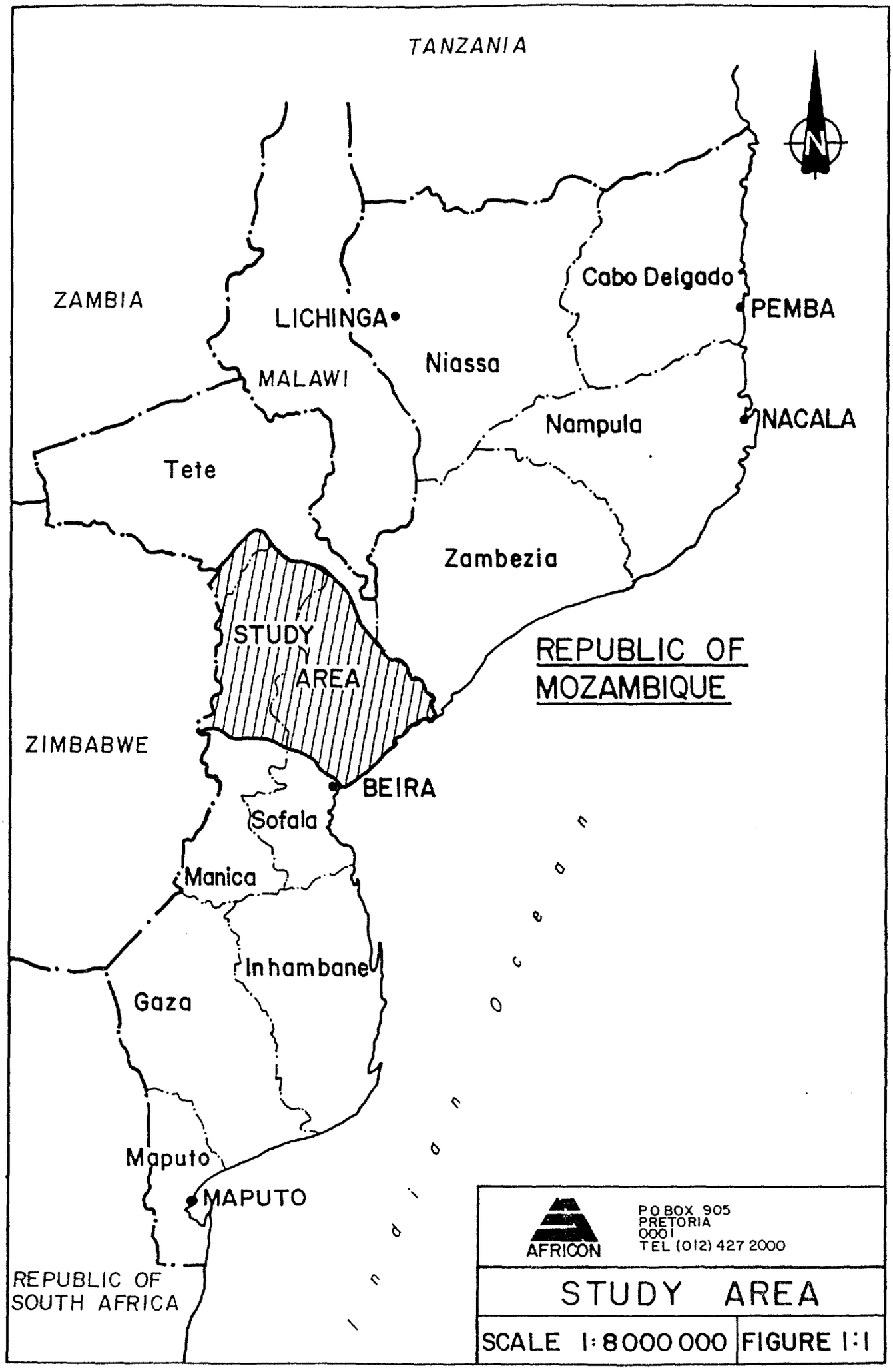
- Numbered route sections (or links). There are two type of route links - those marked with an "A" code representing existing links, and those marked "B" which represent proposed links; and

- Further items shown on the map will be discussed as they are introduced, later in the report.

1.3 PROJECT PLAN

1.3.1 INTRODUCTION

Through the RAP, the Government of Mozambique's National Poverty Reduction Strategy and donor road initiatives under the World Bank's ROCS-2 project, various initiatives are under way to secure access to regions in Mozambique that have traditionally been isolated due to, among other, a lack of transport infrastructure. These programmes have a broad socio-economic (human development)


TANZANIA
ZAMBIA
LICHINGA
MALAWI
Niassa
Cabo Delgado
PEMBA
NACALA
Nampula
Tete
Zambezia
STUDY AREA
REPUBLIC OF MOZAMBIQUE
ZIMBABWE
BEIRA
Sofala
Manica
Inhambane
Gaza
Maputo
MAPUTO
REPUBLIC OF SOUTH AFRICA
Indian Ocean
N
AFRICON
P O BOX 905
PRETORIA
0001
TEL (012) 427 2000
STUDY AREA
SCALE 1:8 000 000
FIGURE 1:1

goal, i.e. to encourage and facilitate economic activity and a concomitant increase in personal income.

Ideally, the programmes should foster both local and regional benefits. Locally, economic growth is foreseen to come mostly from increased agricultural output at first, but should multiply into other areas of economic activity so that there will be an increase in off-farm income over time. The larger regional impact will materialize through linking areas which have previously been alienated (i.e. create traffic through-flow advantages).

1.3.2 ACTIVITIES

There are three major components to this assignment. The first refers to assessing the volume and nature of traffic through Central Mozambique. This task entailed doing surveys of traffic volumes, vehicle types, traffic nature, origin-destination, operating cost and route preference at major junctures on the South-North road network (within the study area). A separate but complimentary activity was a survey of commercial and private vehicle operators to establish mainly operating costs and route preferences.

The operators' surveys link closely with the second and third components of the brief, namely forecasting future vehicle movements and assessing the relative costs and benefits of alternative routes. The operators' surveys gave an indication of how the existing users may expand or adapt their travel patterns for new and alternative routes. Since at least a part of the cost-benefit analysis will have to quantify the relative benefits for them, the operating and other expenses they furnish will be crucial. There will be a similar linkage between the traffic forecast and cost-benefit analyses.

The three components culminate in answering the broad objectives of the assignment, namely to identify the most appropriate routing of the proposed road link and to specify the required level of service of the road.

To fulfill these objectives, the assignment was broken down into five distinct but interrelated activities:

- Activity 1 : Vehicle Surveys
    - Origin and destination surveys

- Traffic counts and axle masses.

- Activity 2 : Operators' Surveys

- Activity 3 : Forecasts of Vehicle Movements

- Activity 4 : Cost-benefit Analyses of Alternative Road Links and

- Activity 5 : Assessment of Best Route and Service Level.

The above mentioned activities are concerned solely with transportation related matters. However, there are also broader socio-economic goals under which this assignment resorts. They relate to household surveys to measure items such as rural household incomes and off-farm incomes. These surveys did not form part of this appointment, but are to be carried out by others, as well as the later measuring of these items for comparison purposes, once the proposed road has been completed.

One of the tools used to assist in the analysis of alternative road links, was the compilation of a transportation model using state-of-the-art software to "model" the existing transport conditions in the study area. This became extremely useful when determining the number of vehicles that will use each of the tested upgrading options.

1.3.3 OVERVIEW OF THE PROGRAMME

The assignment was carried out over a six month period, from 1 August 1996 to 31 January 1997. The detailed Study Programme has been attached as Annexure B.

The programme shows that Activity 1 - the Vehicle Surveys - was the most time consuming of all the activities. The planning and implementation of these surveys took up 16 weeks (almost 4 months) of the 6 month assignment period.

Operators' Surveys took place concurrently with the Vehicle Surveys, in order to save time and also to allow sufficient time for the processing and analyzing of all the data.

1.4 REPORT LAYOUT

The report is structured in the following way:

- This first chapter sketches the background to the assignment, presents the brief and introduces the programme.

- The second chapter describes the methodology followed in the various activities making up the assignment.

- The findings resulting from the various analyses are elaborated upon in chapter three.

- Chapter four provides our recommendations with regard to the most appropriate routing, the required level of service, the construction required as well as further work envisaged.

The following information is contained in the annexures:

- Annexure A : Area Map
- Annexure B : Study Programme
- Annexure C : Origin and Destination Survey Questionnaire
- Annexure D : Operators' Survey questionnaire
- Annexure E : Photographic Record
- Annexure F : List of Operators who supplied information

CHAPTER 2

METHODOLOGY

This chapter sets out the methodology followed by the project team in implementing the various activities making up this assignment.

2.1 INTRODUCTION

The assignment can be broken down into two separate elements, namely the Functional and the Administrative elements.

2.1.1 FUNCTIONAL METHODOLOGY

This refers to the functional approach undertaken in executing the assignment. It consisted of a number of surveys and data collection exercises, followed by analyses of the gathered data, the development of scenarios and a cost/benefit analysis. The functional methodology is described in more detail in Section 2.2

2.1.2 ADMINISTRATIVE METHODOLOGY

The administrative methodology related to the way in which the project was administered and how client liaison was maintained. It commenced with two meetings with the client in Maputo, followed by telephonic and e-mail liaison and monthly Progress Reports. The administrative methodology is further described in Section 2.10.

2.2 APPROACH REQUIRED BY AND NEGOTIATED WITH THE CLIENT

The first requirement of the brief entailed the determination of existing vehicle movements between central and northern Mozambique. In order to achieve this, a specialist origin and destination (O-D) surveyor was sent to the field for twelve weeks to carry out vehicle surveys at five separate locations around the study area. Five field surveyors were recruited locally to accompany him for the full survey period. The vehicle surveys are elaborated upon in Section 2.5.

While the vehicle surveys were taking place, a representative survey of transport operators was conducted in five other locations - three in Mozambique, one in Zimbabwe and one in Malawi. The Operators' Surveys are described in Section 2.6.

In the meantime, various items of information were requested and, where available, were received from both USAID and DNEP and these are set out in Section 2.4. A number of other organisations and Government Departments were also approached for assistance in this regard.

Once the field work had been completed, the existing traffic conditions were created on a computer model. Thereafter, three different future traffic scenarios (realistic, optimistic and pessimistic) were developed, in order to forecast future vehicle movement between central and northern Mozambique. The method employed in traffic forecasting is presented in Section 2.7.

For each of the possible routes between the Beira corridor and the Zambezi River, an assessment of the relative costs and benefits, under the different traffic scenarios, were undertaken (i.e. a cost/benefit analysis). The cost-benefit analysis is introduced in Section 2.8.

The above process culminated in this report which weighs up all the elements of the study and considers the vehicle forecasting and the cost/benefit analysis. Furthermore, it recommends the best possible routing for a rehabilitated, or new South-North highway, and also discusses the appropriate level of improvement, or construction, required.

2.3 INFORMATION REQUESTED AND RECEIVED FROM THE CLIENT

2.3.1 INFORMATION REQUESTED

A list of information requirements were presented during the initial meeting with the client in August 1996. The information required was broken down into two main categories, namely transportation data and demographic/economic data.

Transportation data requirements related to:

- Route plans, basic planning and route specifications
- Historic traffic information per route

- Basic geographic information per route

Demographic/economic data related to:

- Demographic/census information per route
- Economic/production information per route
- Imports/Exports to area north of the Zambezi River
- Imports/Exports to area south of the Beira - Mutare road
- Economic and other development plans for the target area.

DNEP was approached to provide information regarding the transportation data requirements, while discussions were held with USAID as well as various Government Departments regarding the remainder of the information required.

2.3.2 INFORMATION RECEIVED

Where available, information was gladly passed on to the study team to be used on this assignment. However, due to the period of civil unrest and the accompanying decay of infrastructure and institutions, there is very little systematic information available.

For example, vehicle traffic statistics have only been compiled comprehensively since 1995. What was available, was obtained from DNEP. Various items of useful information were also received from USAID and other Government Departments. Amongst others, estimates and forecasts of provincial populations for the period 1990 to 2000 were obtained from the National Directorate of Statistics - Department of Demography. They also managed to supply national forecasts to the year 2000, based on birth and mortality rates.

2.4 ROUTE NETWORK

2.4.1 INTRODUCTION

At present, there are two routes through central Mozambique, between the Beira corridor and the Zambezi River (the study area), namely Dondo-Caia (in the east) and Bandula-Tete (in the west).

However, the Dondo-Caia route is in a poor condition and is virtually impassable during the rainy season.

The only route to the south of the study area, within the borders of Mozambique, connects to the Beira corridor at Inchope. An alternative route to the south is to drive through Zimbabwe. To the north of the study area (i.e. to the north of the Zambezi River), however, there are a number of routes which transporters of goods could follow to reach northern Mozambique.

2.4.2 CORDON AREA

One of the initial tasks was to define a cordon line around the study area. In order to gather the required information for this assignment, it was necessary to define the cordon area in such a way that all vehicles travelling between southern and northern Mozambique would pass through it. If chosen too big, irrelevant and unusable information would be accumulated. The cordon area finally chosen for this assignment is shown on the Area Map (Annexure A). From the map one can see that all routes through central Mozambique were included within the cordon area.

2.4.3 ENTRY AND EXIT POINTS

In order to determine the number of vehicles passing through central Mozambique, it was necessary to count the number of vehicles passing through the cordon line, on each link being cut by this line. However, by carefully choosing the vehicle survey locations, it was not necessary to carry out surveys on every road link being cut by the cordon line.

For example, one survey location at Changara would capture all vehicles travelling to, or from, northern Mozambique via:

- Zimbabwe and passing through the border post just west of Changara
- Zimbabwe and passing through the border post just west of Manica and
- Inchope and Bandula.

2.4.4 IN/OUTFLOW VERSUS THROUGHFLOW TRAFFIC

The explanation regarding the route network has thus far referred only to throughflow traffic, moving between southern and northern Mozambique. These traffic movements are referred to as external-external trips. They originate "external" to the cordon area and also end somewhere "external" to the cordon area. (For example, a trip undertaken from Maputo to Nampula).

A second class of traffic is found to pass over the cordon line and into the cordon area. However, these trips do not pass out of the other side of the cordon area. They terminate at destinations within the cordon area and are referred to as external-internal trips (e.g. Maputo to Mutarara). Two further classes of traffic movements are also encountered, namely internal-external trips (e.g. Beira to Nampula) and internal-internal trips (e.g. Beira to Mutarara).

2.5 VEHICLE SURVEYS

2.5.1 INFORMATION SOUGHT

Vehicle surveys are carried out to determine the existing traffic volumes making use of a section of the road infrastructure. These volumes need to be further broken down into vehicle types, the nature of the traffic, the type and volume of goods transported, the origin and destination of trips, as well as their route preference at major junctures on the road network. Three types of vehicle surveys were undertaken, namely:

- Origin and Destination Surveys
- Traffic Counts
- Axle Mass measurements.

(A separate exercise entailed the surveying of vehicle operators to establish mainly operating costs and route preferences, and this exercise is described in Section 2.6 of this chapter).

2.5.2 METHODOLOGY

Manual surveys and counts were only carried out during the day, as it is both dangerous and expensive to survey manually after dark. However, where possible, electronic equipment was utilised to provide 24 hour vehicle counts.

This assignment provided an ideal opportunity to employ, empower and train local Mozambicans in the art of carrying out vehicle surveys. It was therefore viewed as an important capacity building exercise.

2.5.2.1 Origin and Destination Surveys

These surveys were carried out using a questionnaire prepared in both English and Portuguese, and administered by local field surveyors who attended training sessions prior to the official start of the surveys. The questionnaire was explained to them in detail to ensure that the form would be filled in correctly. On a continuous basis, the specialist O-D surveyor, confirmed the consistency of the data obtained.

With the assistance of the local Police all vehicles passing each of the survey locations were stopped, and the driver of the vehicle was interviewed. (See Photograph Number 1 in Annexure E). The team of field surveyors moved from location to location and spent approximately two weeks at each survey location. (Normally one week at each survey location should be sufficient. However, due to poor existing infrastructure and long travel times, our experience has shown that one week is too short a period for such surveys in the central Mozambique environment. Typically, two weeks are required to capture established travel patterns.)

The supervision of this exercise was carried out by our specialist O-D Surveyor. A copy of the questionnaire used for the O-D Survey is presented in Annexure C.

2.5.2.2 Traffic Counts

The vehicle survey locations were always situated at an intersection on the road network, and O-D surveys were carried out on one leg of the intersection. In order to determine the volume of traffic on the other legs of the intersection, manual counts were undertaken. One member of the survey team would physically count each vehicle passing a predetermined point, and classify the vehicle as either light or heavy. Where the condition of the road surface allowed, electronic equipment was utilised (making use of loops in the road) to provide 24 hour vehicle counts. (See Photograph Number 2 in Annexure E).

2.5.2.3 Axle Mass measurements

The initial intention was to set up weigh-in-motion pads at each survey location. (See Photographs Numbered 3 and 4 in Annexure E). Unfortunately, the road surface in certain areas was of such a poor quality, that this was not possible. In these instances, manual weighing was undertaken, making use of static weigh-pads. Furthermore, the static weight of heavy vehicles was also obtained from permits obtained by each vehicle driver at a Government controlled weigh-bridge along their route.

2.5.3 SELECTION OF SURVEY LOCATIONS

Prior to the commencement of this assignment, it was agreed that 5 survey locations, if properly selected along the main transport routes, would be sufficient to establish the main transport movements within the study area. Initially, the 5 locations selected were Dondo, Inchope, Changara, Vila Nova da Fronteira and Caia. The reasons for their preliminary selection were as follows:

- Dondo is ideally located to survey vehicles traveling to and from Beira (an important port in Mozambique) and also all the vehicles presently using the railway service road that links Dondo to Caia. This is a most suitable location for O-D surveys and vehicle counts to be carried out.
- Surveys at Inchope would strengthen the information concerning traffic moving towards Beira (from both southern Mozambique and Zimbabwe) as well as account for the traffic moving north from Maputo and moving westwards towards Chimoio. This is also a suitable location for surveys to be carried out.
- Surveys at Changara account for traffic entering Mozambique from Zimbabwe and continuing north towards Tete or south towards Beira. It also takes account of the traffic moving along the South-North corridor that use route 102. It is possible that some of this traffic may divert to the proposed new route once it has been constructed.
- Villa Nova da Fronteira is the border post between Malawi and Mozambique. Surveys at this location would be useful to establish the amount of traffic either entering or exiting Mozambique via this route. This traffic would impact directly on the South-North link should it be built.

- Caia is the link to both Beira and Quelimane, and with these being important ports, this survey location would be used to survey traffic moving either north or south within Mozambique.

However, in subsequent discussions with USAID, it was agreed firstly, to substitute the survey location at Vila Nova da Fronteira with one at Mutarara. (Mutarara is situated on the eastern side of the bridge across the Zambezi River, near Vila de Sena.) Any vehicles traveling to Malawi from the south, via Vila Nova da Fronteira, would necessarily be surveyed at Mutarara.

Secondly, the proposed survey location at Caia, was substituted with one at Nicuadala. The reasoning behind this change was that vehicles crossing the Zambezi River at Caia, would either be surveyed at Dondo or Nicuadala. Nicuadala would also serve as a location to survey vehicles traveling to/from northern Mozambique, which might divert off the main Caia-Nicuadala road.

The final selection of 5 vehicle survey locations was therefore as follows:

- Dondo
- Inchope
- Changara
- Mutarara
- Nicuadala.

These 5 locations are shown on the Area Map, which is attached as Annexure A to this report.

2.5.4 VEHICLE SURVEY PROGRAMME

As explained in Section 2.5.2.1, it was agreed that approximately two weeks would be spent at each of the 5 survey locations. However, due to the low vehicle counts at Inchope, it was decided, in consultation with USAID, to spend only 10 days there. Taking the time for preparation, surveying, travelling and data capturing into account, the vehicle surveys were carried out over a period of 16 weeks. The final programme for the vehicle surveys is reflected in Table 2.1, where all dates refer to 1996. (The table does not show travelling time, etc.).

TABLE 2.1 : VEHICLE SURVEY PROGRAMME

Starting Date	Finishing Date	Action
29 August	11 September	Survey at Dondo
14 September	23 September	Survey at Inchope
26 September	9 October	Survey at Changara
12 October	25 October	Survey at Mutarara
28 October	10 November	Survey at Nicuadala

2.5.5 DATA ANALYSIS

All the information contained in the O-D questionnaires, as well as the results from the traffic counts, were captured on a computer database. A separate spreadsheet was created for each of the five survey locations and transport modes, in order to identify the correct vehicle and trip characteristics.

2.5.5.1 Data clean-up

Most of the information contained in the O-D questionnaires was coded, prior to the surveys taking place. This enabled the data capturing process to proceed efficiently. During the data capturing process, attention was given to checking the data for any illogical or erroneous answers which the field surveyors may have marked down on the questionnaires. However, very few errors were detected.

2.5.5.2 Vehicle categories

For the purpose of calculating separate matrices for light and heavy vehicles and determining their travelling routes, O-D surveys and traffic count data was sorted into three vehicle categories:

- light vehicles (including passenger cars and light delivery vehicles)
- heavy vehicles and
- buses.

However, due to relatively high volumes on certain roads (e.g. the Beira corridor), the field surveyors were not always able to classify the vehicles according to all three categories. It was consequently decided to report traffic volumes only as light or heavy.

The values in the matrices for light and heavy vehicles are intrazonal as well as interzonal.

2.5.5.3 Summarizing the data

The outputs obtained from O-D surveys and traffic counts were the following:

- average daily trip matrices for each vehicle category
- total vehicle trip matrix
- travelling speed and times
- routes used by light and heavy vehicles
- road characteristics.

2.5.5.4 Trip matrices

In order to create the trip matrices, potential origin and destination points were determined before the surveys commenced. The initial set of origins/destinations included 21 locations, representing neighbouring countries and towns in Mozambique, external to the study area, as well as all major towns inside the study area. During the field survey period, more origins and destinations were added to the list, as drivers of vehicles stated where their trips had commenced and where they were heading.

The next step was to determine traffic zones, which could include one or more of the initially specified origin/destination locations. It was found that most of the traffic zones which comprise more than one O-D location are located outside of the study area and represent external zones. That is because the roads which cross the boundary of the study area are usually used by vehicles going to, or coming from, several origins/destinations. This process resulted in the matrix becoming smaller and more manageable.

2.5.5.5 Scaling the trip matrices

Transportation models are usually developed to provide daily (24 hours), or peak hour (morning or afternoon) matrices. The decision as to which to use, is made by taking various factors into consideration, e.g. the size of the study area, the traffic volumes generated each day, traffic patterns, etc.

In this particular case, the matrices contained trips made between 7am and 5 pm, over a two week period. Due to the extremely low volumes of traffic travelling in and around the study area, it was decided to calculate matrices representing average annual daily traffic (AADT). Consequently, certain formulas needed to be applied to the existing 10 hour a day, two-week long, light and heavy vehicle matrices, to obtain an annual average daily figure, allowing also for seasonal fluctuations. The formulas, and the accompanying factors, were obtained from a June 1996 Sweroad report prepared for DNEP, entitled "Traffic Counting System - User Manual - Data entry processing and analysis reporting".

2.5.5.6 Verification of counts

The final AADT for each route in the study area, resulting from the O-D surveys and traffic counts of this assignment, were verified with the AADT from a Sweco report of traffic counts for 1995 in the same area.

2.6 OPERATORS' SURVEYS

2.6.1 INFORMATION SOUGHT

Operators' surveys entailed liaison with transport operators (both freight transport and public transport) to establish the status quo, as well as future plans, for their operations. The results of these surveys would enable us to gain an overall insight into the prospective demand for a year-round South-North road link through central Mozambique.

More specifically, the purpose of the operators' surveys was:

- to provide a basis for the verification of the O-D/Traffic Count and Vehicle Mass Surveys, especially regarding traffic volumes, vehicle types and cargoes on the different routes

- to calculate vehicle operating costs (VOCs) for vehicles traveling through the cordon area and

- to contribute to the estimate of potential traffic types and volumes on the proposed route.

Furthermore, items specifically requested by the client were also obtained. These referred to sources of purchase (e.g. fuel and tyres) and driving characteristics.

2.6.2 METHODOLOGY

The first step entailed discussions with the Road Freight Association of South Africa and their correspondent organisations throughout Southern Africa, as well as the Freight Forwarders Association of Southern Africa, to identify specific transport operators who might transport goods through the study area.
Thereafter, each identified operator was contacted telephonically, or by telefax, to determine whether they did, in fact, travel through the study area. During this step, more names of operators were added to the list, who were in turn contacted.

The final step in gathering information was to visit the operators in person, in five separate locations and to interview them, using the questionnaire presented in Annexure D. A total of 29 operators were surveyed in this study, although many more operators in Southern Africa were interviewed telephonically to determine whether they were active in the study area or not. A list of all operators contacted is presented in Annexure F.

2.6.3 LOCATION CRITERIA AND SELECTION

As expected, there are essentially two types of heavy vehicle operators who pass through the catchment area. Small, localised operators were found *ad hoc* on the routes, but the potential of their crossing through the catchment area is relatively restricted. Larger, more formally structured transport operators that travel extensively through the study area, were found in the bigger centra. They operate to some extent on a pre-planned schedule, have fixed contracts with freight companies and have more orderly book-keeping procedures and records.

The operators' surveys were geared towards the larger operators, as our experience has shown that the small operators are both difficult to locate and the information obtained from them is less reliable. The choice of survey locations was therefore geared towards the larger towns and cities.

Once again, it was agreed that surveys at five well selected locations would be sufficient to cover the study area. Initially, discussions revolved around selecting five of the following nine towns:

- In Mozambique:
  - Maputo
  - Beira
  - Milange
  - Vila Nova da Fronteira
  - Mutarara
  - Nampula

- In Zimbabwe
  - Harare
  - Mutare
- In Malawi
  - Blantyre

However, as it was deemed important for the operator survey locations to be chosen for their role as transport nodes, and not merely transit or thoroughfare points, the following five locations were finally decided upon:

- Maputo
- Beira
- Nampula
- Harare
- Blantyre.

2.6.4 OPERATORS' SURVEY PROGRAMME

The planning for the operators' surveys, as well as the implementation of the surveys themselves, took place concurrently with the vehicle surveys. The detailed programme for the operators' surveys is presented in Table 2.2 (where all dates refer to 1996).

TABLE 2.2 : OPERATORS' SURVEY PROGRAMME

Starting Date	Finishing Date	Location
28 October	1 November	Maputo
20 October	23 October	Beira
24 October	26 October	Nampula
21 October	24 October	Harare
28 October	30 October	Blantyre

2.6.5 DATA ANALYSIS

All information received through interviews with transport operators was captured from the questionnaires into a computer database. Where information was clearly not realistic, it was excluded from future calculations.

The outputs from the analysis of operators' survey data is the following:

- Vehicle operating costs
- Trip information
- Cargo information and
- Any special driving circumstances.

For an explanation regarding vehicle operating costs, see Sections 2.8 and 3.4

2.7 TRAFFIC FORECAST

This section presents the study team's approach to forecasting traffic demand in the study area.

2.7.1 THE NEED FOR A TRAFFIC FORECAST

Generally, a traffic demand forecast is required for two main reasons:

- to plan a road with adequate carrying capacity and design standards
- to serve as an input to calculating the costs and benefits associated with a road over time.

In the case of this study, the importance of a forecast is somewhat diminished for two reasons. Firstly, current traffic volumes are extremely low and are likely to continue being so for some time. This implies that a design standard which optimises the trade-off between construction (or rehabilitation) costs of a road and its maintenance costs over time, will in all likelihood exceed the design level required by the projected traffic. Also, traffic volumes are unlikely to reach the capacity limits of the road network in the study area, which would, under normal circumstances, be an important reason for traffic to reallocate over the network. Secondly, for the same reason, low projected traffic volumes are unlikely to justify the design on economic grounds.

2.7.2 IMPORTANT FUNCTIONAL RELATIONSHIPS IN TRAFFIC FORECAST

There are a number of key variables which should be taken into account when modeling or forecasting traffic. It is expected that general trends in the economy will be reflected in traffic volumes - e.g. the amount of production and income and the volume of goods that need to be moved. Since much of transport is private, or passenger related, it is expected that demographic trends (especially the size and geographic distribution of the population) should impact on traffic patterns. Here, vehicle ownership and the size of the vehicle fleet would be used as explanatory variables in the forecast. Often, all these developments are integrally tied up to societal factors such as political stability (although this is not easy to model).

The sophistication of the forecast model used and the manner in which relationships are determined are mostly dependent on the quality of the data available to model with.

2.7.3 CONSTRAINTS IMPACTING ON THE FORECAST

The traffic forecast for this study has been constrained by two key factors, namely structural changes in Mozambique and a general shortage of information.

2.7.3.1 Changing environment

Several structural changes have taken place in Mozambique, the most important of which was the period of civil unrest and the accompanying decay of infrastructure and institutions. Reconstruction of facilities and societal and administrative infrastructure has only commenced relatively recently. These changes argue that large growth should be expected for some time (a structural adjustment) which will level off after a certain time. Such a trend is expected especially in those areas greatly

affected by the war and the accompanying migration. Growth should occur at a more 'normal' rate in areas less affected.

2.7.3.2 Lack of information

Accompanying the breakdown of administrative structures and procedures, there is a dire shortage of systematic information on items which would ideally be required to base a traffic forecast on. A list of required information was included in the Inception Report of the study, but few of the items were obtainable. The lack of information was confirmed by the study team during visits to Mozambique.
For purposes of a traffic forecast, the only reliable information which was readily obtainable was demographic statistics (although not at the required disaggregated level). Apart from macro-economic statistics at national level, economic information was largely qualitative (anecdotal), and also slightly dated (up to 1993). Vehicle traffic statistics have only been compiled comprehensively since relatively recently (1995), which implies that trend information was not available. Origin-destination traffic statistics were not available either, which discounted the use of gravity-type models to predict future traffic. In general, information was not available as time series data, which made extrapolation and modeling of trends very difficult.

2.7.4 THE FORECAST APPROACH

It is expected that the proposed link between the Beira Corridor and the Zambezi River will cater for and encourage local transport demand, but ultimately, its main function will be to serve as a link between the South and North of the country and is accordingly of national importance. It is therefore expected that the traffic volumes in the study area will reflect to a large extent the average traffic growth pattern over Mozambique as a whole, which argues strongly to base the traffic forecast on national, rather than regional trends.

Given the constraints on the forecast, it was assumed that the main driving forces behind traffic growth are population growth and growth in economic activity. Population growth would explain demand for passenger transport services, and economic growth the movement of goods.

The outcome of the above-mentioned approach is presented in Section 3.3 and summarised in Table 3.5.

2.8 VEHICLE OPERATING COSTS

2.8.1 BACKGROUND

Vehicle operating costs (VOCs) refer to the costs incurred by vehicles and drivers associated with their travelling on alternative roads. The differing characteristics of one road vs. another leads to relative vehicle operating advantages and accordingly to the preference of one route over another. Apart from external benefits of building a road (e.g. employment opportunities and increased access to transport), the major component of benefits associated with a particular road are related to the savings in VOCs for the total traffic using that road.

In principle, VOCs are related to two factors - road characteristics and vehicle characteristics. Road characteristics refer to the surface type, the riding quality (roughness), and road geometry (slope, curvature and super elevation/camber). Vehicle characteristics include the type of vehicle, engine capacity, load, age and fuel consumption. Driver characteristics may also be a contributing factor to vehicle characteristics. Although these factors are interrelated (i.e. road and vehicle qualities influence each other), vehicle characteristics are normally assumed to be fixed so that VOCs can only be improved by changing the quality of the road.

VOCs are divided into two categories - direct and indirect VOCs. Direct vehicle operating costs refer to the day-to-day expenses of running a vehicle and are normally related to the vehicle's operating conditions (including the roads on which it travels).

The following items make up the direct VOCs:

- fuel consumption
- consumption of oil and lubricants
- tyre wear
- parts, maintenance and labour
- crew costs (including the driver and any assistants) and
- time costs (of passengers, but also cargo handling times).

Indirect VOCs are constituted, among other, by:

- depreciation

- insurance
- financing and financial (e.g. taxes) costs and
- overheads.

The direct VOCs are also the variable costs of operating a vehicle and change as the operating environment changes, while the indirect VOCs are mostly fixed costs which do not change substantially with the operating environment.

2.8.2 THE STUDY APPROACH TO VOCs

VOCs may be calculated on the basis of a functional model based on the engineering relationships between road quality and vehicle characteristics. Such an approach requires detailed inputs on road and vehicle characteristics for which the scope of the study did not allow. In this study, an alternative (aggregate) approach was followed with VOCs determined by means of surveying vehicle operators' stated costs of using alternative types of roads. I.e., a survey was conducted in which operators indicated the perceived size of the various direct VOC components over time, which were then related to the distances travelled over the same period.

The study focussed on direct, and not total VOCs. Indirect VOCs (which make up the difference) will only change on a large scale when the operator's route network changes drastically, implying that it should remain relatively constant over time (and therefore not be reflected as a cost or benefit associated with a new route). Also, the indirect VOC component of expenses differs substantially according to the size of the vehicle operator, his route network and vehicle fleet composition (the vehicle operator survey located operators with fleets of up to 170 vehicles and up to seven vehicle types).

Accordingly, the following process was followed to calculate the direct VOCs:

2.8.2.1 Vehicle type

Operators were asked to distinguish between each type of vehicle in their fleet in the cases where they had more than one type or one vehicle. In the eventual calculation of VOCs, two vehicle types were distinguished - light (4 wheeled vehicles) and heavy (6 wheels and more).

2.8.2.2 Road type

Operators were asked to distinguish between the rates of use of inputs (e.g. fuel) for good and bad roads. Good roads refer to all-weather riding quality (usually a sealed, i.e. paved road), while bad roads refer to roads subject to inclement weather (usually unsealed i.e. gravel or earth roads). Apart from the impact different roads have on vehicle wear and tear, the distinction between road types should also account for costs associated with different speeds.

In many cases, operators found it difficult to distinguish between rates of use on different road types since they are accustomed to a specific mix of road conditions in their operations network. This non-distinction led to a relatively small differential in the VOCs for good and bad roads.

2.8.2.3 Cost items

Rates of usage were surveyed for the following cost items and expressed as a rate per kilometer, per type of road and per vehicle type:

- fuel consumption
- consumption of lubricants
- tyre wear
- maintenance (parts)and
- maintenance (labour).

2.8.2.4 Time value

Time values per kilometer and per vehicle type were computed for the vehicle crew (driver, assistants and other crew) on the basis of average vehicle and crew utilisation rates, and crew remuneration as reported by the operators.

Due to the likely different profiles of passengers in light vehicles (more affluent), it was assumed that the time value for these passengers is the same as for the driver. In the case of heavy vehicles, passengers' time value was assumed to be one third of the drivers'.

2.8.2.5 Exchange rates

All reported costs were converted into US dollars at the effective exchange rates as reported by the operators.

2.8.2.6 Unit costs

All cost items were expressed as a cost per kilometre in US dollars. The individual cost items were aggregated to obtain total direct VOCs. The results of this exercise are summarised in Table 3.8.

2.8.2.7 Good Road vs Bad Road VOCs

The VOCs calculated differentiate between good roads and bad roads. The underlying philosophy here is that certain expenditures per kilometre increase as roads deteriorate (especially time value as the trips then take longer), while others increase as roads improve (most notably fuel expenditure as the price per kilometre increases at higher speeds).

2.9 TRANSPORTATION DEMAND MODEL

2.9.1 THEORY

Model building is a very useful, and usually an essential, part of the transportation planning process. The term "model" is used to describe both simple mathematical relationships and complementary linked systems of relationships, such as the transportation planning process.

The full transportation model is very complex. It attempts to describe the travel patterns of large numbers of people, using a series of the following linked sub-models:

- trip generation, which models a person's decision to make a trip
- trip distribution - models a person's selection of a destination
- modal split - models a person's selection of a transport mode
- assignment - models a person's route choice.

Depending on the size and complexity of the study area, each of these submodels can be further subdivided in order to develop a fully representative model of transport conditions.

One of the most important steps in model building, is a choice of parameters and statistics which should be chosen to represent typical homogeneous or average groups of people, land use, traffic patterns, etc. Their choice determines the size, scope and detail of the survey required to obtain information.

Models can be used to predict future transport conditions based on the forecasting of future population and economic growth. Various different transport facilities, infrastructure and policies can be tested by repeated use of a model.

2.9.2 CENTRAL MOZAMBIQUE TRANSPORTATION MODEL

The transportation model for the study area was developed to aid the planning of transportation infrastructure upgrading in this region.

Considering the very low level of development in the study area from both the transportation and the economic perspective, it was not necessary to build and analyze all the main submodels (trip generation, distribution, modal split and assignment), separately. It was clear that most of the elements required to develop the model could be derived directly from O-D surveys, interviews of transport operators' and traffic counts.

In order to develop the model, the following elements were required as input:

- The road network
- O-D matrices
- Flow delay functions.

The model was developed on the EMME/2 transportation software programme. EMME/2 is an interactive-graphic state-of-the-art multimodal transportation planning system. It offers a complete and comprehensive set of tools for demand modeling, multimodal network modeling and analysis and for the implementation of evaluation procedures. It is suitable for modeling on the metropolitan and provincial levels.

2.9.2.1 Road network

The road system, in the computer model, is defined by a series of links and nodes. A link is defined as a length of a road network which has the same physical characteristics, constant alignment and no major intersections. The links are bounded by nodes, which are defined as the point at which a link terminates.

Nodes usually represent a junction at the intersection of two roads. Other locations where nodes are defined, could be points where a road changes its characteristics, e.g. from two lanes to one lane per direction, or where the road alignment is changed.

Another element of the road network which is identified and numbered is a zone centroid. This represents the point of origin or destination of all trips generated by, or attracted to, that zone. It is located at the centre of gravity of all trips from that zone. The centroid is connected to the network at selected nodes.

Road links are classified according to the road hierarchy and the condition of the roads belonging to the same hierarchical level. Special classifications are determined for the portions of the road network heavily influenced by natural constraints, e.g. river crossings.

2.9.2.2 Flow delay functions

Flow delay functions are mathematical functions that are used to determine the travel time on a link. Each road link type (classified by road hierarchy and condition) has a certain free flow time and capacity per lane. In the present study, flow delay functions were typically used to model the time spent in travelling along certain roads which are at present in a very poor condition. Time penalties were added to model the crossings of the Zambezi River, by means of the ferry at Caia and by the one-directional bridge at Sena

2.9.3 ASSIGNMENTS

The purpose of the assignment stage of the transport model is to simulate route choice. The assignment of vehicle trips on the road network results in estimates of traffic flows along each link of the network. This process can be used in the following transportation tasks:

- to determine deficiencies in the transport system, both now and in the future
- to aid in developing a future transport system and network
- to test the effects of changes or additions to the system
- to provide estimates of link and vehicle flows
- to prioritize infrastructure improvements
- to provide feedback to the planning process.

The input required for the assignment process is a matrix of trip demand between traffic zones, road network and flow delay functions. The demand trips are assigned to the road network according to applicable assignment techniques. The generalized cost assignment technique was used in this model, enabling one to model time-flow relationships, as well as physical costs or time penalties associated with infrastructural elements, such as the ferry at Caia, or the one-directional bridge at Sena.

Light and heavy vehicles were assigned separately on the same road network, because of the differences in vehicle and trip characteristics between transport modes, as well as different costs affecting their trips.

2.10 COST-BENEFIT ANALYSIS

2.10.1 THEORY

The aim of developing a transport model is not just to predict the future traffic flows, but also to influence and assist in making a desicion of which alternative policies would be preferred, or which transport project should be implemented. For that purpose, the results of different plans and projects need to be evaluated and compared to the possible consequences thereof. To decide whether the proposed plan or project is justified is not easy, as there are many factors, not only economic factors, which need to be considered.

The basic principle of the cost-benefit analysis is to compare the expected benefits with the initial cost of implementing the project. The standard procedure is to express the annual benefits of a project as some fraction, or rate of return on the initial costs.

In detail evaluations, factors which need to be included in calculating initial costs are construction costs, land costs and delays during construction. On the other hand, factors like transport user

benefits, changes in accident and maintenance costs and indirect economic benefits should be included in benefit calculations.

2.10.2 METHODOLOGY

2.10.2.1 Evaluating existing vehicle operating costs

Vehicle operating costs are expressed in a rate per kilometre, as described in a previous section. Using a calibrated transport model, the daily trip matrix of each vehicle category is assigned to the road network, separately, in order to determine vehicle volumes on the road links. VOC rates are applied to the number of vehicles on each link and to the length of that link, resulting in the total daily operating costs of light and heavy vehicles in the study area.

2.10.2.2 Evaluating future costs assuming no improvements on the road network

The same procedure is used as in the first step. However, instead of assigning base year trip matrices, future daily trip matrices, obtained by applying growth factors, are assigned to the existing road network. In this step it is assumed that there will not be any improvements to the road network. It is therefore clear that total operating costs will be higher due to the increase in vehicle demand, and consequently higher vehicle volumes on the road links.

2.10.2.3 Implementing alternatives and calculating costs

In this step, one of the road planning projects (alternatives) is applied to the existing road network within the transport model. Usually, it is either an improvement of the existing road thereby increasing the capacity and speed, or by adding a completely new road. Construction or improvement costs are also expressed in rates per kilometer, which are applied to the length of improved or built road section, to obtain total implementation costs.

2.10.2.4 Evaluating future vehicle operating costs on an improved road network

Future daily trip matrices are now assigned to the improved road network for each alternative upgrading option, and the same calculation procedure as in previous steps is performed to obtain daily operating costs with improved network conditions.

2.10.2.5 Comparing vehicle operating costs before and after project implementation

VOCs, before and after project implementation, are compared. It is expected that VOCs, calculated after road network improvements, will be lower. In other words, network improvements should produce some economic benefits.

However, it is possible that certain improvements to the road network will attract certain vehicles into making trips of a longer distance, but shorter in time. In that instance, benefits are dependent on the relationship of time cost rates to the cost rates of the other factors involved in the total calculation of the VOCs.

2.10.2.6 Comparing benefits to the implementation costs

It is usual that benefits are calculated on an annual level and compared to the implementation costs. However, it was expected from the outset that for this assignment the cost of upgrading the road network would outweigh the benefits to transport operators by such a large degree, that a cost-benefit analysis would possibly not justify the upgrading procedure. The main reason for this is the very low traffic volumes on the roads in the study area.

2.10.2.7 Repeating necessary steps for each proposed project

For each of the proposed projects (alternatives), the previous steps are repeated.

2.10.2.8 Summarising costs and benefits for all proposed projects

Finally, all tested alternatives are summarised and prioritised according to the calculated benefits. It should be pointed out, however, that a cost-benefit analyses is only one factor which will influence the final decision.

2.11 PROJECT ADMINISTRATION

This section of the report briefly describes how the project was administered, and how continuous liaison with the client took place.

2.11.1 CLIENT LIAISON

Early in August 1996, the contract was signed in Maputo, and a preliminary survey design and work plan was presented to USAID. Two weeks later, a draft Inception Report was presented to both USAID and DNEP, in Maputo. During this visit the need for demographic and economic information was discussed with USAID. Various members of the DNEP Planning Division were also consulted regarding existing DNEP procedures for similar work, and to review existing traffic count and O-D survey data.

Thereafter, for the duration of the contract period, USAID was contacted regularly by telephone and e-mail. Continuous liaison also took place by means of a monthly Progress Report.

2.11.2 REPORTS

2.11.2.1 Inception Report

The first deliverable from this study was the draft Inception Report which contained the following:

- Draft survey design and work plan
- Detailed study programme
- Proposed vehicle survey locations
- Proposed operators' survey locations
- Proposed O-D survey questionnaire
- Proposed operators' survey questionnaire and
- Area map.

Once approved by USAID and DNEP, the Inception Report was finalised.

2.11.2.2 Progress Reports

Brief monthly Progress Reports were submitted to USAID, who undertook to pass them on to DNEP. The purpose of these monthly reports was to brief the client on progress being made, problems encountered, and adherence to the study programme.

CHAPTER 3

FINDINGS

This chapter presents the findings of the various activities which were described in the previous chapter. It consists of the following:

- a description of the *status quo* of the study area
- the existing levels of traffic in the region
- the traffic forecast that was presented
- a discussion and presentation of the vehicle operating costs
- the definition of alternative routes to be considered
- the traffic analysis of the alternative routes
- the cost-benefit analysis of the alternative routes
- a summary evaluation of alternatives.

3.1 STATUS QUO/BACKGROUND DESCRIPTION

3.1.1 INTRODUCTION

The study area is situated in the centre of Mozambique and comprises much of the Sofala province, a large part of Manica and some districts of Tete and Zambezia Provinces. The second largest city of the country, Beira, is situated on the Indian Ocean Coast. It forms the centre of commercial, industrial and transport activities within the study area, as well as being a major population concentration. Various smaller settlements are found in the region, especially along the Beira corridor. It is important to note that much of the study area was directly affected by the period of civil unrest. The area was accordingly characterised by relatively large migration - both to the cities (Beira) as well as to neighbouring provinces.

The following sections briefly present the main geographic, climatic, economic and demographic characteristics of the area.

3.1.2 GEOGRAPHY AND CLIMATE

The eastern part of the study area (the districts of Marromeu, Cheringoma, Muanza and Dondo) consists of a flat, sandy plain, characterised by open forest. To the west, the topography becomes more hilly, with the Gorongosa mountain (in the north-west of the district with the same name) being the outstanding natural feature. Here, vegetation is mostly mixed forest and savannah.

The eastern and western parts of the study area are separated by a water divide which runs roughly along a line that connects Caia to Dondo. The three main rivers forming the divide are the Pungue, the Mucombeze and the Zangue.

Sofala province is characterised by a tropical and sub-humid climate for most of the year, largely due to the stabilising influence of the Mozambique current. Manica has a tropical and rainy climate, with dry periods during winter.

3.1.3 ECONOMIC FEATURES

Economic activity in the study area is largely agriculture-based. Most agricultural activity prior to 1975 was conducted on private landholdings, with a small contribution by family-based smallholdings. Large-scale farming was directed at cotton, maize, sunflowers, beans and sugar cane. Family holdings produced mainly corn, rice, beans, cotton and peanuts.

Today, subsistence farming is distributed over Sofala province as follows:

- Gorongosa used to be the major area of maize production, but this has shifted towards Nhamatanda due to the period of civil unrest
- rice is produced mainly from Beira to the Mandruze valley near Dondo, and in pockets in the Marromeu district
- 'mapira' is cultivated along the Zambezi River
- 'mandioc' is produced in the Beira-Dondo area. Both mapira and mandioc are largely produced by subsistence farmers
- Nhamatanda and Gorongosa are the major areas where beans are cultivated, although not in great quantities
- sweet potatoes and vegetables are grown from Beira to Dondo and Nhamatanda.

Industrial crops are distributed as follows:

- cotton is cultivated along the Zambezi from Caia to Chemba, and also in Nhamatanda. It is estimated that production declined more than 40% between 1980 and 1990 due the impact of the civil unrest. Today, most cotton production is carried out by the firm LOMACO
- sugar cane plantations occur along the Zambezi, and in the Pungue valleys. Especially the Marromeu district housed large scale sugar plantations, with a sugar mill located at the town of Marromeu itself (Sena Sugar Estate). There was also a mill north of Dondo prior to the period of civil unrest
- it was reported to the study team that tea is being cultivated in the Inhaminga district.

The province of Sofala contributes roughly 50% of the national production of wood, with logging taking place mostly in the districts of Cheringoma and Muanza. Logging is also said to occur increasingly in the Gorongosa-Maringue area.

Livestock production takes place over the whole of the study area (mostly cattle), but is concentrated in the districts of Nhamatanda and Caia. In Nhamatanda, Dondo and Beira pig farming undertaken.

Today, agricultural production is State-run, mixed, co-operative, private or family-run. Family-run agriculture is mostly subsistence farming on small parcels of land (0,5 - 1 ha) and based on traditional (manual) technology. There is little access to support or extension. Small-scale farmers (and logging concerns) are responsible for much of the deforestation taking place in the study area.

Large-scale or industrial farming is effected mostly by larger (State, mixed and private) organisations, mostly in the primary districts and Nhamatanda (i.e. along the Beira corridor and the Zambezi river). It is estimated that State-owned corporations are responsible for the cultivation roughly 40%, mixed institutions 10% and private companies 50% of commercial farmland in Sofala. There is an increasing trend towards privatisation of State-owned firms.

Other economic activity relates mainly to the primary and secondary sectors. The main economic activities are:

- a stone quarry in Nhamatanda
- a cement factory in Dondo

- a lime quarry at Muanza
- a marble quarry in Dondo district
- a pottery factory in Dondo
- basic industries in Beira.

Apparently mining activity is going on in the Canxixe area.

Tourist-wise, the five yearly strategic plan for Mozambican tourist development (issued in 1993) identifies large parts of Muanza, Cheringoma, Marromeu, Caia, Chemba and Maringue districts as natural reserves ('reserves do bravio'). The Gorongosa-Maringue border is identified as an area of 'special protection'. The plan targets the areas of Beira and Gorongosa as zones which can be developed in the short term as tourist attractions. Beira already has some basic tourist infrastructure, although somewhat decayed. Gorongosa used to be a park of international standing and it is indicated as a high priority to upgrade it to its potential. Especially the park's central location makes Gorongosa important as a component of tourist routes in Central Mozambique. There used to be the Buffalo reserve of Marromeu - its current wildlife resources are unknown and it is quite inaccessible. The study team was informed that tourism concessions (safari parks) have been earmarked between Nhamacolomo and Caia.

The main agricultural and other economic activities are indicated in the following Land Use figure.

3.1.4 MAIN DEMOGRAPHIC ATTRIBUTES

The study area includes the largest parts of Sofala and Manica provinces, and some districts from Tete and Zambezia provinces. Sofala (1,6 million inhabitants) and Manica provinces (800 000) contribute approximately 9% and 5% respectively towards the total population of Mozambique. Combined, the districts in the study area (as defined by the cordon line) make up roughly 13% of the total population. (The population figures quoted here are extrapolations of the 1980 and 1993 population numbers and growth rates as reported by the National Directorate of Statistics.)

Population growth in Sofala province is estimated to have been 2,4% per annum, and for Manica half of that (1,2% per annum) between 1980 and 1993. This compares to the national growth rate of 2,3% per annum over the same period. The districts with above average growth rates were Dondo (6,0%), Beira City (3,7%) and Cheringoma (3,4%).

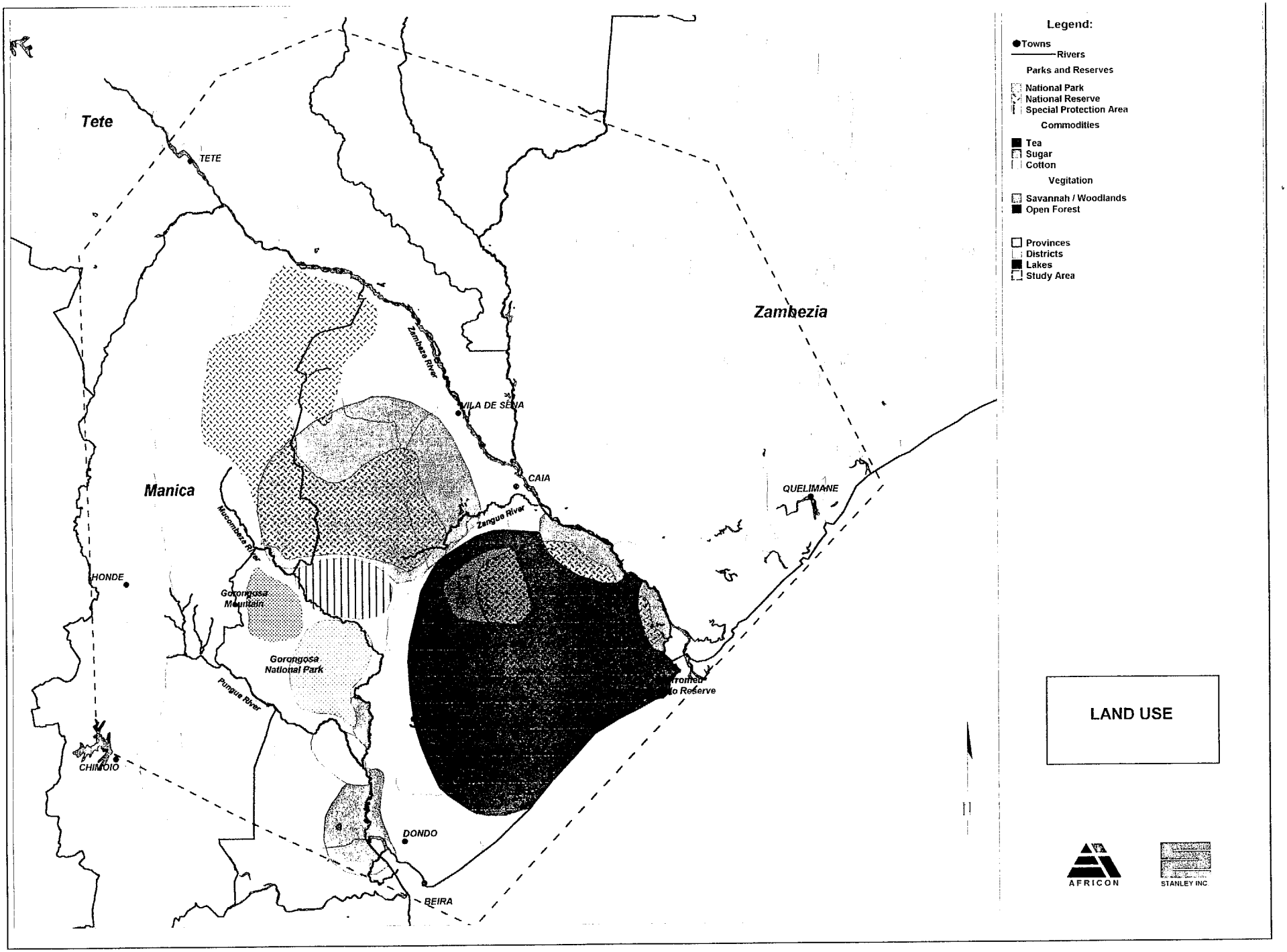


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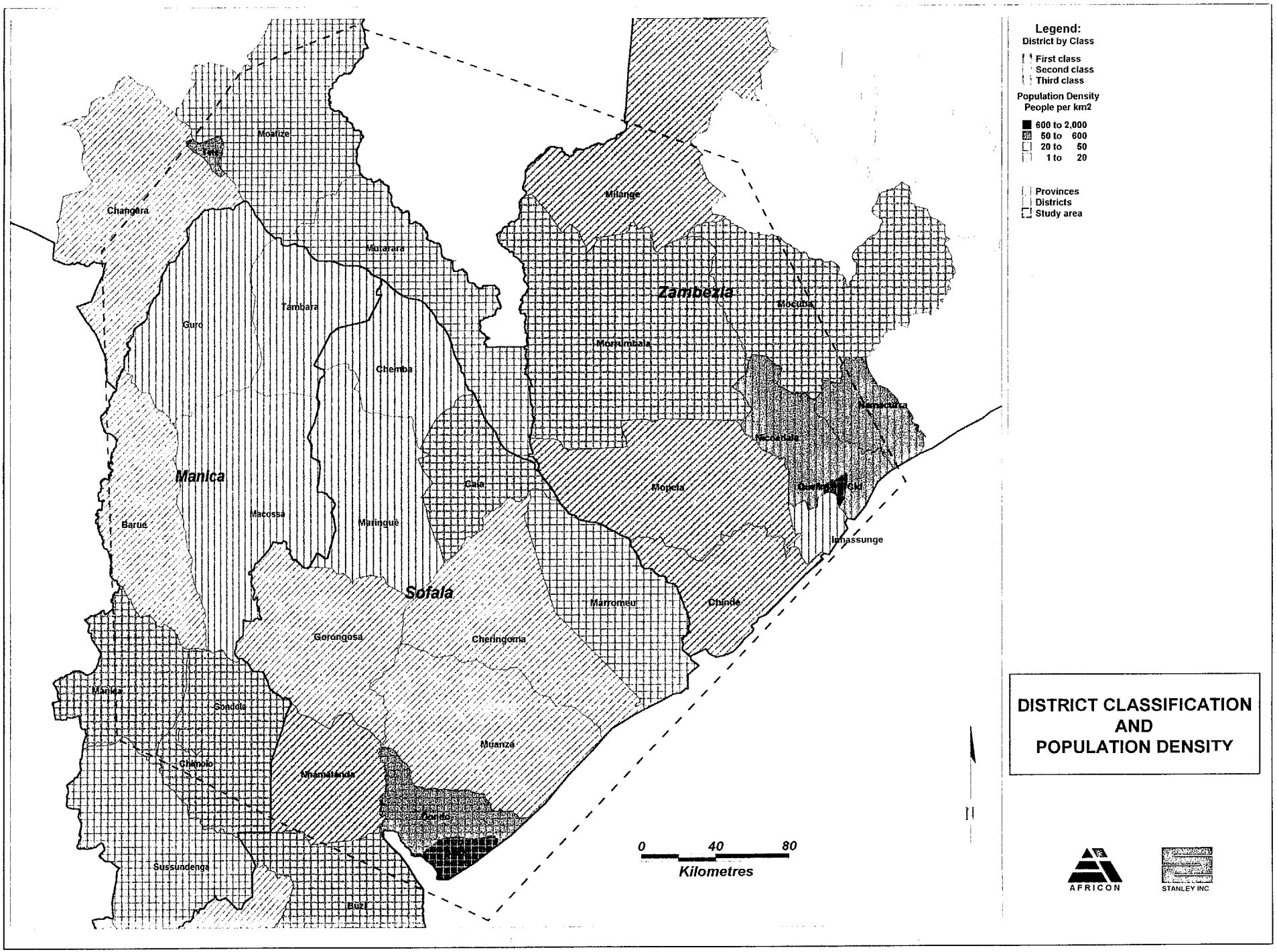
Table 3.1 presents the estimated population and population growth rates for the districts making up the study area.

TABLE 3.1 : POPULATION AND POPULATION GROWTH RATES

Province	District	Population			Growth
		1980	1993	1996 (forecast)	('80 - '93)
Mozambique	TOTAL	12,129,996	16,221,913	17,347,412	2.3%
Sofala	Total	1,065,200	1,453,668	1,570,589	2.4%
	Caia	87,270	90,704	91,515	0.3%
	Chemba	46,871	55,486	57,689	1.3%
	Cheringoma	45,186	69,810	77,181	3.4%
	Dondo	60,156	128,770	153,494	6.0%
	Gorongosa	70,137	82,847	86,093	1.3%
	Marromeu	81,621	90,562	92,761	0.8%
	Maringue	70,397	75,338	76,527	0.5%
	Muanza	24,041	31,089	32,989	2.0%
	Nhamatanda	73,474	87,963	91,693	1.4%
	C. Beira	230,744	371,752	415,003	3.7%
Manica	Total	641,200	745,469	778,928	1.2%
	Barue	61,302	62,478	62,753	0.1%
	Gondola	64,457	105,971	118,854	3.9%
	Guro	55,552	66,000	68,678	1.3%
	Tambara	28,586	39,778	42,930	2.6%
	Macossa	14,882	25,110	28,332	4.1%
	C. Chimoio	74,372	124,013	139,544	4.0%
Tete	Total	831,000	877,546	888,652	0.4%
	Mutarara	139,780	77,813	67,975	-4.4%
	Changara	92,139	104,219	107,224	1,0%
	Moatize	104,504	131,063	138,094	1,8%
	C. Tete	48,064	132,106	166,822	8,1%
Zambezia	Total	2,500,196	3,153,004	3,326,401	1.8%
	Morrumbala	204,198	294,508	320,479	2.9%
	Inhassunge	74,293	91,622	96,164	1,6%
	Nicuadala	142,451	193,978	208,303	2.4%
	Mopeia	66,516	138,768	164,433	5.8%
	Chinde	141,191	196,324	211,842	2.6%
	C. Quelimane	62,174	161,578	201,418	7.6%

Source: National Directorate of Statistics; 1996 population figures forecast based on 1980 - 1993 annual growth rates.

The following figure sets out the population distribution over the study area. The national ratio of persons to area is 21 inhabitants per square kilometre. In Sofala, this ratio is 23 and in Manica 13. The Beira Corridor is the most densely populated, especially Beira City itself (680) and the Dondo



DISTRICT CLASSIFICATION AND POPULATION DENSITY

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district (65). Compared to the rest of the area, Caia is also relatively densely populated with a ratio of 26 inhabitants per square kilometre.

The population distribution figure also indicates the classification of districts (as made by the National Institute of Physical Planning). Districts are the basic economic and administrative planning units in Mozambique. 'First class' districts are those where economic and social activities of national importance congregate and which lend themselves to rapid development. 'Second class' districts are those with good economic and social potential but where infrastructure needs to be created to stimulate growth. 'Third class' districts are those which are deemed only possible to develop with great effort.

Compared with their population densities, the districts of Marromeu and Muanza appear to have been granted a relatively higher status in terms of their district classification, in that Marromeu is a first class and Muanza a second class district. On the other hand, the districts of Chemba and Maringue both appear to have a lower development status than their population densities would seem to indicate.

3.1.5 DESCRIPTION OF THE ROAD NETWORK

This section discusses three topics, namely:

- Roads, through the study area
- The bridge at Vila de Sena
- The Caia Ferry.

3.1.5.1 Roads through the study area

Two South-North routes exist through the study area, between the Beira corridor and the Zambezi River, namely Bandula-Tete (in the west) and Dondo-Caia (in the east). **The Bandula-Tete route** is a paved, national road in good condition, but is viewed as a detour, as it does not lead directly to northern Mozambique. It is therefore used by vehicle operators between southern and northern Mozambique *inter alia* because the Dondo-Caia route is in such a poor condition.

The road between Dondo and Caia was originally constructed as a service road for the adjacent railway line, and was not intended to serve as a major route carrying (heavy) vehicles on a daily basis. This road passes through very sandy terrain, and as road building material is not readily available in this area, the road is basically a "sand" road, which is in poor condition. The surface of the road is also well below the level of the surrounding terrain. (See Photograph Number 5 in Annexure E.) Consequently, in the rainy season, the road is for all practical purposes, a river, and will require a vast quantity of fill material in order to rehabilitate it. In the dry season, the 180 km trip between Dondo and Caia normally takes approximately seven hours, but during the rainy season, it can take much longer. However, this route does not cross many rivers and therefore requires very few bridges.

Portions of **a third South-North route** through the study area also exist, namely **Inchope-Gorongosa-Caia**. This route originally formed part of the planned national south-north road network. Consequently, certain sections of this route already exist, along with a few bridges which were built at the time, but which are now mostly in a state of disrepair. This route crosses many rivers necessitating the construction of a number of additional bridges. The section from Inchope to Gorongosa is in a reasonable condition - far better than the condition of the Dondo-Caia road. The bridges between Inchope and Gorongosa have been sufficiently repaired (through the erection of Bailey bridges) to carry 30 ton articulated (i.e. horse and trailer) vehicles, although the bridge over the large Pungue River remains the critical junction, as the bridge needs to be repaired. Further north, the Gorongosa mountain plays a major role in determining a possible route, as the road needs to make quite a detour, either west or east around the mountain.

West of the Gorongosa mountain, the section of road between Gorongosa and the Mucombeze River presently consists of a portion of good surfaced road, with the remaining (larger) portion a "drivable" gravel road. Some rehabilitation work is, however, still required on two large and two smaller bridges (especially the bridge approaches). The relatively large bridge over the Mucombeze River was destroyed during the war, and still needs to be repaired, which makes this route totally impassable at present. Between the Mucombeze River and the town of Nhamacolomo the road has not yet been demined. Just north of Nhamacolomo is the town of Maringue, which was Renamo's headquarters during the years of civil unrest. Most road and bridge infrastructure was destroyed during this time, to limit access to the area.

East of the Gorongosa mountain, there is an existing track between Gorongosa and Nhamacolomo, which is a shorter alternative to the road west of the mountain. It can be travelled in approximately

two hours in the dry season, but is not always drivable during the rainy season. The area has perennial water in relatively large rivers, and the (timber) bridges are in dire need of rehabilitation. The disadvantage of this route, is the fact that the road cuts through the Gorongosa National Park. This creates the negative ecological impact of opening up the heart of the park, as well as the potential of opening the area in and around the park to agriculture.

Between Nhamacolomo and Caia, the road foundation has already been constructed, but the layer works were never completed. South of Caia, there is approximately 40 km of good surfaced road, although the bridge over the Zangue River needs to be repaired. South of the surfaced road (towards Nhamacolmo), the route becomes impassable once the first bridges are reached.

3.1.5.2 The bridge at Vila de Sena

The Zambezi River forms a major obstacle to south-north movement in Mozambique, and there are only three points at which to cross the Zambezi River in Mozambique:

- The bridge between Tete and Moatize
- The Dona Anna bridge linking Vila de Sena and Mutarara and
- The ferry at Caia.

However, in travelling to northern Mozambique via the shortest route, there are really only two crossing points to consider - the Dona Anna bridge and the Caia ferry.

Initially, the bridge at Sena was a railway bridge which was damaged during the war, by demolishing two of the spans which then dropped into the river. In rehabilitating the bridge, it was also converted to carry only vehicular traffic.

The bridge is approximately 3,5 kilometres long and can accommodate one-way traffic only. Once every hour, the direction of travel across the bridge is reversed. Consequently, its capacity is probably not more than 300 vehicles per day. However, the bridge is presently isolated between roads in a poor state of repair and does not attract much traffic.

3.1.5.3 The Caia Ferry

Prior to the war of independence, there were two ferries crossing the Zambezi River at Caia. Each ferry could accommodate two articulated vehicles, and the use of two ferries ensured the overall integrity of the system. During the war, both ferries were taken to Quelimane to be used as troop carriers in the sea. They subsequently rusted, and one sank.

For a period up to December 1995, Mariners was responsible for the operation of the existing ferry. Mariners is an NGO involved in shipping related matters. They overhauled the ferry shortly before the operating thereof was put out to tender. It is now operated by TRANSMAR, who leases the ferry from DNEP.

The existing ferry can only accommodate one articulated vehicle and two non-articulated vehicles at a time. Alternatively, the ferry can carry two four-wheel-drive passenger vehicles in the place of each heavy vehicle. Large articulated vehicles therefore wait for much longer periods than smaller vehicles, of which more can be accommodated on the ferry for each crossing. Consequently, the majority of heavy vehicles using the ferry are non-articulated vehicles. (See Photograph Number 6 in Annexure E.)

Unfortunately, the ferry is rather unreliable, as it is often out of order. It is apparently not uncommon for the ferry to be out of order for two weeks at a time. Further problems relate to the following:

- The river embankment is not protected in any way, and is very steep on the northern side. This causes problems for heavy vehicles which consequently need to "race" on and off the ferry, especially when the level of the river is low.

- There is a large sandbank close to the southern bank of the Zambezi which prevents the ferry from crossing when the water level is low.

- It is possible for water to be released from the Cahorra Bassa dam to raise the level of the river at Caia, which then enables the ferry to operate. However, coordination in this regard takes place through a circuitous process of telephoning the contact person in Maputo, who in turn contacts those at the dam. Bureaucracy often delays this process.

- During the overhauling of the ferry, it was decided that all four engines should be mounted at the after end of the ferry, thereby doing away with a "drive-through" configuration. Consequently, only one side of the ferry can be used for docking purposes. Vehicles therefore need to drive onto the ferry and reverse off (or *vice a versa*). Depending on the level of the river, the reversing process can be dangerous, or even impossible.

The result is that the ferry is most operational in the rainy season, when heavy vehicles find the roads leading to the ferry the most impassable, while the ferry is often not able to operate (due to the low level of the river) when the roads are "drivable".

Approaching the Caia ferry from the south and discovering a long delay, it is possible to drive to Vila de Sena and cross the Zambezi via the bridge. However, the road between Caia and Sena is also in a poor condition and virtually impassable during the rainy season. A contract has been awarded to repair and seal the Caia-Sena road. Approaching from the north and deciding to divert to Sena due to a delay with the ferry, would require vehicles to backtrack a long way on the Nicuadala road (which is presently in a worse condition than the Dondo-Caia road) and then follow the longer option to Sena via Morrumbala. (A contract has also been awarded to upgrade the Caia-Nicuadala road - but excluding repairs to the bridges).

Transport operators travelling between Beira and Nampula strongly favour the more direct route via the Caia ferry. However the unreliability of the ferry results in operators at times avoiding the Dondo-Caia route, and following the much longer Inchope-Changara-Tete route instead. A reliable ferry service at Caia is so important that many vehicle operators in Nampula have discussed the possibility of getting involved in providing this service themselves. A bridge at Caia therefore offers to be the optimal solution. Apparently, some Japanese investors have already made funds available for a bridge over the Zangue River, south of Caia.

3.1.6 TRANSPORT OPERATING ENVIRONMENT

There is a difference in the axle mass allowed in Mozambique as opposed to the rest of Africa. In other African countries, the load restriction is generally 56 tonnes per vehicle, while in Mozambique it is only 48,5 tonnes per vehicle. Interlinks are also not allowed. Vehicle operators feel that by using interlinks they will be in a position to supply a more efficient service to their clients.

Drivers are not willing to travel at night not only due to the security risk, but also due to the high risk of accidents where other vehicle drivers do not use warning triangles, and also because one cannot see the potholes in the road as easily as during the day. On a very informal basis, drivers of vehicles often form groups and travel in convoy. Unfortunately, the Police are not in a position to provide formal escorts for convoys.

On the Dondo-Caia route there is also the threat of being attacked by rebels/bandits. These are the so-called "Chimwenjes", and they date from the pre-civil unrest era. Their recent actions have been prompted by the employment of a Zimbabwean contractor on the northern end of the Dondo-Caia road. They have now become more indiscriminate and are not only harassing the contractor, but road users as well. However, this is not a permanent threat on the Dondo-Caia road, as the "Chimwenjes" appear to move around indiscrimanantly.

There is a problem in general with bridges, especially those that were at some time repaired by means of Bailey bridges. The carrying capacity of the bridges are not known and the transporters are often unsure whether the bridges can carry their loaded trucks. (They are often unaware of the actual weight of their cargo as well). They require that the maximum carrying capacity of the bridges be specified.

3.1.7 TRANSPORT BY OTHER MODES

Despite the existing poor condition of the road network through the study area, road transport is still the major mode for transporting goods between southern and northern Mozambique. Long distance road transport experiences very little competition from the rail or sea modes of transport.

3.1.7.1 Rail Transport

The lack of competition from rail transport is due to the fact that the railway routes which are at present in operation, are generally in an east-west direction, namely:

- The Beira corridor (which is the southern boundary of the study area) leading into Zimbabwe
- Far south of the study area in the vicinity of Maputo and
- North of the study area on the Nacala-Nampula-Malawi route.

The rail routes which would compete strongly with road transport through the study area are Beira-Sena-Tete and Beira-Sena-Vila Nova da Fronteira. These lines used to serve coal mining activities at Moatize (near Tete), sugar and tea exports from Malawi, agricultural produce from the Inhaminga-Caia-Marromeu district, and lime from the Muanza quarry to the cement factory in Manga (near Beira). Northwards from Beira, the line carried mostly fuel, at a rate of 10 wagons (400 000ℓ) per day. The line from Malawi used to carry 500 000 tonnes of goods per year in the early 1980s. The whole line is now unserviceable. Large sections of the line between Dondo and Caia were totally destroyed during the war and sleepers will need to be replaced on a large scale. Although several studies have been undertaken into the feasibility of rehabilitating the line, it is unlikely that this will take place in the short term. However, should the Dondo-Caia railway line be rehabilitated, it will be necessary to upgrade the adjacent road which will need to serve as access to the railway line rehabilitation project.

3.1.7.2 Sea transport

Sea transport relies heavily on good administration of the ports. The reason why road transport is not experiencing competition from shipping is the poor administration and management of the ports.

The port of Beira also needs constant dredging. In the absence thereof, only small-draught vessels can enter the port. At present, operators and freight forwarders prefer to use the ports of Durban and Richards Bay.

One of the problems at Quelimane is the fact that roads leading to the port are in such a poor state of repair. Operators will only consider using Quelimane if the access roads are rehabilitated and the port is upgraded and placed under more efficient management.

The port of Nacala has limited capacity. Security is also a problem, as well as the low serviceability of the cranes.

3.2 EXISTING LEVELS OF TRAFFIC

3.2.1 INTRODUCTION

In carrying out the O-D surveys, each vehicle passing a survey location was stopped, and a questionnaire was filled in. At Dondo and Mutarara, the O-D surveyor discovered that some vehicles were making many short, local trips past the survey location each day. He therefore decided to not stop them every time, but only twice a day (once in each direction), in order to obtain their trip characteristics. These vehicles were, however, counted each time they passed the survey location. It should be noted though, that as these short local trips will not influence the final decision as to which route through central Mozambique should be upgraded, they were not included in the trip matrix.

Manual classified traffic counts of light and heavy vehicles and buses were carried out simultaneously with the O-D surveys. These were carried out on the legs of intersections where the O-D surveys were not being performed. However, in some instances, only the total vehicle volumes were obtained, as the field surveyors did not always manage to classify the vehicles, due to the higher volumes on the roads, i.e. the Beira corridor. Consequently, it was decided to report traffic volumes only as light or heavy.

3.2.2 ORIGIN DESTINATION MATRIX

Prior to the surveys taking place in the field, a set of 21 origins and destinations was established, and printed on the survey forms. However, some drivers of vehicles informed the field surveyors that their origins/destinations were not on the original list, and 15 further locations were consequently added to the original list of origins and destinations. The O-D matrix therefore ended up with 36 origins/destinations. The matrix was then compressed (as described in Paragraph 2.5.5.4) to an O-D matrix with 22 traffic zones. The final O-D matrix is presented in Tables 3.2 and 3.3, showing O-D pairs for light and heavy vehicles respectively.

3.2.3 AVERAGE DAILY TRAFFIC

Figures 3.1 and 3.2 show plots from the computer model of current (i.e. 1996) annual average daily traffic, for light and heavy vehicle trips, separately.

TABLE 3.2: 1996 DAILY LIGHT VEHICLES TRIP MATRIX (Annual Average Daily Traffic)

destination zones

origin zones	S.Africa	Zimbabwe	Zambia	Malawi 1	Malawi 2	N.Mozambique	Quelimane	Beira	Maputo	Dondo	Inchope	Gorongosa	Savana	Derunde	Inhaminga	Caia	V.de Sena	Mutarara	Nicuadala	Tete	Changara	Chimoio	sum
S.Africa	0	0	0	1	0	0	0	164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167
Zimbabwe	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
Zambia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malawi 1	0	46	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	49
Malawi 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
N.Mozambique	0	0	0	0	0	0	14	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Quelimane	0	0	0	0	0	17	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	20
Beira	153	0	0	1	0	2	2	0	0	1	0	6	4	0	4	1	0	0	0	6	0	0	181
Maputo	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	5
Dondo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Inchope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gorongosa	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
Savana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Derunde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inhaminga	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Caia	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
V.de Sena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	8
Mutarara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	9
Nicuadala	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tete	0	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	5	12
Changara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chimoio	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	5	0	0	10
sum	154	46	0	40	0	23	17	181	3	1	1	10	4	0	5	3	9	9	1	13	0	7	527

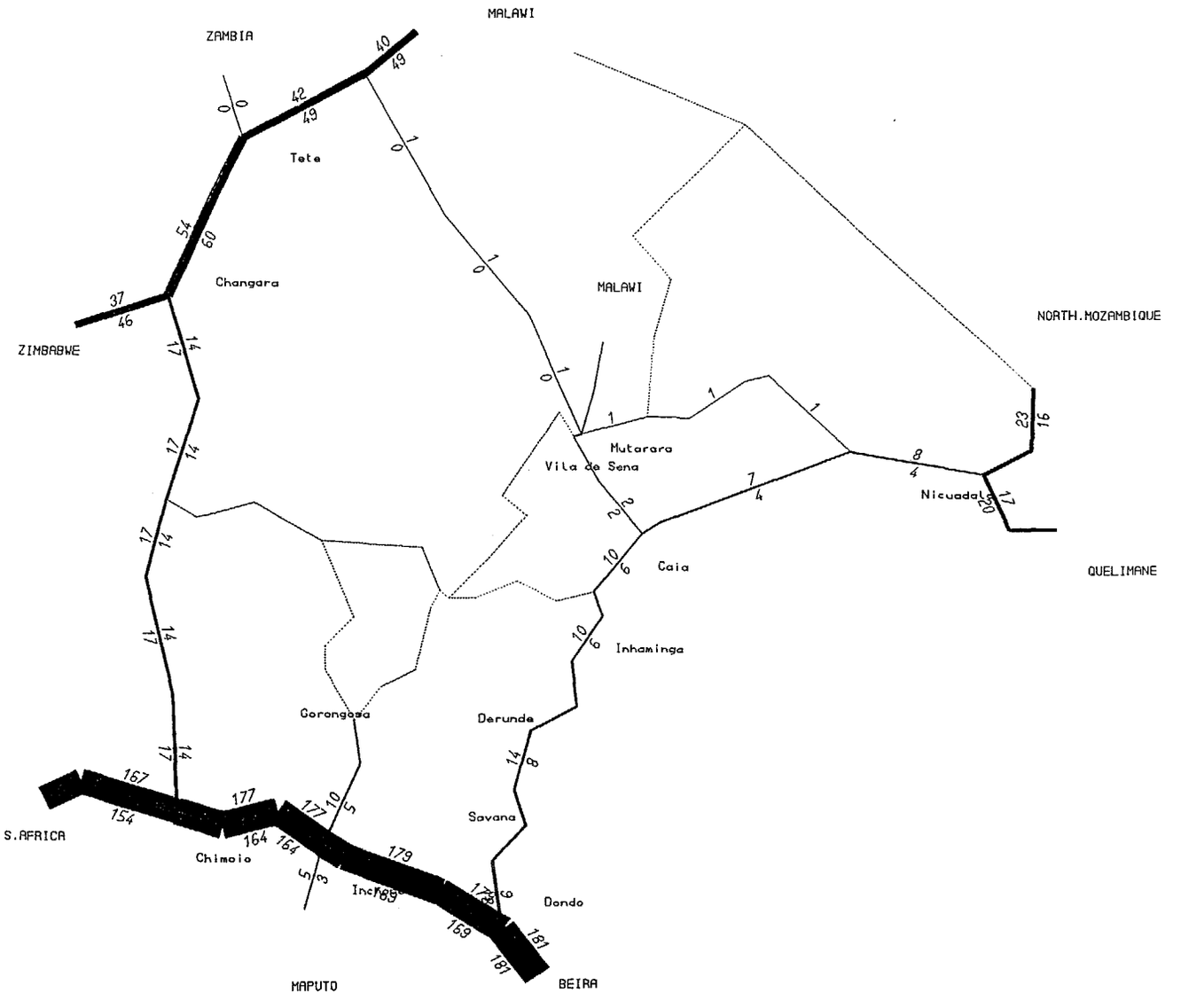
TABLE 3.3: 1996 DAILY HEAVY VEHICLES TRIP MATRIX (Annual Average Daily Traffic)

destination zones

origin zones	S.Africa	Zimbabwe	Zambia	Malawi 1	Malawi 2	N.Mozambique	Quelimane	Beira	Maputo	Dondo	Inchope	Gorongosa	Savana	Derunde	Inhaminga	Caia	V.de Sena	Mutarara	Nicuadala	Tete	Changara	Chimoio	sum
S.Africa	0	0	0	0	0	0	0	273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	273
Zimbabwe	0	0	0	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89
Zambia	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Malawi 1	0	82	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99
Malawi 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
N.Mozambique	0	0	0	0	0	0	23	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	30
Quelimane	0	0	0	0	0	28	0	2	2	0	0	0	0	0	0	0	0	0	2	0	0	0	33
Beira	256	0	1	19	0	2	4	0	43	1	0	6	6	1	5	3	0	1	0	10	1	0	360
Maputo	0	0	0	0	0	4	2	37	0	0	0	1	0	0	0	0	0	0	0	3	0	0	46
Dondo	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2
Inchope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gorongosa	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
Savana	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
Derunde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inhaminga	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Caia	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
V.de Sena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	4
Mutarara	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	4
Nicuadala	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tete	0	0	0	0	0	0	0	6	3	0	0	0	0	0	0	1	1	0	0	0	0	6	16
Changara	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Chimoio	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	7
sum	256	82	1	109	0	35	30	354	51	2	2	9	7	1	6	4	4	4	2	18	1	8	986

LIGHT VEHICLE VOLUMES (1996 Annual Average Daily Traffic)

emme/2



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WINDOW:
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31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.1

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MODULE: 6.12
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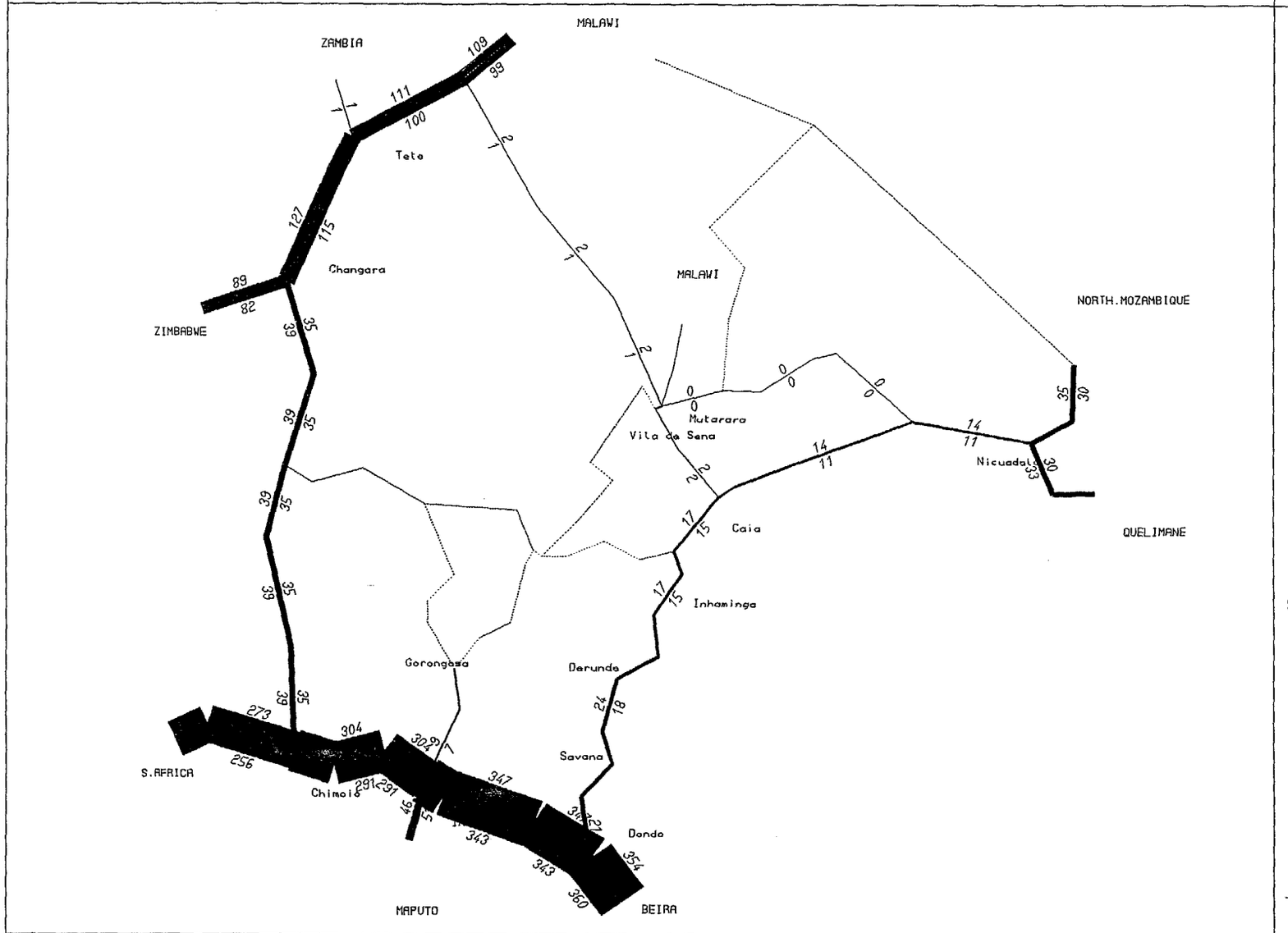
34C

HEAVY VEHICLE VOLUMES (1996 Annual Average Daily Traffic)

emme/2



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EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.2

AFRICON

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44

By combining the results of the two plots, it is clear that while a fair amount of traffic moves along the Beira corridor (approximately 1 000 vehicles per day in both directions) and between Zimbabwe and Malawi/Northern Mozambique (approximately 300 vpd), **very little traffic is found on any roads between the Beira corridor and the Zambezi River**. However, the two significant flows of traffic mentioned above will not influence the choice of route through central Mozambique to be recommended for upgrading.

On average, 55 vehicles travel along the Dondo-Caia road each day, in both directions, while 105 vehicles use the Chimoio-Changara road. The plots also show that **there are approximately twice as many heavy vehicles as light vehicles travelling in the study area at any given time**.

It is also interesting to note that while the volume of traffic crossing the Zambezi River by ferry at Caia is low, the volume crossing via the bridge at Vila de Sena is negligible. The reason for this is because at the time of our surveys, the ferry at Caia was operating satisfactorily. The vast majority of traffic was therefore using this route.

3.2.4 EXTERNAL ZONES

It was explained in Paragraph 2.5.5.4 how a number of origins and destinations from outside of the study area were combined to form external zones. However, it is not possible to show all origins and destinations on the computer model printouts. The following therefore presents the origin/destination names as shown on the printouts, along with the list of origins/destinations represented by each name:

-	Maputo	-	Maputo
		-	Swaziland
		-	Southern Mozambique
-	South Africa	-	South Africa
		-	Zimbabwe
		-	Angola

-	Zimbabwe	-	Zimbabwe
		-	Zambia
		-	South Africa
		-	Lesotho
-	Zambia	-	Zambia
-	Malawi	-	Malawi
		-	Tanzania
		-	Northern Mozambique
-	Northern Mozambique	-	Northern Mozambique
		-	Pemba
		-	Nampula
		-	Namaqurra
		-	Mocuba.

3.2.5 DESIRE LINES

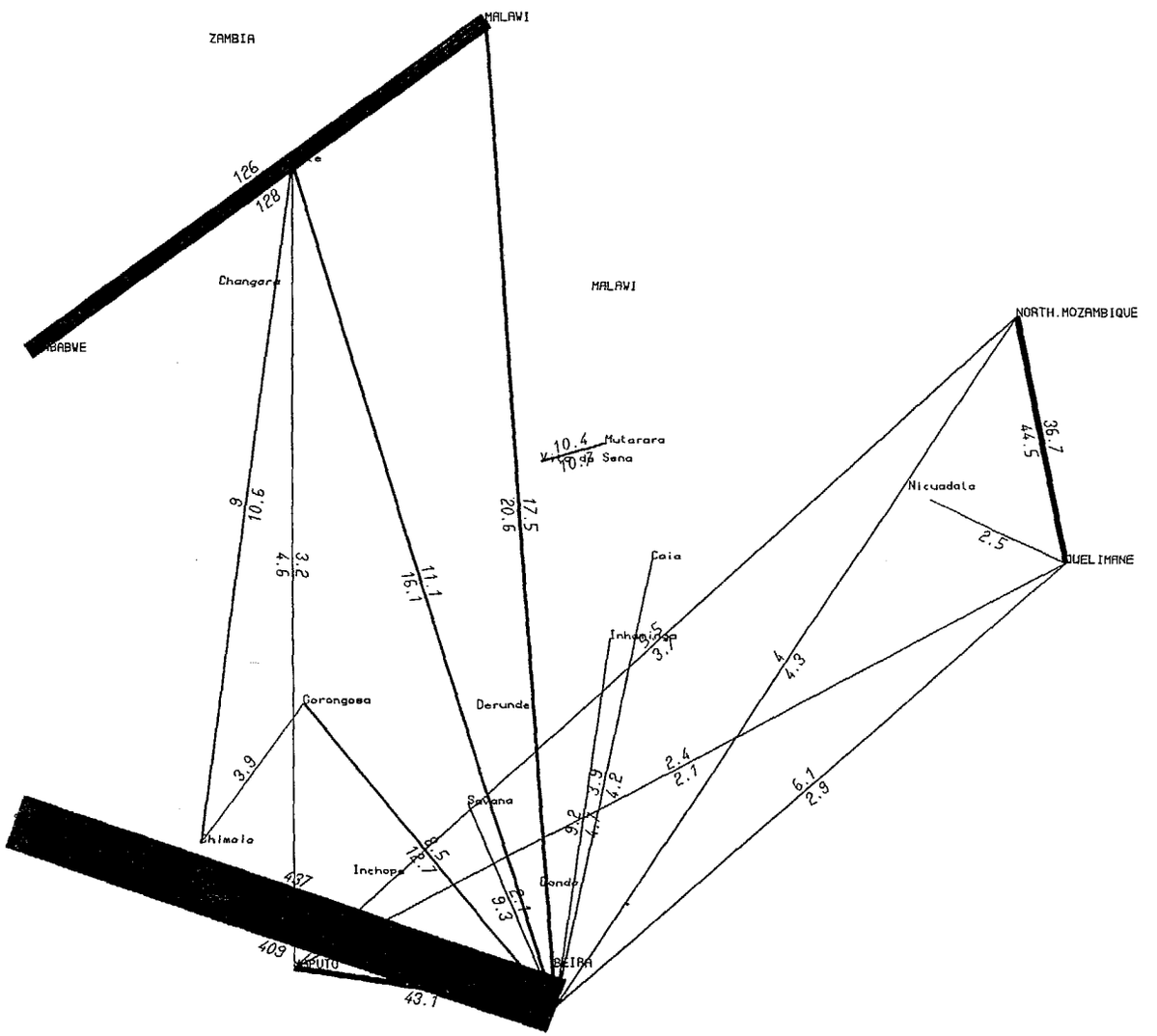
Figure 3.3 shows a plot from the computer model of current (i.e. 1996) so called "desire lines". The lines on the plot do not represent any specific route, but merely the traffic demand between traffic zones, of all vehicle trips.

This plot confirms the results of the assignment of traffic to the network, i.e. that the major demand is along the Beira corridor, and that a second, but smaller demand exists between Zimbabwe and Malawi/Northern Mozambique. The plot also shows that while there is a small demand between Beira and some internal zones, there is really no demand of note between any of the other internal zones. However, the important item to emerge from the desire line plot, is the fact that **there is a much larger regional demand between Beira and Malawi, than a national demand between Maputo and northern Mozambique**.

Furthermore, because of the limited choice of routes through the study area, the number of trips seen on the desire line printouts will virtually all use the same route between origin and destination pairs. If a number of alternative routes had existed through central Mozambique, it would be noticeable how certain routes were used more than others.

DAILY INTERZONAL DEMAND OF ALL (light+heavy) VEHICLE TRIPS - Base year (1996)

emme/2



PLOT MATRIX:
mf24: 24tv96

CONSTRAINT:
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UPPER: 2
EXCLUDE

SCALE: 25

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WINDOW:
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36333/-170559

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR
MATRIX mf24: 24tv96 1996 daily.all purp.total veh trips

FIGURE 3.3

AFRICON

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MODULE: 3.13
AFRICON....afc

46A

3.3 TRAFFIC FORECAST

The lack of sufficient information placed a serious constraint on the forecasting technique. Given this constraint, it was assumed that the main driving forces behind traffic growth are population growth and growth in economic activity.

3.3.1 POPULATION FIGURES

Population and population growth estimates were supplied by the National Directorate of Statistics - Department of Demography, who provided the study team with estimates and forecasts of provincial populations for the period 1990 to 2000. National forecasts extended to the year 2030, based on birth, mortality and fertility rates as established by the Department of Demography.

Table 3.4 presents the main population trends between 1980 and 2015.

TABLE 3.4 : NATIONAL POPULATION ESTIMATES FOR 1980 to 2015

Population 1980	Growth/yr 1980-1990	Growth/yr 1990-1995	Growth/yr 1995-2015	Population 2015
12,102,619	1.58%	4.25%	2.51%	28,626,803

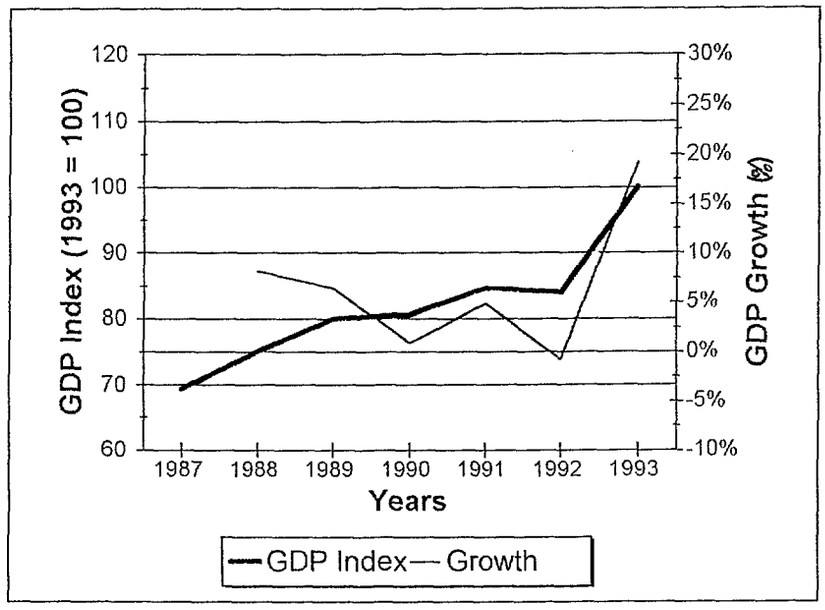
The growth rates between 1980 and 1990 reflect the impact of the unstable situation in the past, with relatively low population growth in most of the provinces (an actual decline in Tete and Manica). There was a robust population expansion during the next five years, with large rates of growth in especially those provinces which had stagnated during the previous decade. For the period 1995 to 2000, the average national population growth per year has been forecast to be 2,87%, with all the provinces following the same trend (the standard error for provincial growth rates is 0,3 percentage points). The salient conclusion from the above data as far as the forecast is concerned, is that it appears that provincial population growth rates (and therefore the national rate as well) will largely have normalised before the end of the century (i.e. the effects of migration should then have been completed).

It is forecast that the average annual growth rate of the Mozambique population should be approximately 2,5% annually between 1995 and 2015, which represents an absolute increase of roughly 64%.

3.3.2 ECONOMIC GROWTH ESTIMATES

Gross Domestic Product (GDP) estimates were obtained from the 'Plano Economico e Social - Republica de Mocambique', and subsequently projected statistically by the study team. Annual GDP values were available for 1987 to 1993, and are presented in Figure 3.4.

FIGURE 3.4 : GDP INDEX AND ANNUAL GROWTH FROM 1987 TO 1993 (index : 1993 = 100; Nominal GDP deflated by GDP deflator)



The Mozambican economy was characterised by strong growth in output since the second half of the 1980s. Growth averaged 6,3% between 1987 and 1993, and from 1990 to 1993, a healthy 7,5% per annum.

3.3.3 FORECAST METHODOLOGY

The traffic forecast was made for a period of approximately 20 years (i.e. to 2015), as this is seen as the realistic life of a road. The forecasting methodology applied to obtain likely future traffic volumes was as follows:

3.3.3.1 GDP Forecast

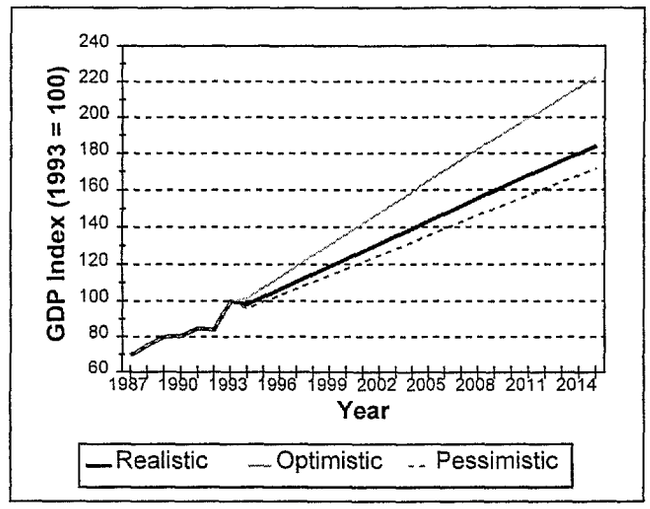
The population forecast made by the Department of Demographics was used as an external input into the model. In the case of GDP, the study team had to project future trends itself. This was done by regressing three series of GDP data on time to obtain long term statistical trends. Three scenarios were accordingly produced, namely:

- a 'realistic' scenario, based on the assumption that GDP growth would maintain a long-term growth path as it had between 1987 and 1993 (the years for which growth rates are available);
- a 'pessimistic' scenario assuming that GDP would grow in the way it had during 1987 to 1990; and
- an 'optimistic' scenario assuming that the economy would continue to expand as it had from 1990 to 1993.

Because the regressions are linear ('straight line'), the actual annual rate of growth will decline over time. This is consistent with structural readjustments and consequent high growth rates which are expected to take place during the initial period of the forecast, to then taper off later. Therefore, although the economy grew at 6,3% between 1987 and 1993 (the 'realistic' scenario), the linear regression results in an average annual growth rate of 2,8% between 1993 and 2015.

The results of these GDP forecasts are presented in Figure 3.5.

FIGURE 3.5 : REALISTIC, PESSIMISTIC AND OPTIMISTIC GDP FORECASTS (index : 1993 = 100)



3.3.3.2 Weighting of the two exogenous variables

Regarding the relative importance of the population and GDP as explanatory variables, in the absence of trend information to test the relationships, it was assumed that demographic and economic factors would contribute in the same proportion to traffic growth.

Accordingly, each variable was indexed with 1993 as base, and then summed and averaged per year, so that the single resultant index would apportion weight according to the relative growths of each index. Since there were three GDP indexes, three averaged indexes corresponding with the realistic, pessimistic and optimistic scenarios were produced.

3.3.3.3 Sensitivity of demand

Regarding the sensitivity of traffic volumes to either variable, experience has shown that traffic reacts disproportionately to growth in real variables (i.e. traffic generally grows at a faster rate than the population or the economy). This phenomenon was taken into account by augmenting the three traffic growth scenarios by assigning to each a different growth coefficient. In this case, the pessimistic scenario was upgraded by a factor of 1,33, the realistic scenario by 1,67 and the optimistic scenario by a factor of 2,00.

3.3.4 FORECAST RESULTS

Table 3.5 presents the main findings of the forecasting exercise.

TABLE 3.5 : FORECAST TRAFFIC GROWTH RATES : Realistic, Optimistic and Pessimistic Scenarios (1993 = 100)

Year	Population Index	GDP Index			Forecast Scenarios		
		Pessimistic	Realistic	Optimistic	Pessimistic	Realistic	Optimistic
1993	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000	125.2	117.5	122.8	136.2	126.0	136.8	154.7
2005	142.2	135.6	143.3	165.0	148.6	171.0	211.2
2010	160.1	153.6	163.7	193.8	175.2	213.8	288.4
2015	178.6	171.7	184.2	222.6	206.6	267.4	393.9
Average growth/year	2,7%	2,5%	2,8%	3,7%	**3,4%**	**4,6%**	**6,4%**

Table 3.5 indicates that traffic in the realistic scenario is projected to grow at roughly five per cent per year. For the three scenarios, the absolute growth between 1993 and 2015 should be 107%, 167% and 294% for the pessimistic, realistic and optimistic scenarios respectively.

3.3.5 TARGET YEARS

It was decided to predict and analyse traffic conditions for two future target years, 2005 and 2010. The two target years provide indications of the short to medium term situations. Projecting for the year 2010 and beyond is a difficult task, as it is impossible to predict the pace of economic development in the country or in the Sofala province, at this stage. However, predictions for both target years will be presented in the following sections, keeping in mind that any development in this region can significantly change traffic conditions.

3.3.6 GROWTH SCENARIOS

Each of the three growth rates were applied to the base year (1996), light and heavy vehicle trip matrices in order to calculate trip matrices for the future target years (2005 and 2010). As a result,

2005 and 2010 trip matrices for all three growth scenarios were obtained. The predicted number of vehicle trips for each matrix is shown in Table 3.6.

TABLE 3.6 : NUMBER OF DAILY VEHICLE TRIPS PREDICTED BY DIFFERENT GROWTH SCENARIOS

SCENARIOS	NUMBER OF DAILY VEHICLE TRIPS		
	LIGHT	HEAVY	TOTAL
Base year (1996)	527	986	1 513
Pessimistic 2005	709	1 326	2 035
Optimistic 2005	923	1 727	2 650
Realistic 2005	788	1 474	2 262
Pessimistic 2010	836	1 564	2 400
Optimistic 2010	1 261	2 359	3 620
Realistic 2010	985	1 843	2 828

The next exercise was to assign each of the vehicle trip matrices to the existing road network and analyse the traffic conditions and situations obtained. As expected, the traffic patterns did not change, or they had trivial variations. The explanations for these findings are in the transportation characteristics of the study area. Firstly, there is a very limited choice of routes between traffic zones. Secondly, daily traffic flows are very low. As the traffic flows will not cause capacity problems, congestion or delays, vehicles will not be forced to change their routes. Consequently, if there are no road network improvements in the future, every assignment exercise with any of the future trip matrices will produce the same visual image on the road network, differing only in the traffic volumes. It was therefore decided to present and discuss only the results of the 2010 realistic scenario.

3.3.7 REALISTIC SCENARIO FOR THE YEAR 2010

2010 light and heavy vehicle trip matrices, calculated by using the realistic growth rate of 4,6% per annum, were assigned separately to the existing road network for comparison purposes. The EMME/2 plots showing the assignments of light and heavy vehicles are presented as in Figures 3.6 and 3.7. Comparing these to Figures 3.1 and 3.2, showing the assignments of the 1996 matrices, it is evident that the traffic pattern characteristics are the same as described for the existing situation,

LIGHT VEHICLE VOLUMES (2010 "Realistic" Annual Average Daily Traffic)

emme/2

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150
200
250

WINDOW:
-33255/-220529
31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.6

AFRICON

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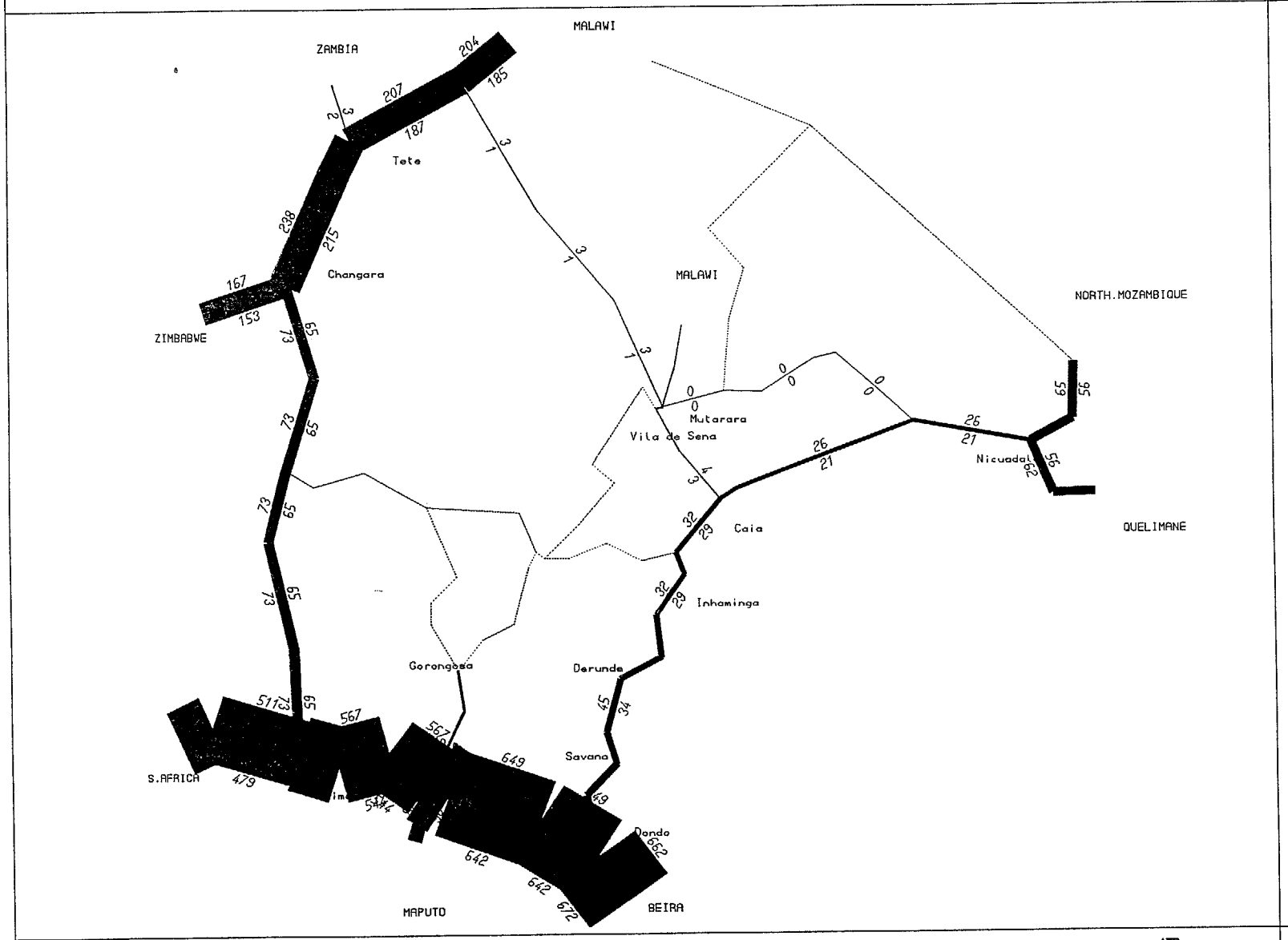
MODULE: 6.12
AFRICON....afc

524

HEAVY VEHICLE VOLUMES (2010 "Realistic" Annual Average Daily Traffic)

emme/2



LINKS:
type=11 32

SCALE: 20

50
100
150
200
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WINDOW:
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31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.7

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differing only in the link volumes due to the traffic growth. Figure 3.8 shows the total desired vehicle trip demand between the traffic zones.

3.4 VEHICLE OPERATING COSTS

3.4.1 COMMENTS ON THE SURVEYS

Before referring to the results of the operators' survey and the calculation of the direct VOCs, it is useful to reflect on the context within which the surveys were carried out and the data collected.

As has been found in similar circumstances internationally , the level of record keeping was relatively low throughout the survey - except in the case of the larger operators. Business information often resorts in the individual running the operation and not in a database of any kind. This is probably not surprising given the trying business and other environment within which transport is conducted in the study area. Often, business decisions have to be taken according to what the circumstances of the day requires (e.g. choice of routing). The result is that the operators often estimated information for the survey. Especially the more hidden costs (e.g. lubrication costs and tyre wear) were sometimes difficult to quantify. Only six operators could readily provide their own calculation of VOCs.

Costs were often network based, i.e. operators found it difficult to translate their cost profile into a 'worse case' or 'best case' scenario for hypothetical circumstances. As stated previously, this may have contributed to the convergence of good road and bad road VOCs.

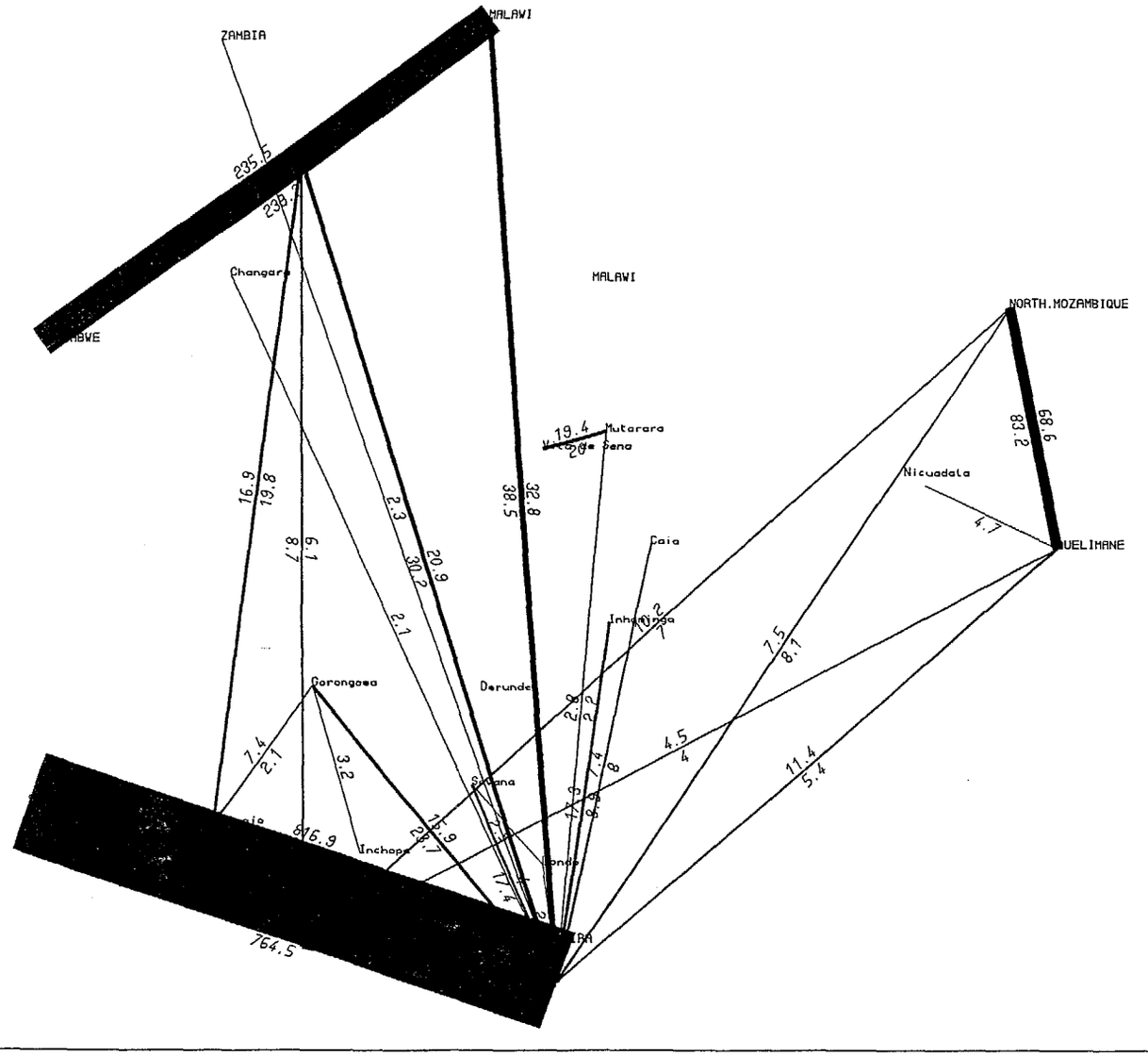
Relatively large discrepancies were sometimes found in the cost estimates for similar vehicle types. However, in the final analysis, extreme values were excluded and the aggregation of information also smoothed out the results.

3.4.2 SURVEY RESULTS

Table 3.7 summarises the main traits of the survey sample.

DAILY INTERZONAL DEMAND OF ALL (light+heavy) VEHICLE TRIPS - 2010 "realistic"

emme/2



PLOT MATRIX:
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CONSTRAINT:
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UPPER: 2
EXCLUDE

SCALE: 25

50
100
150
200
250

WINDOW:
-35993/-224804
36333/-170559

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR
MATRIX mf25: 24tv10 2010 daily.real. growth.tot veh trip

FIGURE 3.8

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53A

TABLE 3.7 : NUMBER OF VEHICLES AND OPERATORS IN SURVEY SAMPLE

Location	4 wheels	6-10 wheels	12+ wheels	Total	Operators
Beira	1	29	62	92	8
Blantyre	0	30	79	109	2
Harare	0	329	175	504	7
Maputo	3	0	0	3	4
Nampula	0	23	20	43	12
TOTAL	4	411	336	751	33

Of the 33 operators surveyed, the information obtained from 26 was found to be useful to calculate the direct VOCs.

The results of the VOC calculations are presented in Table 3.8, where all figures are presented as US$ cents per kilometer. In the table, the figures for "heavy" vehicles is a weighted average for 6 - 10 wheeled vehicles and vehicles with 12 or more wheels.

TABLE 3.8 : VEHICLE OPERATING COSTS (US$ cents per km)

	4 wheels/Light		6 - 10 wheels		12+ wheels		Heavy	
Road	Good	Bad	Good	Bad	Good	Bad	Good	Bad
Fuel	5.62	5.62	9.87	11.46	26.88	28.61	15.39	17.02
Lube	0.17	0.17	0.51	0.51	1.08	1.59	0.69	0.86
Tyres	3.29	3.29	8.44	12.11	26.52	28.13	14.93	17.86
Maint	2.94	2.94	17.84	17.84	40.43	40.43	25.56	25.56
Labour	2.45	2.45	5.90	5.90	15.87	15.87	9.13	9.13
Crew Time	1.90	1.90	2.75	2.75	2.38	2.38	2.62	2.62
TOTAL	16.37	16.37	45.30	50.55	113.16	117.01	68.33	73.06
Pax Time	1.90	1.90	0.77	0.77	0.79	0.79	0.78	0.78

Good road and bad road VOCs for 4-wheel vehicles are the same mainly because the operators were not able to differentiate between their costs for each road type.

- Zambezi joining and crossing points

There are two logical points for crossing the Zambezi River, where infrastructure is already in place, namely at Caia and Sena, although both points have limitations.

These basic starting points were used to define three alternative routes for evaluation, as follows:.

1. Improving the Dondo-Caia road
2. Improving and constructing an Inchope-Vila de Sena road link
3. Improving and constructing an Inchope-Caia road link.

These alternatives are shown graphically in Figures 3.9 to 3.11, and are discussed in more detail below. The cost of upgrading each alternative is based on "rule of thumb" indicators contained in a cost table received from DNEP. The table shows rehabilitation, upgrading and construction costs as applied on road projects throughout the country.

3.5.2 LEVEL OF UPGRADING

This proposed south-north route will form part of the principal arterial system of the country. It will therefore form a link between provincial capitals, main centres of population and also production centres. However, the volumes of traffic on the road are so low, that a formal level-of-service type analysis for the design thereof, is not required. It is merely necessary for this route to fall in line with general DNEP road planning standards.

It is therefore considered appropriate to refer to the recommendations on road design standards for the geometric design of rural roads, as published by the Southern Africa Transport and Communications Commission (SATCC), and also to take note of recent construction and rehabilitation work undertaken by DNEP on other sections of the main south-north highway in Mozambique.

The existing paved road between Caia and Nicuadala has 3,5 m wide lanes and is presently being resealed. This road does not have paved shoulders, probably due to the low volume of traffic on the road. South of the study area, and much closer to Maputo, approximately 50 km of the main south-north highway was recently upgraded between the towns of Marracuene and Manhica. This paved road has 3,5 m lane widths, with 2,5 m wide paved shoulders on both sides of the road.

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ALTERNATIVE 1: DONDO - CAIA

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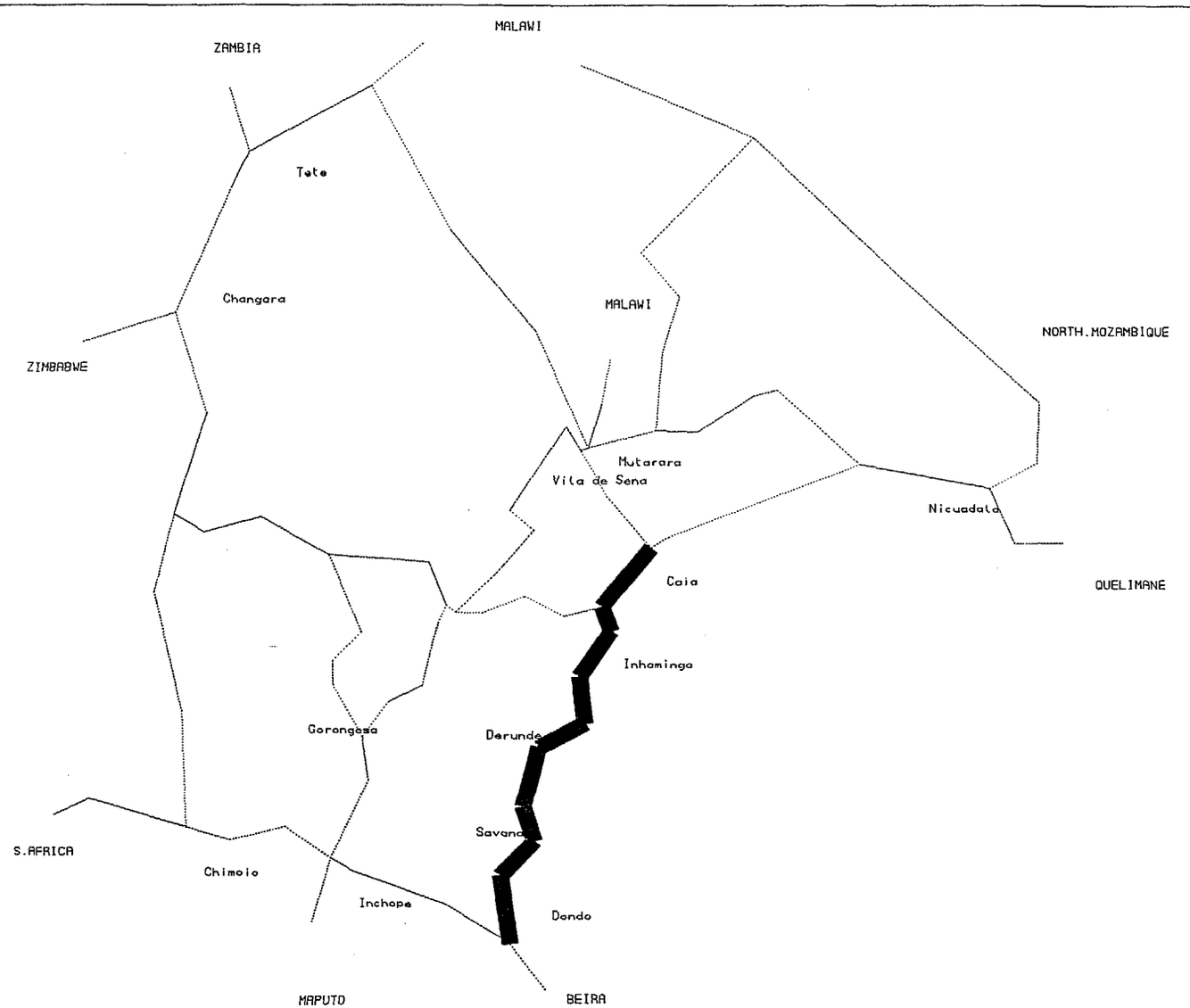

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WINDOW:
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31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.9

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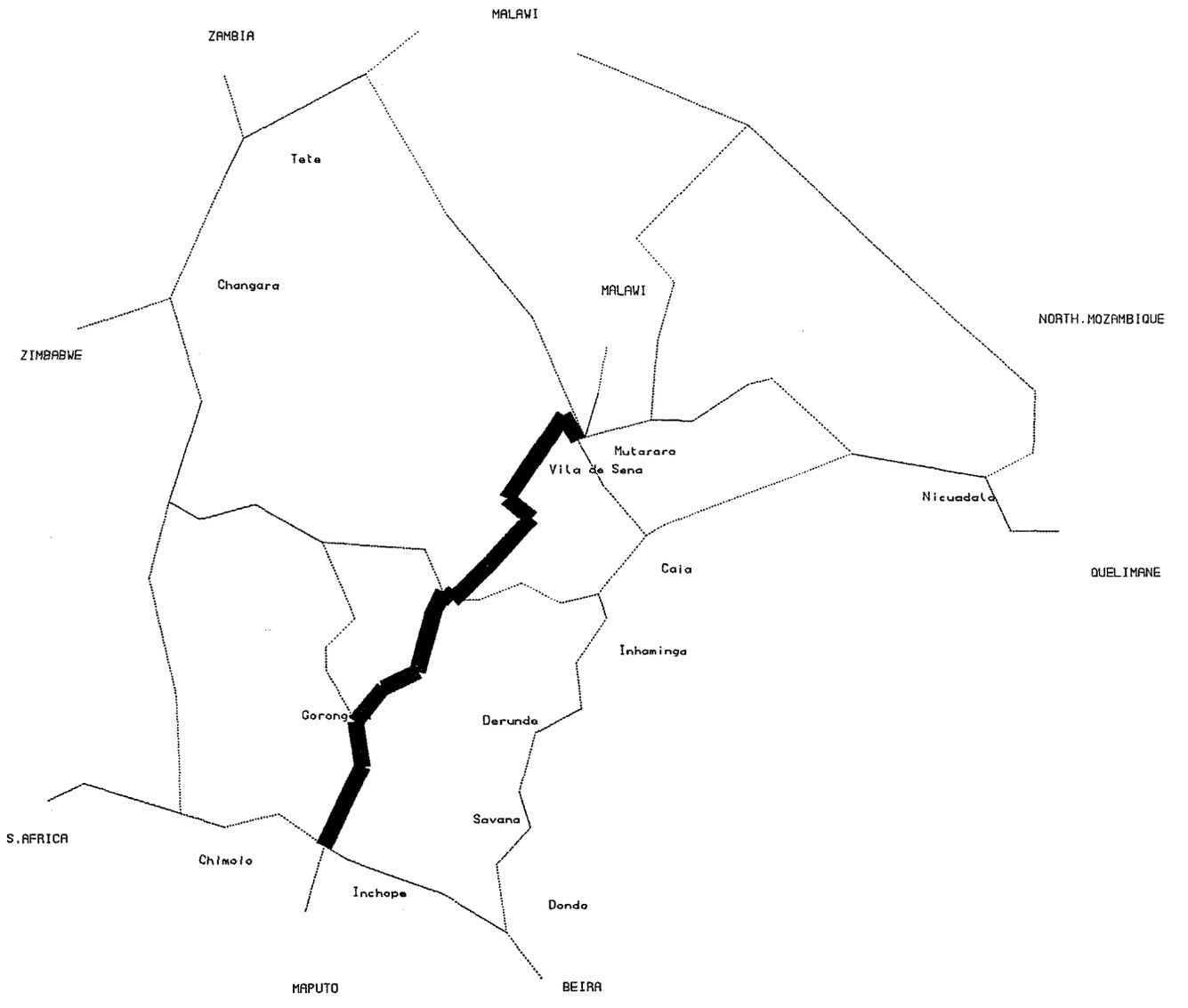
ALTERNATIVE 2: INCHOPE - VILA DE SENA

emme/2



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SCALE: .2

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WINDOW:
-33255/-220529
31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.10

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ALTERNATIVE 3: INCHOPE - CAIA

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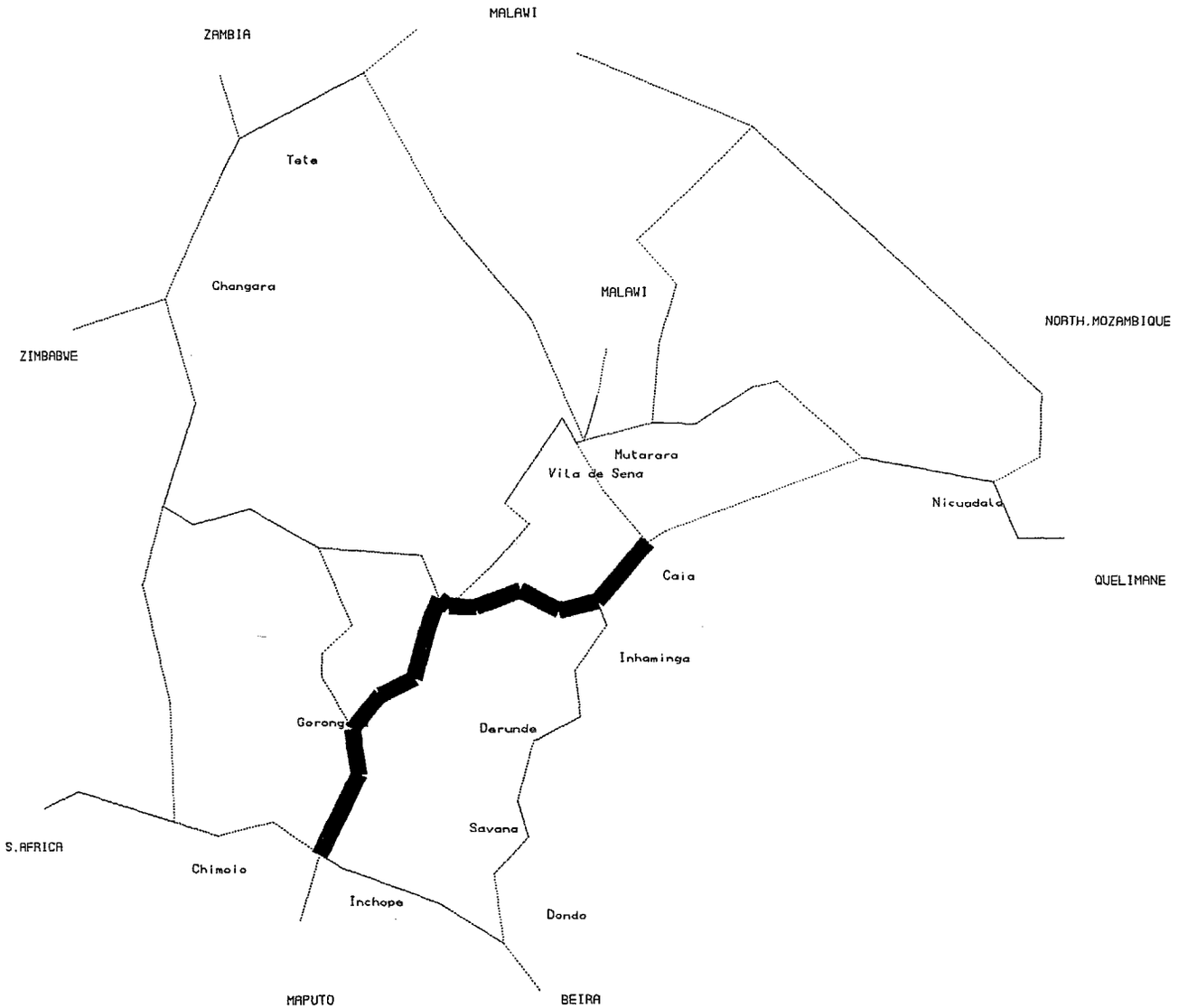

LINKS:
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SCALE: .2

.5
1
1.5
2
2.5

WINDOW:
-33255/-220529
31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.11

AFRICON

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MODULE: 2.13
AFRICON....afc

56

Due to the importance of the planned link between the Beira corridor and the Zambezi River, and taking the above-mentioned roads into account, it is considered appropriate to provide a paved road. In addition to this, gravel road maintenance costs tend to be rather high due to the high incidence of wash-aways on gravel roads in the area, as a result of the high rainfall. However, due to the low volumes of traffic expected on the road, it is not deemed necessary to provide paved shoulders from the outset, but rather to plan for a "phased" approach, in which paved shoulders could be provided at a later stage, if deemed necessary.

The SATCC document presents three types of road which fall into the above-mentioned classification, two of which have 3,5 m lane widths, and one with 3,35 m wide lanes. However, due to the fact that a high percentage of the vehicles which will use the road are expected to be heavy vehicles, 3,5 m wide lanes are deemed appropriate. SATCC shoulder widths vary from 1,5 m to 2,5 m.

Taking all the above into consideration, it is envisaged that the upgraded (or newly constructed) road should meet the following criteria:

- A paved surface
- 100 km per hour design speed
- Two lanes - one in each direction
- 3,5 metre wide lanes
- 1,5 to 2,0 metre wide gravel shoulders.

3.5.3 ALTERNATIVE 1 : DONDO-CAIA

Location : between Dondo, on the Beira corridor, and the crossing point of the Zambezi River at Caia.

Existing facility : it is basically a "sand" road in a very poor condition. During the rainy season it is almost impossible to drive over. The only tar section of the road link approaching Caia, is also in a poor condition.

Proposed construction : two-way arterial with one lane in each direction. (Existing tar section of the road also needs rehabilitation).

Length : 190 km for construction and 30 km for rehabilitation.

Estimated cost : US$40 m.

3.5.4 ALTERNATIVE 2 : INCHOPE-VILA DE SENA

Location : between Inchope, on the Beira corridor, and the bridge over the Zambezi River at Vila de Sena.

Existing facility : the section between Inchope and Gorongosa is a tar road in bad condition. Existing gravel roads from Gorongosa to the north are in a very bad condition and are impossible to drive for most of the year.

Proposed construction : rehabilitation of the tar road section and construction of the two-way arterial with one lane in each direction between Gorongosa and Vila de Sena, going around the eastern side of the Gorongosa mountain.

Length : 60 km for rehabilitation and 215 km for construction.

Estimated cost : US$52 m.

3.5.5 ALTERNATIVE 3 : INCHOPE-CAIA

Location : between Inchope along the Beira corridor and the crossing point of the Zambezi River at Caia.

Existing facility : there are two usable tar road links on this route. The first is between Inchope and Gorongosa, and the second is the link approaching Caia. In between these tar sections is a gravel road in poor condition, impossible for driving most of the year.

Proposed construction : rehabilitation of the tar road sections and construction of a two-way arterial in between with one lane in each direction, going around the eastern side of the Gorongosa mountain.

Length : 90 km for rehabilitation and 160 km for construction.

Estimated cost : US$45 m.

A summary of the basic characteristics for each alternative is given in Table 3.9.

TABLE 3.9 : SUMMARY OF BASIC CHARACTERISTICS

ALTERNATIVE ROUTES	LENGTH OF ROAD			ESTIMATED IMPLEMENTATION COST (US$)
	FOR REHABILITATION (km)	FOR CONSTRUCTION (km)	TOTAL km	
Dondo-Caia	30	190	220	40 m
Inchope-Vila de Sena	60	215	275	52 m
Inchope-Caia	90	160	250	45 m

3.6 TRAFFIC ANALYSIS OF ALTERNATIVE ROUTES

The alternative routes were analysed by using EMME/2, a regional transportation planning tool, which is useful in testing road network alternatives. The network was merely altered for each alternative by adding or deleting links, or else the attributes were changed to model improvements to road conditions.

The 2010 "realistic" light and heavy vehicle matrices were assigned separately to the existing and alternative road networks. Factors, outlining traffic conditions, were obtained by analysing the assignment results for both transport modes. Those factors are vehicle hours, vehicle kilometres and the average speed. They are given in Table 3.10 for comparison purposes between the alternative road networks.

TABLE 3.10 : ASSIGNMENT RESULTS FOR THE FULL NETWORK

ASSIGNMENT OUTPUT				
			AVERAGE NETWORK SPEED	
ALTERNATIVE ROUTES	DAILY VEHICLE HOURS OF TRAFFIC	DAILY VEHICLE km OF TRAFFIC	LIGHT VEHICLES	HEAVY VEHICLES
Current network	17 830	881 654	56	47
Dondo-Caia	17 274	881 590	58	48
Inchope-Vila de Sena	17 622	891 084	57	48
Inchope-Caia	17 444	891 921	58	48

The "speed" shown in Table 3.10 represents the average speed for all vehicles on the network, including the larger volumes of traffic along the Beira corridor. By upgrading the alternative routes in the analysis, the average speed of vehicles along this route will increase. However, due to the extremely low volumes of traffic along this route, the average NETWORK speed increases very little.

Factors outlining traffic conditions on the current Dondo-Caia route and on the alternative corridor routes are given in Table 3.11.

TABLE 3.11 : ASSIGNMENT RESULTS FOR THE ALTERNATIVE CORRIDOR ROUTES

ASSIGNMENT OUTPUT				
			AVERAGE SPEED	
ALTERNATIVE ROUTES	DAILY VEHICLE HOURS OF TRAFFIC	DAILY VEHICLE km OF TRAFFIC	LIGHT VEHICLES	HEAVY VEHICLES
Current network (Dondo-Caia)	883	25 903	33	28
Dondo-Caia	335	26 231	100	70
Inchope-Vila de Sena	353	26 757	100	68
Inchope-Caia	417	32 916	100	70

It will be noted that by analysing only this part of the network, relative improvements of traffic factors are much more obvious. The "speed" on the alternative routes now increase significantly.

Other factors often analysed in transportation models and related to the capacity analysis are not considered in this instance, as the level of traffic flow in the study area is far below network capacity. The only delays and queues in the study area, occur at the river crossings because of the poor conditions of the bridges or the unreliable ferry services. The most severe delays are experienced at the crossing points of the Zambezi River, especially at Caia. The level of service of the ferry service at Caia has already been described in an earlier chapter. The eventual investment in constructing a road to Caia would not make sense without improving the ferry service or building a bridge over the Zambezi River. Therefore, it was decided to drastically reduce delays at that link in the transportation model, when testing Alternatives 1 and 3.

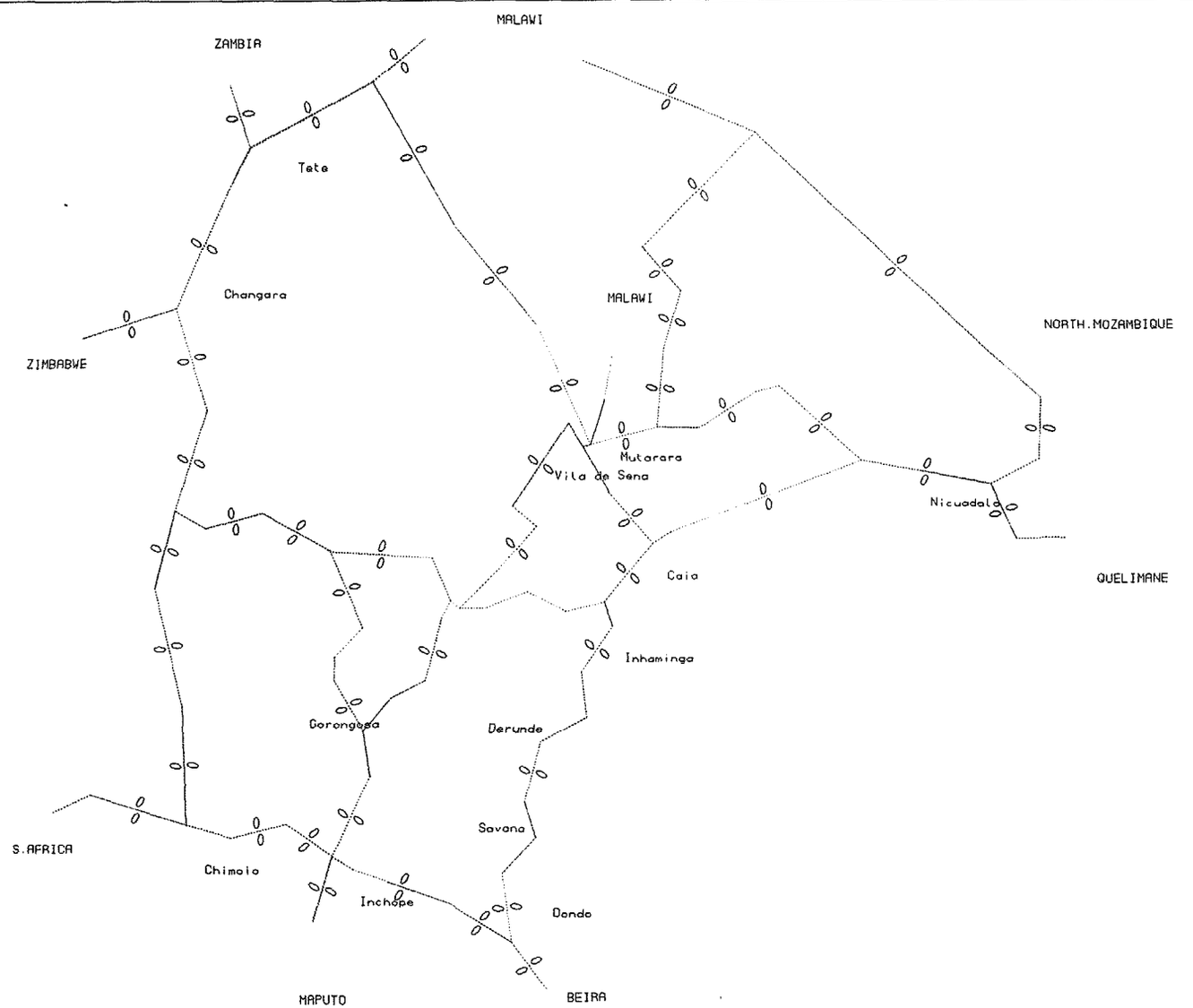
The graphical presentation of traffic impacts of the alternative network improvements are shown in Figures 3.12 to 3.14, for Alternatives 1, 2 and 3. These figures indicate the difference in link volumes between two assignments, the first being the assignment of the 2010 heavy vehicle trip matrix ("realistic") to one of the three future alternative networks. The second is the assignment of the same matrix to the existing road network. Keeping that in mind, positive values appearing as red lines on the plots mean that more vehicles use the particular link if the matrix is assigned on one of the future networks, than on the existing network. Negative values appearing as green lines mean the opposite, while zero values mean that in both assignments, the same number of vehicles were assigned on the particular link. (The same exercise was done for the light vehicles and the same variances of traffic flow patterns were obtained).

Analysing the factors given in Table 3.10 it is evident that there is no significant change in traffic conditions when comparing any of the alternative network improvements to the existing road network. As mentioned earlier, that was expected. Every project implementation resulted in a slight reduction of vehicle hours, and only the implementation of Alternative 1 in a reduction of vehicle kilometers. That is explained by the fact that vehicle drivers prefer to make trips longer in distance, but shorter in time. **Comparing the three alternatives, it can be concluded that Alternative 1 results in the greatest reduction of vehicle hours and it is the only one which results in the decrease of the vehicle kilometers. Therefore, as far as the impact on traffic conditions is concerned, Alternative 1 is the first choice, but only marginally so when compared to the other alternatives.**

ALTERNATIVE 1 Network Assignment - PRESENT Network Assignment

2010 heavy vehicles ("realistic" growth)

emme/2



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SCALE: 10

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-40

60

-80

100

WINDOW:
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31757/-171770

EMME/2 PROJECT: MOZAMBIQUE Alt. 1: DONDO-CAIA
SCENARIO 2: ALTERNATIVE Central Corridor
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.12

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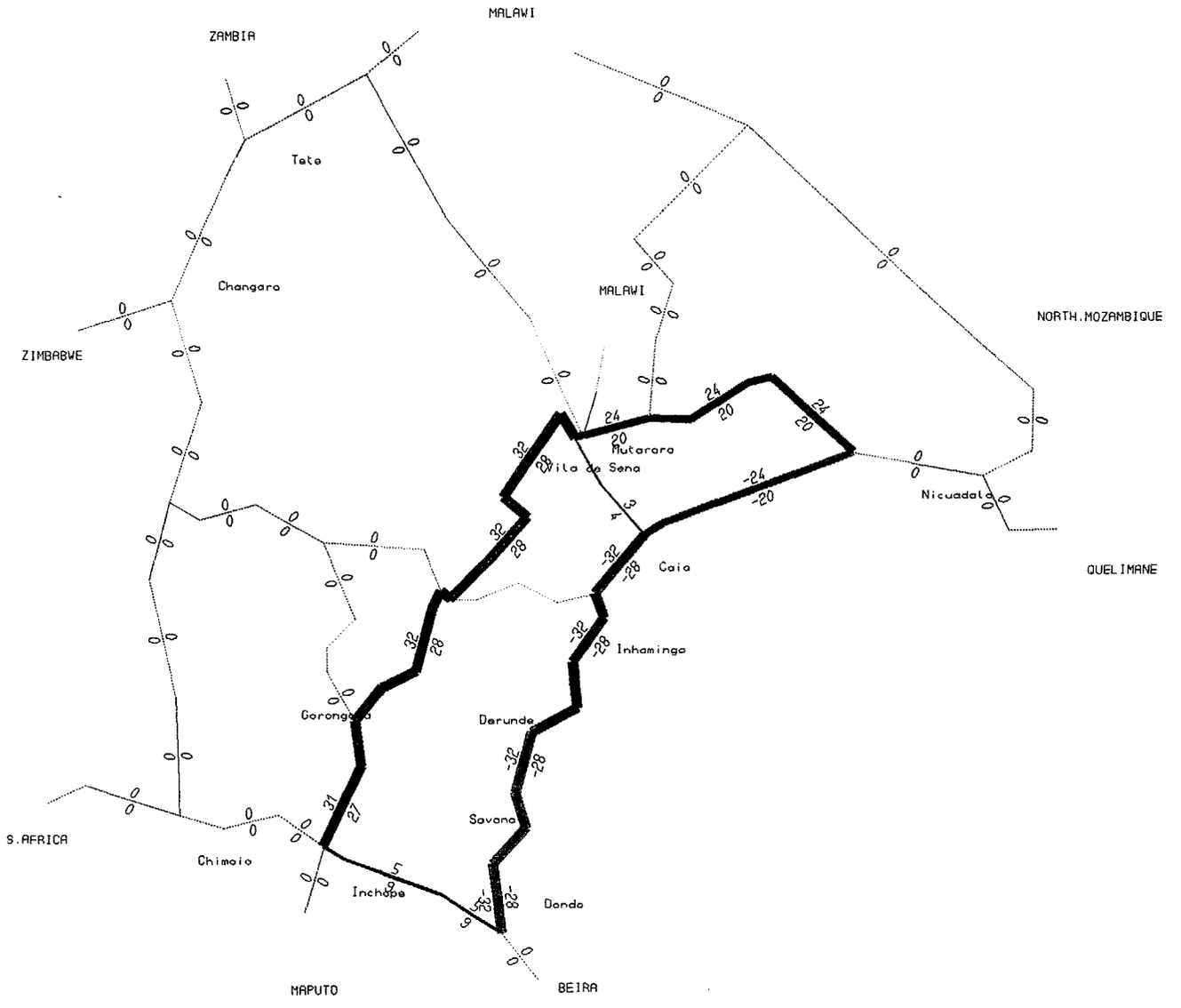
ALTERNATIVE 2 Network Assignment - PRESENT Network Assignment

2010 heavy vehicles ("realistic" growth)

emme/2



DIFF: 2- 1

LINKS:
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SCALE: 10

20

-40

60

-80

100

WINDOW:
-33255/-220529
31757/-171770

EMME/2 PROJECT: MOZAMBIQUE — Alt. 2: INCHOPE-VILA DE SENA
SCENARIO 2: ALTERNATIVE Central Corridor
SCENARIO 1: CENTRAL CORRIDOR

FIGURE 3.13

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ALTERNATIVE 3 Network Assignment - PRESENT Network Assignment

2010 heavy vehicles ("realistic" growth)

emme/2

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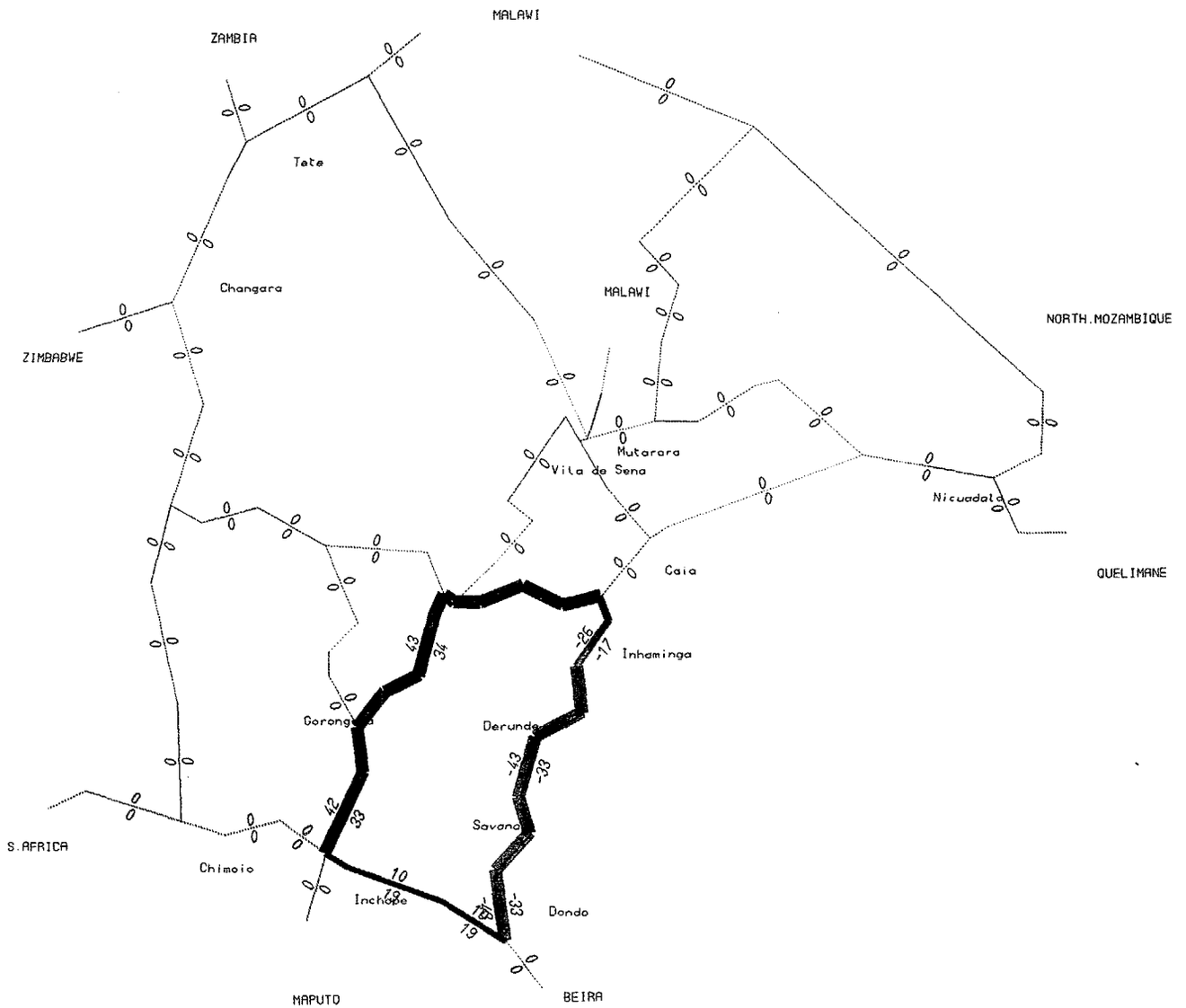

SCALE: 10

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-40

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-80

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WINDOW:
-33255/-220529
31757/-171770

EMME/2 PROJECT: MOZAMBIQUE
SCENARIO 2: ALTERNATIVE Central Corridor
SCENARIO 1: CENTRAL CORRIDOR

Alt. 3: INCHOPE-CAIA

FIGURE 3.14

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MODULE: 6.13
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612

3.7 VEHICLE OPERATING COSTS AND BENEFITS OF ALTERNATIVE ROUTES

In the cost-benefit methodology section it was explained that in areas with poor road networks, passive transport characteristics and low cost man-power, it does not necessarily follow that road network improvements will always reduce the total transport costs. As it turns out, this scenario is found in the central Mozambique area. Analysing the factors included in preparing the VOCs, it was found that the time cost of vehicle drivers, their assistants or accompanying passengers, have a marginal effect on the total costs, related to the fuel and maintenance costs. In other words, **the cost of an additional distance unit made during a trip has much more impact on total transport costs than the reduction of a time unit**.

It is therefore clear that with such low daily traffic in the study area, whatever trend the VOCs showed after alternative projects were tested, the transport cost variancies were basically insignificant and should not take a high priority in the final project implementation decision.

Table 3.12 shows the total transport costs (sum of VOCs and passenger costs), calculated after each of the trip matrices (of all three growth scenarios of both target years) were assigned to the each of the alternative road networks. Transport costs were calculated separately for light and heavy vehicles and combined for the table input.

TABLE 3.12 : DAILY VOCs CALCULATED FROM ASSIGNMENT OF FORECAST TRIP MATRICES ON ALTERNATIVE NETWORKS (US$)

TRIP MATRICES	DAILY VOC's ON NETWORK (US$)			
	BASE YEAR (1996) NETWORK	ALTERNATIVE 1 Dondo-Caia	ALTERNATIVE 2 Inchope-Vila de Sena	ALTERNATIVE 3 Inchope-Caia
1996 matrix	77 808	-	-	-
2005 realistic	116 302	116 229	117 510	117 650
2005 pessimistic	104 645	104 579	105 731	105 857
2005 optimistic	136 302	136 216	137 717	137 881
2010 realistic	145 420	145 328	146 930	147 105
2010 pessimistic	123 387	123 310	124 669	124 817
2010 optimistic	186 133	186 016	188 065	188 289

Construction and improvement of the Dondo-Caia road, known as Alternative 1, is the only project which resulted in a slight reduction of transport costs. Analysing the 2010 realistic scenario results, a daily saving of US$92 is found. This amounts to about US$34 000 annually. Comparing that amount to the project implementation cost indicates that the transport costs should have a very limited effect on the decision of which alternative project to implement.

3.8 SUMMARY EVALUATION

In this chapter, the findings of the various surveys and analyses that were done were presented.

It is evident from the results of the cost-benefit analysis that none of the three alternatives are significantly superior to the others. It also became clear in the execution of the study that there are several other factors that would affect the decision on a south-north link in central Mozambique.

The consultants therefore deemed it appropriate to make a summary of evaluation criteria that would be influential in making a decision on the selection of the appropriate route. These are discussed below.

3.8.1 COSTS OF IMPLEMENTING LINK

The costs of implementing the alternatives were given in Table 3.9 From this table it was evident that **Alternative 1 costs US$ 5 million less than Alternative 3, and US$ 12 million less than Alternative 2**.

3.8.2 BENEFITS

The benefits of each alternative can be defined as the reduction in total system VOC's relative to the other alternatives. The analysis of VOC's, summarized in Table 3.12, shows that **none of the three alternatives have significantly lower system VOC's,** for reasons discussed in Section 3.7.

3.8.3 REGIONAL TRANSPORTATION PERSPECTIVE

The regional transportation perspective refers to the more localised impact a new/upgraded road would have (as opposed to a more national impact as discussed in Section 3.8.4 : South-North Strategic Link).

The O-D matrix of the study area and beyond, presented in Tables 3.2 and 3.3, identified specific travel patterns in the region. Significant traffic flows could be identified along the following corridors:

- The Beira Corridor, i.e. between Beira and the Zimbabwe border
- The Tete Corridor, i.e. linking Zimbabwe and Malawi via Tete.

On the eastern side of the study area, the only traffic flow observed was between Dondo and Caia, with traffic attracted to Quelimane or to northern Mozambique. From a regional perspective, it appears that Quelimane attracts a fair amount of traffic, although it does not appear that significant numbers of this traffic moves further south. In all cases this traffic is significantly less than those on the other two corridors.

The desire line analysis showed the most significant required line of travel from the eastern part of the study area is between Beira and Malawi. This implies that such traffic currently uses the Beira and Tete Corridors, and would be attracted to one of the alternatives considered, should it be built. The volumes are however very low.

The main conclusion from this is that there is no significant traffic flow through the area where the three alternatives are located, nor any supported evidence that the construction of any of the alternatives would attract significant numbers of vehicles if constructed. This issue can of course only be fully addressed by compiling a final comprehensive O-D matrix for all regions in Mozambique, which was outside the scope of the study.

Another factor that comes into play is the upgrading of the port of Beira. Indications are that landlocked Malawi will use this port for exports and imports, strengthening the need for a shorter link between Beira and Malawi than the Beira and Tete Corridor. The projected traffic can however not be estimated at this time.

Given these considerations, **it appears that Alternative 1 (i.e. Dondo-Caia link) is the most appropriate from a regional point of view, although present and future predicted traffic flows are very low.**

3.8.4 SOUTH-NORTH STRATEGIC LINK

One of the main objectives of the study was to investigate the location of an appropriate south-north link through central Mozambique.

From a geographic perspective, and **taking into consideration that the main link between Maputo and the Beira Corridor connects at Inchope, the argument can be made that Alternatives 2 and 3 are better than Alternative 1, for purposes of continuity**. According to the existing DNEP road classification, the Gorongosa route is the link planned to form part of the national route EN 1.

3.8.5 ZAMBEZI CROSSING

The alternatives developed incorporated two existing crossing points, namely the ferry at Caia and the bridge at Sena.

Seen in isolation, both points have some limitations. The bridge at Sena only carries one-way traffic, which is not a serious constraint given the low traffic flow. The ferry at Caia's limitations are low river levels at times, and operational problems regarding configuration of the river bank approaches and reliability of the ferry.

In a wider context, the ferry at Caia appears to be preferred by operators, because of the Dondo-Caia link (Alternative 1) being accessible most of the time, and the Sena crossing constituting a detour via Caia.

In summary, **both crossings have advantages as well as disadvantages, and do not necessarily strengthen any of the alternatives**.

3.8.6 ENVIRONMENTAL IMPACTS

The scope of this study did not include an evaluation of the environmental impacts of any of the alternatives developed. However, consultation with various stakeholders indicated that the route to the east of the Gorongoza Mountain, which is part of both Alternative 2 and 3, **has significant negative environmental impacts.**

It would of course be possible to do the routing via the western side of the mountain, implying an increase in costs.

3.8.7 POPULATION ACCESSIBILITY

As discussed in Section 3.1.3, the only significant population concentration on the alternatives leading north from Inchope, is at Gorongoza. On the Dondo-Caia road (Alternative 1) there are significant population concentrations at places such as Muanza and Inhaminga.

It can therefore be argued that by implementing Alternative 1, a higher number of people will be given improved accessibility.

3.8.8 INDUSTRIAL ACTIVITY

As there is no significant present industrial activity on any of the alternative routings, no benefit will be derived by industries due to one alternative implemented versus another. Of course, increased accessibility in general can stimulate economic activity.

3.8.9 OPERATORS' PREFERENCE

Discussions with operators currently travelling through the area showed a preference for Alternative 1, i.e. the Dondo-Caia route.

3.8.10 EVALUATION MATRIX

The consultants subsequently compiled an initial evaluation matrix, based on the criteria discussed above, with the purpose of providing a first comprehensive assessment of the three alternatives. Unweighted rankings were given to each alternative, according to the reasoning discussed above.

TABLE 3.13 : UNWEIGHTED RANKING ASSESSMENT OF ALTERNATIVES

CRITERIUM	ALTERNATIVES		
	1 : Dondo-Caia	2 : Inchope-Vila de Sena	3 : Inchope-Caia
Costs of implementing link	3	1	2
Benefits	2	2	2
Regional transportation perspective	3	2	2
North-south strategic link	2	3	3
Zambezi crossing	2	2	2
Environmental	2	1	1
Population accessibility	3	2	2
Industrial activity	2	2	2
Operator preference	3	1	1
TOTAL	21	16	17

Note : 3 = high/good; 2 = average/same; 1 = low/worse.

From this exercise, it is evident that Alternative 1 i.e. the Dondo-Caia alternative achieves a slightly higher score than the Inchope-Caia alternative.

3.9 FURTHER EVALUATION

After consultation with USAID and DNEP, it became clear that the environmental and cost components could change the proposed ranking somewhat, as discussed below.

3.9.1 ENVIRONMENTAL IMPACTS

It was explained in Section 3.8.6 that a routing around the western side of the Gorongosa mountain would result in a higher cost for Alternatives 2 and 3, since both routes would become longer. This

would therefore make these two routes less attractive compared to the Dondo-Caia route, from a costing point of view.

In the case of a western routing, the ranking of the environmental impact can be amended to show equal weights for all alternatives, resulting in an environmental ranking of two each, in the absence of more detailed information.

3.9.2 COSTS OF IMPLEMENTING LINK

As stated in Section 3.5.1, "rule of thumb" indicators (based on unit costs) contained in a cost table obtained from DNEP, were used to determine the cost of implementing each link. This was subsequently refined through a more disaggregate analysis (again with the assistance of DNEP), as well as a higher cost for the western route around the Gorongoza mountain. The result of this exercise was that the cost of implementing either Alternative 1 (Dondo-Caia) or Alternative 3 (Inchope-Caia), would be very similar. This results in a ranking of three for each of these alternatives. Alternative 2 retains a ranking of 1.

Consultations indicated that culverts, embankments etc. were constructed on the Inchope-Caia route, north of the town of Gorongosa, approximately 20 years ago. This could have the effect of lowering the cost estimate for this alternative. However, the condition and extent of this infrastructure is not known, and should be the subject of a detailed study to obtain more accurate cost estimates. Such an investigation falls outside the scope of this project. It should also be undertaken on the Dondo-Caia route, to obtain comparative cost figures.

3.9.3 AMENDED EVALUATION MATRIX

Table 3.14 shows the amended ranking for the two items discussed above for Alternatives 1 and 3.

TABLE 3.14 : AMENDED UNWEIGHTED RANKING ASSESSMENT OF ALTERNATIVES

CRITERIUM	ALTERNATIVES	
	1 : Dondo-Caia	3 : Inchope-Caia
Cost of implementing link	3	3
Environmental	2	2
REVISED TOTAL	21	19

CHAPTER 4

CONCLUSIONS AND RECOMMENDATION

4.1 CONCLUSIONS

The purpose of this study was to define, analyse and evaluate alternatives regarding the creation of an adequate south-north road link through central Mozambique, effectively linking the Beira Corridor and the Zambezi River.

In the course of the study the following was done:

- Vehicle surveys at five locations through the study area, including origin-destination surveys, traffic counts and vehicle weighing.

- An operators' survey of transporters travelling through the region, conducted in five regional centra with 29 operators.

- Preparation of a forecast in three scenarios of future traffic on the roads in the region, using socio-economic and other relevant data.

- Development of a transportation model of the region, using state-of-the-art software.

- Definition of three alternatives for evaluation.

- A cost-benefit analysis of each alternative, using the transportation model and information acquired from operators.

- A summary evaluation of the alternatives.

The cost-benefit analysis showed that there is no significant difference between the three alternatives in terms of the vehicle operating costs incurred. The cost of the three alternatives indicate that Alternatives 1 and 3 will be similar, with Alternative 2 being somewhat more expensive. A factor that could not be quantified in this study is the extent and condition of partial infrastructure (e.g. culverts) that were constructed two decades ago.

The conclusion from this analysis was therefore that none of the alternatives was significantly superior to the other alternatives. Subsequently, the consultants proceeded to do a brief non-weighted ranking exercise of the three alternatives, incorporating other criteria that are also deemed to be appropriate.

The outcome of this exercise was that Alternatives 1 and 3 result in very similar rankings.

4.2 RECOMMENDATION

From the data collected and the subsequent analysis thereof, our conclusion is that there is very little to choose between the Dondo-Caia or Inchope-Caia options, and the client can safely select either.

However, due to the fact that there was already some construction undertaken on the Gorongosa-Caia road approximately 20 years ago, it appears appropriate that a more detailed costing exercise should be undertaken on both the Inchope-Caia and Dondo-Caia roads to establish more appropriate costs (an analysis which was not within the scope of this study). However, it must be emphasised that a similar costing methodology should be used for both roads.

Since the cost of the road has been identified as the single most important item in the selection of route alternatives, we recommend that once a detailed costing of the two alternatives (i.e. Inchope-Caia and Dondo-Caia) has been carried out, the option with the lowest cost be selected.

ANNEXURE A

AREA MAP

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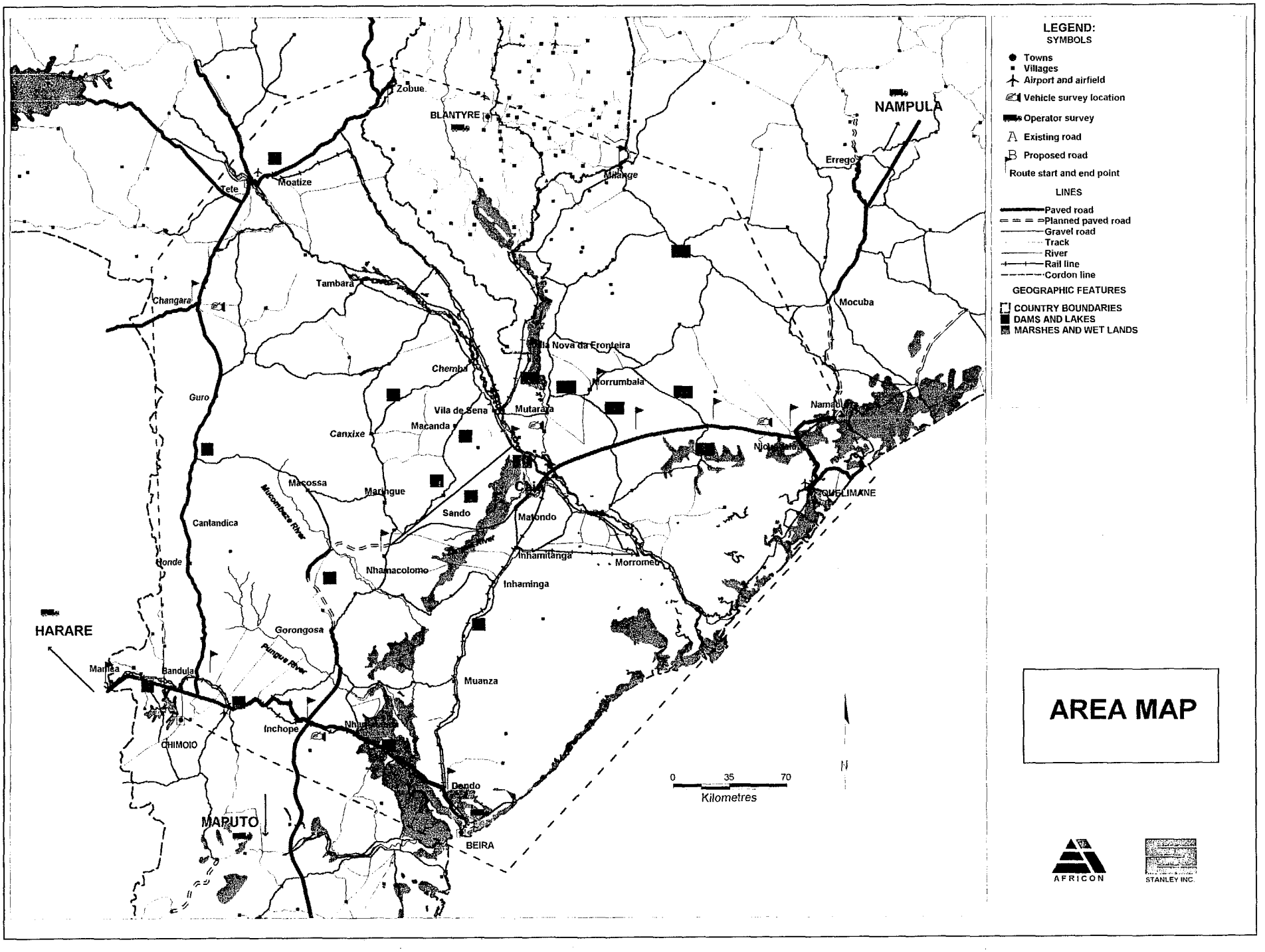

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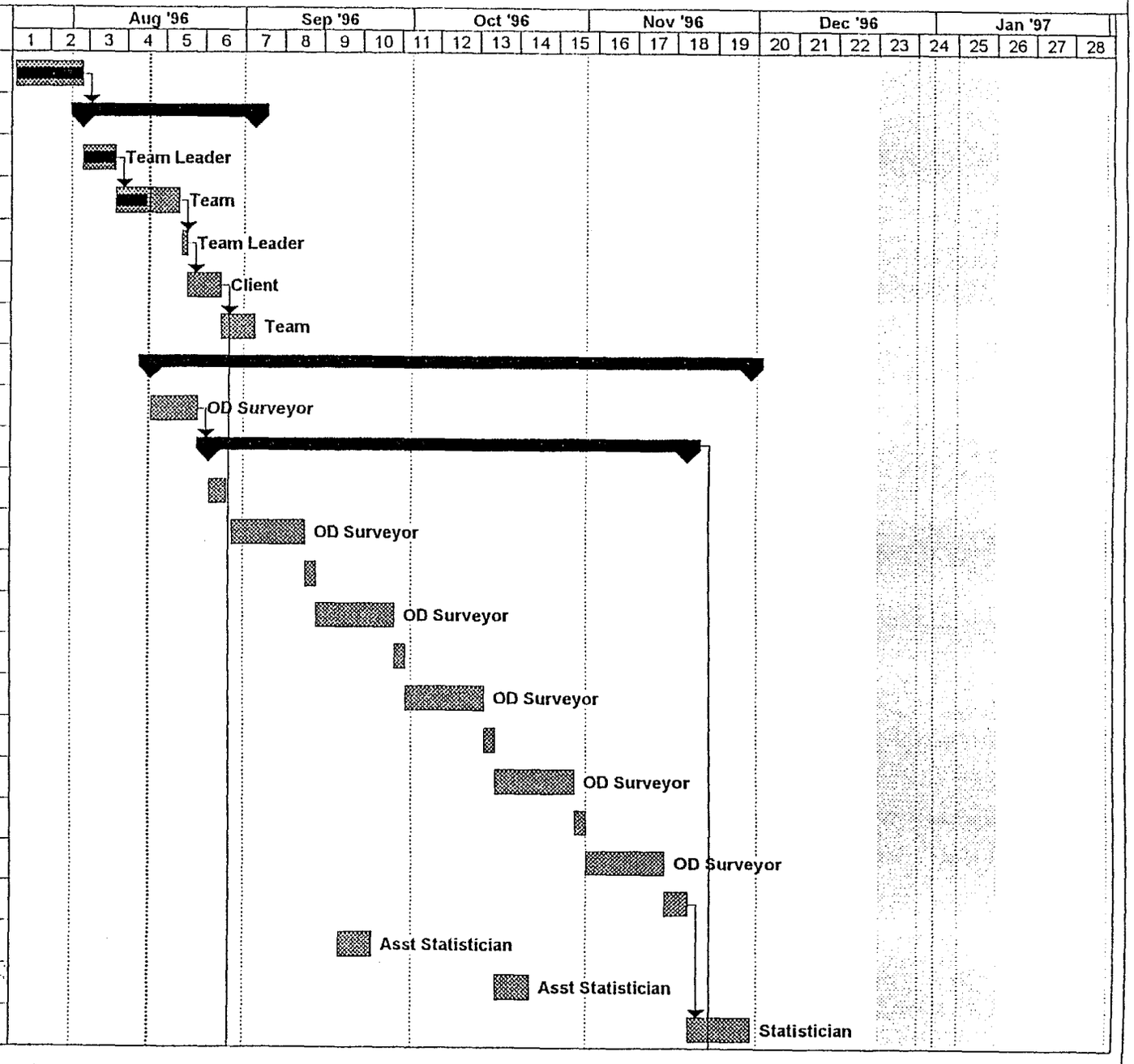
ANNEXURE B

STUDY PROGRAMME

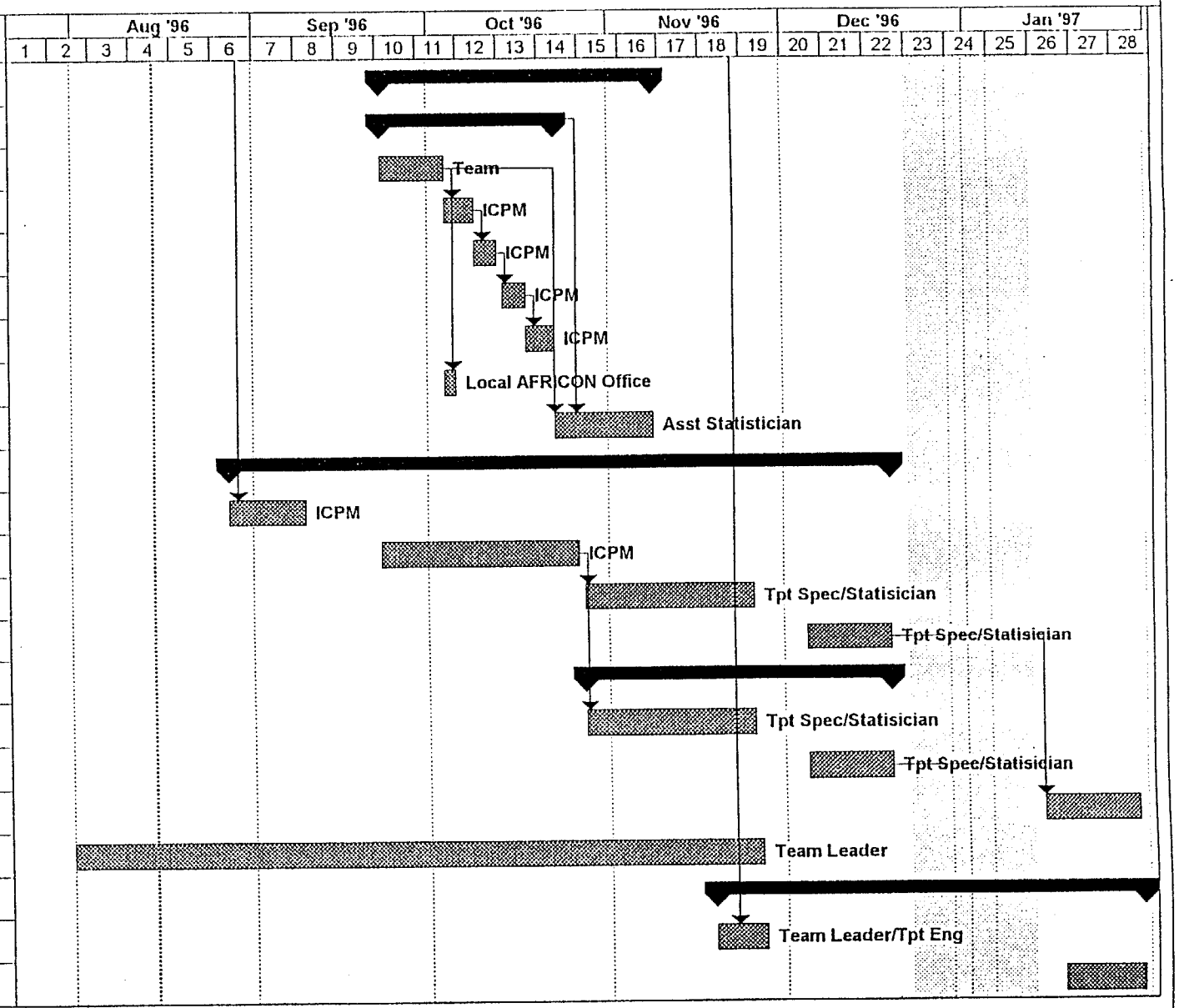
Origin & Destination / Vehicle Traffic Count Survey in Central Mozambique

ID	Task Name
1	1. MOBILISATION
2	2. SURVEY DESIGN
3	2.1 Meet with Client and sign document
4	2.2 Prepare survey design and work plan
5	2.3 Meet with Client and Review Existing Data
6	2.4 Approval by client
7	2.5 Prepare final survey design
8	3. ACTIVITY 1: VEHICLE SURVEYS
9	3.1 Prepare for surveys and counts
10	3.2 Carry out surveys and counts
11	Travel: Pta - Beira
12	Survey Dondo
13	Travel: Dondo - Inchope
14	Survey Inchope
15	Travel: Inchope - Changara
16	Survey Changara
17	Travel: Changara - Mutarara
18	Survey Mutarara
19	Travel: Mutarara to Nicuadala
20	Survey Nicuadala
21	Travel: Nicuadala - Pretoria
22	3.3.1 Capture data - month 1
23	3.3.2 Capture data - month 2
24	3.3.3 Capture data - month 3



Origin & Destination / Vehicle Traffic Count Survey in Central Mozambique

ID	Task Name
25	4. ACTIVITY 2: OPERATORS' SURVEYS
26	4.1 Carry out surveys of transport operators
27	Operators Data and Arrange meetings
28	Maputo
29	Beira
30	Harare
31	Blantyre
32	Nampula
33	4.2 Write up data
34	5. ACTIVITY 3: TRAFFIC FORECASTING
35	5.1 Collect data 1
36	5.1 Collect data 2
37	5.2 Develop model
38	5.3 Generate scenarios
39	6. ACTIVITY 4: COST-BENEFIT ANALYSIS
40	6.1 Develop model
41	6.2 Analyses
42	7. ACTIVITY 5: FINAL REPORT
43	8. PROJECT MANAGEMENT
44	9. REVIEW
45	9.1 Review 1
46	9.2 Review 2



ANNEXURE C

ORIGIN AND DESTINATION SURVEY QUESTIONNAIRE

ORIGIN DESTINATION SURVEY

Date / Data (11/04/94)	d d m m y y
Quest no.	
Time / Tempo (is 10:30 or 16:30)	h h m m
Interviewer / Intervistador	
Survey Point / Ponto de observacao	
Vehicle mass / Peso do veículo	(kg / kilogramas)

A) VEHICLE INFORMATION
A) INFORMACAO RESPEITANTE AO VEICULO

1. Registration number / Numero de Registo

2. Type of vehicle / Tipo de veiculo

	Car / Carro
	Bus / Autocarro
	Minibus / Autocarro ligeiro
	LDV / Carrinhas
	Motorcycle / Motocicleta
	2 Axle Truck / Camiao 2 Eixos
	3 Axle Truck / Camiao 3 Eixos
	4 Axle Truck / Camiao 4 Eixos
	5 Axle Truck / Camiao 5 Eixos
	Tractor with trailer / Tractor com Atrelado
	Tractor without trailer / Tractor sem Atrelado
	Other / Outro

3. Owner / Dono

4. Age / Idade (years / anos)

5. Country of registration
5. País de zegistraçao

Zimbabwe / Zimbabwe	Angola / Angola	Botswana / Botswana	Kenya / Kenya	Lesotho / Lesoto	Malawi / Malawi
Mosambique/ Mocambique	Namibia / Namibia	South Africa / Africa do sul	Swaziland / Swazilandia	Tanzania / Tanzania	Zambia / Zambia

6. What is the tare weight of the vehicle?
6. Tara do veículo (kg / kilogramas)

B) LOAD INFORMATION
B) INFORMACAO RESPEITANTE A CARGA

1. Number of occupants / Quantas pessoas no veiculo

2. Do you carry any cargo? / Leva carga? YES / SIM | NO / NAO

3.1 If yes, what type of cargo? 1 2 3 4 5 6 7 8 9 10 11 12 13
3.1 Sendo a resposta sim, que especie de carga?
3.2Specify / Specificado

4. How much cargo? / Quanta carga

25 % FULL 25 % CHEIO	50 % FULL 50 % CHEIO	75 % FULL 75 % CHEIO	100 % FULL 100 % CHEIO

5. Volume (tons, bags, etc.)
5. Volume (tonolado, numero de sacos de mercadoria)

6. Value / Valor US $ | R | Meticais

C) TRIP INFORMATION / INFORMACAO RESPEITANTE A VIAGEM

1. Direction / Direcao 1 | 2

2. Where did your trip begin? / Onde comecou a viagem?
2.1 Outside Mozambique /
2.1 Fora de Mocambique

Zimbabwe / Zimbabwe	Angola / Angola	Botswana / Botswana	Kenya / Kenya	Lesotho / Lesoto	Malawi / Malawi
Mozambique / Mocambique	Namibia / Namibia	South Africa / Africa do sul	Swaziland / Swazilandia	Tanzania / Tanzania	Zambia / Zambia

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2.2 Inside Mozambique / 2.2 Dentro de Mocambique	Beira	Maputo	Quilmane	Chimoio	Tete
	Other / Outro Name of town / Nome de cidade				
	Southern Mozambique / Sul de Mocambique				
	Central Mozambique / Centro de Mocambique				
	Northern Mozambique / Norte de Mocambique				

3. What is the final destination of your trip? / Quai a sua destinacao final?

3.1 Outside Mozambique/ 3.1 Fora de Mocambique	Zimbabwe / Zimbabwe	Angola / Angola	Botswana / Botswana	Kenya / Kenya	Lesotho / Lesoto	Malawi / Malawi
		Namibia / Namibia	South Africa / Africa do sul	Swaziland / Swazilandia	Tanzania / Tanzania	Zambia / Zambia

3.2 Inside Mozambique / 3.2 Dentro de Mocambique	Beira	Maputo	Quilmane	Chimoio	Tete
	Other / Outro Name of town / Nome de cidade				
	Southern Mozambique / Sul de Mocambique				
	Central Mozambique / Centro de Mocambique				
	Northern Mozambique / Norte de Mocambique				

4. How many hours do you expect to travel from the origin to the destination?
4. Quanto tempo espera que leva da partida ate chegar a destinacao final? [ ][ ][ ][ ][ ]

5. Do you use an alternative route sometimes?
5. Vai por um caminho difirente as vezes?

YES / SIM	NO / NAO

6.1 If yes, which route do you use?
6.1 Sendo esse o caso qual e o caminho que usa?
6.2 Why?
6.2 Porquê?

7. Do you use the same route coming and going?
7. Vai e volta pelo o mesmo caminho?

YES / SIM	NO / NAO

8.1 If not, which route do you use?
8.1 Sendo esse o caso qual e o caminho que usa?
8.2 Why?
8.2 Porquê?

9. What is the purpose of your trip? / Por que razao e que viaga?

9.1 Passenger vehicles / Veiculos passageiros	Work/Business / Trabalho/Negocio	To/From Work / Trabalho	Other / Outro
	Convey Passengers / Transportacao de Passageiros	Non Work/Recreation/Leisure / Turismo/Ferias	
9.2 Heavy vehicles / Veiculos pesados	Transport goods Transportcao de Carga	Non Work/Recreation/Leisure / Turismo/Ferias	
	Convey Passengers / Transportacao de Passageiros	Other / Outro	

10. How often do you use this road (route)? / Quantas vezos usa este caminho?

1	ONCE A DAY	UNA VEZ POR DIA
2	TWICE A DAY	DUAS VEZES POR DIA
3	ONCE A WEEK	UNA VEZ POR SEMANA
4	TWICE A WEEK	DUAS VEZES POR SEMANA
5	MONTHLY	MENSALMENTE
6	RARELY	RARO

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CATEGORIES OF GOODS CARRIED	
CATEGORY	**DESCRIPTION**
1	Live animals, animal products (live animals, meat, fish, chickens, eggs, milk, honey, diary products, wild game [meat])
2	Vegetable and fruit products (trees, plants, bulbs, flowers, vegetables, fruit, nuts, tea, coffee, cereals, wheat, mealie meal, corn, maize ground nuts, cashews, beans, cotton, vegetables, rice, fruit, tea)
3	Animal and vegetable fats and oils (edible fats, vegetable waxes)
4	Prepared foodstuffs, beverages, spirits, canned food, tobacco (Preparations of meat, fish, sugars, cereals, flour, animal feed, tobacco, spiritus, vinegar, beef, wine, canned/bottled food)
5	Mineral products (salt, sulphur, earths and stone, lime, cement ores slag, ash, mineral fuels, mineral oils and distilled products, bituminous substances)
6	Wood and articles of wood, charcoal, cork
7	Pulp of wood, cellulosic material, paperboard, paper (Pulp of wood, cellulosic material, scrap of paper, paperboard, printed books, newspapers, products of the printing industry)
8	Textiles and textile articles (silk, wool, cotton, filaments, staple fibres, special yarns, ropes, carpets, apparel and clothing)
9	Footwear, headgear, umbrellas, sun umbrellas, walking sticks, feathers
10	Articles of stone, plaster, cement, asbestos, mica, ceramic products, glass and glassware
11	Raw hides and skins, leather, furskins (raw hides and skins, articles of leather, saddlery, harnesses, hand bags, furskins)
12	Miscellaneous non-food consumer goods, medicines, used clothing, kerosene, soap, matches, building materials.)
13	Agricultural inputs (fertilizer, seeds, farm implements (tools), pesticides)

LISTA DE INFORMAÇÃO

INFORMAÇÃO RESPEITANTE A CARGA	
SECÇÃO	DESCRIÇÃO
1	Animais vivos e produtos derivados (Animais vivos, carne, peixe, galinhas, ovos, leite, mel, produtos lácteos, carne de caça)
2	Produtos vegetais e frutos (árvores, plantas, flores, vegetais, frutos, nozes, castanhas, chá, café, cereais, trigo, milho, grão de cereais, amendoim, caju, feijão, algodão, arroz)
3	Gorduras de animais ou vegetal assim como produtos derivados das gorduras de animais ceras de origem animal ou vegetal
4	Comidas pré-preparadas (bebidas, bebidas alcoólicas, comida enlatada, tabaco, preparações feitas de carne, peixe açúcar, cereais, farinha, rações para animais, comida engarafada, vinagre)
5	Produtos minerais (sal, súlfur, terra e pedras, cal, cimento, minério, resíduo mineral/minério, combustível mineral ou de óleo, produtos distilados, produtos betuminosos)
6	Madeira e artigos feitos de madeira (carvão de lenha (macala) cortiça, artigos feitos de cortiça, artigos feitos de palha, de esparto ou de outro material que é capaz de ser trançado, material para fazer cestos e objectos de vime)
7	Massa de madeira ou de outro material fibroso, de celulose, papeis ou cartões inutilizados: papel e cartão assim como artigos feitos desse material
8	Têxteis e artigos feitos de têxteis (seda, algodão, lã, fibra, fio, alcatifas, roupas, vestidos)
9	Sapatos, chapéus, sombrinhas, sombrinhas de praia, bengalas, assentos portáveis, chicotes e acessórios para esses artigos, penas e artigos confeccionados de penas, flores artificiais e artigos feitos de cabelo humano
10	Artigos de pedra, estuque, cal cimento, asbestos, mica ou feitos de materiais semelhantes, produtos cerâmicos, vidro e artigos de vidro
11	(Peles de animais, curtidas ou não, artigos de cabedal, selas, arreios, carteiras de mão, peles de animais)
12	Artigos acessórios (medicamentos, roupa usada, petróleo, sabão, fósforos, material de construção, materiais e acessórios de consumo)
13	Produtos agriculturais (fertilizantes, sementes, ferramenta agrícola, pesticidas)

ANNEXURE D

OPERATORS' SURVEY QUESTIONNAIRE

Origin and Destination / Vehicle Taffic Count Survey in Central Mozambique

Operators' Survey

Form No	

Please complete all the following questions as thoroughly as possible. There are some instances where you will have a choice of questions.

You are assured of CONFIDENTIALITY at all times. All information will be aggregated to ensure that individual operators' information does not become available.

Operator's and Interview Information

Name of Operator (this question is optional)	
Location	

Interview conducted by ...			
... for the operator (optional)		Date of Interview	
... for the study team		Time of Interview	

A. Fleet Information

		Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E
A.1	What TYPES of vehicles do you operate? *(e.g. Hino FF173)*					
A.2	NUMBER of vehicles of each type?					
A.3	What is the ENGINE CAPACITY (cc) of each type?					
A.4	How many WHEELS does each type of vehicle have?					
A.5	How many AXLES does each type of vehicle have?					
A.6	What type of FUEL does each type use?					
A.7	What is the average AGE of the vehicles ...					
A.7.1	... in YEARS?					
A.7.2	... in KILOMETRES?					
A.8	How many kilometres does each vehicle travel on average per year?					

Please proceed to section B.

B. Operating Costs

		Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E
B.1	How much FUEL (litres) does each vehicle type use per 100 km ...					
B.1.1	... on average?					
B.1.2	... on tarmac road?					
B.1.3	... on gravel road?					
B.2	How much do you spend on LUBRICANTS per vehicle type per 100 km ...					
B.2.1	... on average?					
B.2.2	... on tarmac road?					
B.2.3	... on gravel road?					
B.3	How many kilometers does one TYRE last ...					
B.3.1	... on average?					
B.3.2	... on tarmac road?					
B.3.3	... on gravel road?					
B.4	What are the WAGES per month for the following persons ...					
B.4.1	... driver?					
B.4.2	... assistant?					
B.4.3	... other crew?					
B.5	How many DAYS does each person work per month ...					
B.5.1	... driver?					
B.5.2	... assistant?					
B.5.3	... other crew?					
B.6	What is the OPERATING COST PER KM (US$c/km)?					
	or US$c/pax-km?					
	or US$c/ton-km?					

Please proceed to section C.

C. Maintenance

	Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E
C.1 How much is spent on average on PARTS per vehicle type per month?					
C.2 How much is spent on LABOUR FOR MAINTENANCE of vehicles per month?					

Please proceed to section D.

D. Purchasing of fuel, oil, tyres and spares

Where do you purchase ...	Location A	Location B	Location C	Location D	*En Route*
D.1.1 ... FUEL?					
D.1.2 At what price per litre? (If en route - average price)					

D.1.3 Are there specific reasons why you purchase fuel there?

D.2.1 ... TYRES?					
D.2.2 Do you purchase new tyres (N) or retreads (R)?					
D.2.3 At what price per tyre?					

D.2.4 Are there specific reasons why you purchase tyres there?

D.3.1 ... LUBRICANTS?					

D.3.2 Are there specific reasons why you purchase lubricants there?

D.4.1 ... SPARE PARTS?					

D.4.2 Are there specific reasons why you purchase spares there?

Please proceed to section E.

E. Trip Information

The area of interest to our study is presented in the CORDONED AREA on the attached map.

E.1 Do your vehicles travel in or through the cordoned area (see map)? Yes ☐ No ☐

If "Yes", please proceed to question E.3.
If "No", please proceed to question E.2.

E.2 Are there specific reasons why you do not travel in or through the cordoned area? Please elaborate.

If E.2 has been answered, the questionnaire is now complete. Thank you for your assistance.

E.3 Do you dedicate specific vehicles to the cordoned area? Yes ☐ No ☐

If "No", please proceed to Question E.3.3.
If "Yes", please proceed to Question E.3.1.

E.3.1 How many vehicles out of each vehicle category do you dedicate to the cordoned area?

Vehicle A	Vehicle B	Vehicle C	Vehicle D	Vehicle E

E.3.2 What are the reasons for dedicating specific vehicles to these routes? Please elaborate.

E.3.3 Each route section on the map has been numbered. Given the typical origins and destinations of your journeys, which would be the ROUTES that your vehicles follow? Please indicate these routes with reference to the relevant route sections. Should the route extend outside of the cordon line, please select the origin/destination closest to the cordon line. Please ignore all sections numbered B... .

Route	Origin	Section	Section	Section	Section	Section	Destination
Route A							
Route B							
Route C							
Route D							
Route E							

E.3.4 How many VEHICLE TRIPS do you do ON AVERAGE PER MONTH per route? (Coming and going = 2 trips.) What is the travel time over the route through the cordoned area? At what average speed (km/h)?

Route	Trips	Travel Time	Avge Speed
Route A			
Route B			
Route C			
Route D			
Route E			

E.3.5 Please indicate how the number of TRIPS PER MONTH DIFFER over a typical year. The total trips should correspond with the monthly average (indicated in E.3.4) times twelve.

Route	Jan	Feb	Mrc	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Route A													
Route B													
Route C													
Route D													
Route E													

E.3.6 For each of the routes identified in E.3.3, please indicate what your PREFERRED ROUTING will be should the preferred route be upgraded to an all-weather standard. You may include sections marked B... .

Route	Origin	Section	Section	Section	Section	Section	Destination
Route A							
Route B							
Route C							
Route D							
Route E							

E.3.7 How many VEHICLE TRIPS PER MONTH do you expect you will do assuming that the routes (as defined in E.3.6) are upgraded in the next year? What do you expect the travel time will be after the upgrade? What do you expect the average travelling speed (km/h) will be?

Route	Trips	Travel Time	Avge Speed
Route A			
Route B			
Route C			
Route D			
Route E			

E.3.8 Given your route preferences expressed in E.3.3 and E.3.6, what would be your RELATIVE PREFERENCE of crossing the Zambezi River (A) via ferry at Caia, or (B) via the bridge at Sena?

Route	Relative Preference in %	
	A: Caia ferry	B1: Sena Bridge
Route A		
Route B		
Route C		
Route D		
Route E		

Please proceed to section F.

F. Special Driving Circumstances

The following questions relate to the cordoned area on the map. Please average out your answers over all the routes identified in E.3.3.

F.1 Do you drive at NIGHT? Never ☐ Sometimes ☐ Always ☐

Please provide reasons for your answer.

F.2 Do you drive in CONVOY? Never ☐ Sometimes ☐ Always ☐

Please provide reasons for your answer.

F.3 Do you use POLICE ESCORTS? Never ☐ Sometimes ☐ Always ☐

Please provide reasons for your answer.

Please proceed to section G.

G. Cargo Information

A list of various types of CARGO are attached hereto. Each type has a specific code.

G.1 Which would be the TYPICAL CARGOES your vehicles carry per route (as defined in E.3.3)? What percentage of cargo on the route would you attribute to each cargo type?

Route	Cargo	%	Cargo	%	Cargo	%	Cargo	%	Cargo	%	Cargo	%	Cargo	%
Route A														
Route B														
Route C														
Route D														
Route E														

G.2 Please indicate how the volumes of each type of cargo identified in G.1 DIFFER OVER A TYPICAL YEAR, e.g. 20% of animal products are transported in each of January, February, March and April, and the remaining 20% in the rest of the year (i.e. 2,5% per month).

Cargo	Jan	Feb	Mrc	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Cargo													
Cargo													
Cargo													
Cargo													
Cargo													

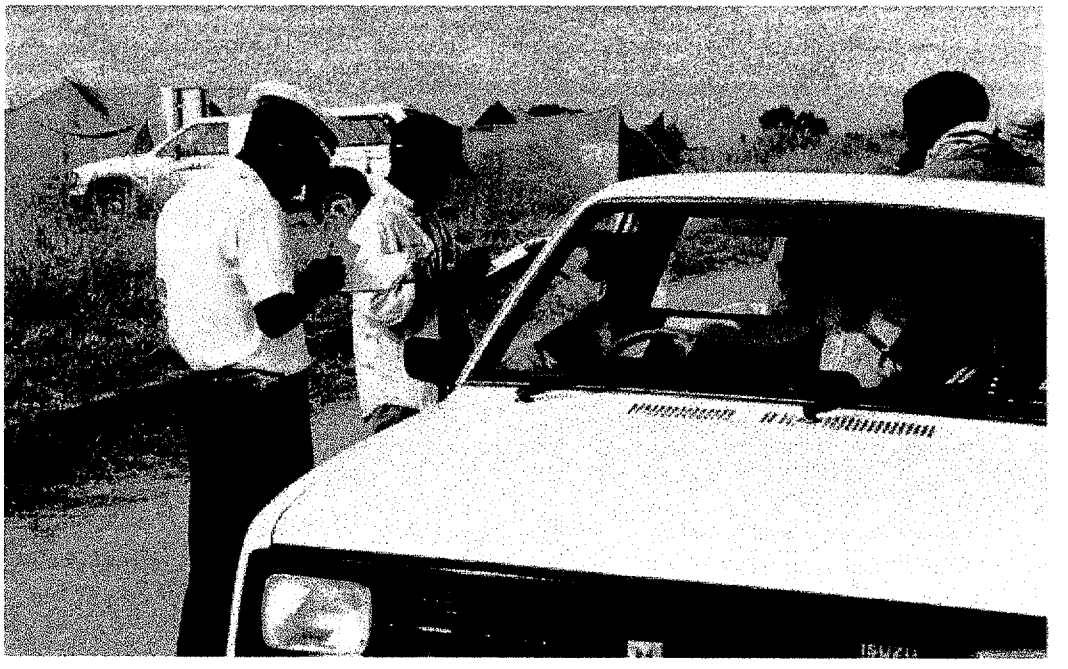
Thank you for your assistance.

CATEGORIES OF GOODS CARRIED	
CATEGORY	**DESCRIPTION**
1	Live animals, animal products (live animals, meat, fish, chickens, eggs, milk, honey, diary products, wild game [meat])
2	Vegetable and fruit products (trees, plants, bulbs, flowers, vegetables, fruit, nuts, tea, coffee, cereals, wheat, mealie meal, corn, maize ground nuts, cashews, beans, cotton, vegetables, rice, fruit, tea)
3	Animal and vegetable fats and oils (edible fats, vegetable waxes)
4	Prepared foodstuffs, beverages, spirits, canned food, tobacco (Preparations of meat, fish, sugars, cereals, flour, animal feed, tobacco, spiritus, vinegar, beef, wine, canned/bottled food)
5	Mineral products (salt, sulphur, earths and stone, lime, cement ores slag, ash, mineral fuels, mineral oils and distilled products, bituminous substances)
6	Wood and articles of wood, charcoal, cork
7	Pulp of wood, cellulosic material, paperboard, paper (Pulp of wood, cellulosic material, scrap of paper, paperboard, printed books, newspapers, products of the printing industry)
8	Textiles and textile articles (silk, wool, cotton, filaments, staple fibres, special yarns, ropes, carpets, apparel and clothing)
9	Footwear, headgear, umbrellas, sun umbrellas, walking sticks, feathers
10	Articles of stone, plaster, cement, asbestos, mica, ceramic products, glass and glassware
11	Raw hides and skins, leather, furskins (raw hides and skins, articles of leather, saddlery, harnesses, hand bags, furskins)
12	Miscellaneous non-food consumer goods, medicines, used clothing, kerosene, soap, matches, building materials.)
13	Agricultural inputs (fertilizer, seeds, farm implements (tools), pesticides)

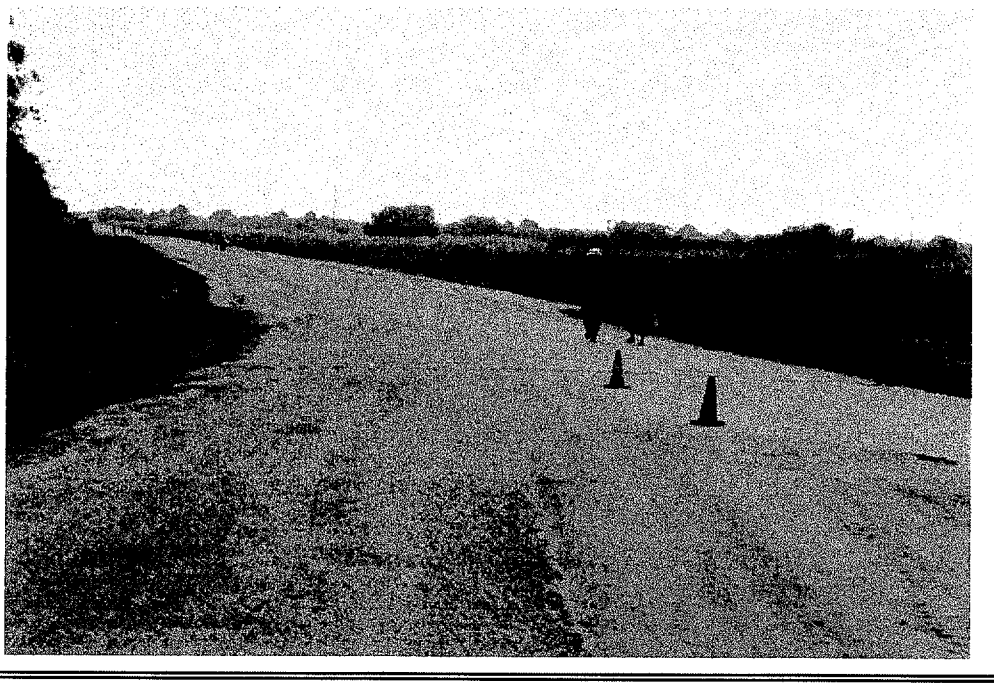
ANNEXURE E

PHOTOGRAPHIC RECORD

VEHICLE SURVEYS



1. Origin and destination surveys in progress



2. Loops in road for electronic vehicle count

WEIGH-IN-MOTION MEASUREMENTS OF AXLE MASSES

3. Setting up equipment at Nicuadala

4. Loops and weigh-pads in place at Changara

DONDO-CAIA ROUTE

5. Road surface below level of surrounding terrain

6. Caia ferry across Zambesi River

TYPICAL ROAD CONDITIONS

7. Mutarara to Nicuadala

8. Maputo to Beira

ANNEXURE F

LIST OF OPERATORS WHO SUPPLIED INFORMATION

The following vehicle operators were visited for questionnaires to be completed in order to obtain the necessary information regarding vehicle operating costs, etc.

In Maputo:

- Oliveira's
- CMC
- Mocargo
- Manica

In Beira:

- GDC
- Transcarga LDA
- COTAM
- Electro Sul
- Transportes Carlos Oliveira
- Transportes Cassamo
- R Nagibo
- A Concalves

In Nampula:

- Transportes Macedo
- Industrial de Transportes
- Transportes Narcisso
- Transportes Sadardine
- Agnaldo Lobo
- CCCH Ruguater
- O Victorino Vaz
- AA Bai Baba
- CJT Bettencourt
- JM de Sousa Theresa
- Gill Matias

- MF Praghii

In Blantyre:

- Unitrans
- Zagat Transport

In Harare:

- GDC
- Henrey Trucking
- Whelson Transport
- MTS
- Glen's Removals
- Colbro Transport
- Wheels of Africa.

The vehicle operators named above are not the only ones that were contacted. However, as the rest of the operators had indicated telephonically that they do not transport goods through the study area, their names were not included in the list.