The socio-economic effects of road maintenance in Iringa rural and Mufindi districts, Tanzania : an explorative case study into the input-functions for the calculation of maintainable core-networks

Daemen, L.

Award date:
2002

The Socio-Economic Effects of Road Maintenance in Iringa Rural and Mufindi Districts, Tanzania

An explorative case study into the input-functions for the calculation of maintainable core-networks

M.Sc. Thesis Paper

Loek Daemen **November 2002**

Student:
Loek Daemen, s376808

Supervising comittee:

Drs. H. Gaillard
Drs. W. Ruiter
Dr. H. A. Romijn

Technology and Development Studies
Faculty of Tachnology Management
Eindhoven University of Technology
Den Dolech 2
Postbus 53

Executive summary

Theoretical background

An appallingly condition of the road network has since long been one of the basic characteristics of developing countries, especially in Sub-Saharan Africa. In many of these countries it is not uncommon to find more than half the country's network being in poor condition, leaving vast parts of the country virtually inaccessible. The poor condition of the road network is an often-cited constraint for socio-economic development.

It is widely recognised that the bad state of the road network is caused by lack of maintenance funding. For decades developing countries have focussed on the construction of new roads rather than on maintaining the existing network. Over the last decade the emphasis has switched to road maintenance resulting in better maintenance funding. However, in most developing countries the maintenance funds do not meet the requirements for maintaining the entire network. For instance, it is estimated that the maintenance funding in Tanzania only suffices to maintain one-third of the entire network.

In order to tackle part of the problem international organisations such as the World Bank are focussing on the development of maintainable core-networks in order to spend the little funds as efficiently as possible in order to sustain socio-economic development. Developing maintainable core-networks requires prioritisation of roads within the network. In order to calculate the optimum maintainable core-network the economic effects of road maintenance need to be quantified. The quantifications then form the input-functions for the calculations.

Research set-up

The research is an explorative case study into the input-functions for the calculation of maintainable core networks. The **aim of the research** is defined as follows:

> *'To explore the input-functions for the calculation of maintainable core-networks of roads in the United Republic of Tanzania based on the socio-economic effects of road maintenance and their underlying mechanisms'*

The case study has been conducted in the Iringa Rural and Mufindi Districts in Iringa Region, Tanzania. The region has been selected based on the national long-term development goals and the national economic setting. The research area is a rural area that relies entirely on agriculture. The area has been selected for its economic importance to the country. The **research question** for the case study has been stated as follows:

> *'What are the socio-economic effects of road maintenance and their underlying mechanisms in Iringa Rural and Mufindi Districts in the United Republic of Tanzania?'*

For the purpose of planning road maintenance at network level the research aimed at determining the socio-economic effects for:

- Roads that are entirely maintained or unmaintained condition and
- Unmaintained roads that are connected by maintained roads

Selection of relevant socio-economic factors

The selection of the socio-economic factors is based on the long-term development goals and the guiding policy stances. **The economic factors** that have been selected **are agriculture, industry and tourism.** The **social factors** that have been selected **are market access, government, education and healthcare.**

Field research

In order to determine the socio-economic effects of road maintenance the field research has been split up into four partial studies.

The **first field study** focused on analysing **the effect of road maintenance on producer prices** for agricultural products. The effect of road maintenance on producer prices has been analysed by comparing the producer prices on maintained roads with those found on unmaintained roads. The data concern the six most important crops and have been taken from 27 villages.

The **second field study** analysed **the effect of road maintenance on agricultural production.** The effect has been analysed by comparing the sales production per person in villages on maintained roads with the sales production in villages located on unmaintained roads. The analysis has been performed for the four agro-ecological zones in the research area in order to exclude the effects of the different average yields in per hectare typical for the agro-ecological zones. 138 villages have been included in the analysis.

Combined the first two field studies determine the effect of road maintenance on income per capita from agriculture.

The **third field study** focussed on **the effect of road maintenance on the industrial and tourist sectors**. The effect of road maintenance on the industrial and tourist sectors is analysed by looking at the individual companies in the sectors and their relationship with transport. The population consists of all industrial and tourist companies active in Iringa Rural District

The **fourth field study** has analysed **the effect of road maintenance on the selected social factors**. The effect is measured by the number of trips made to centres that provide the social services, i.e. markets, health facilities, government headquarters and schools. The effect is analysed by comparing the average number of trips made from villages located on maintained roads with the average number of trips made from villages located on unmaintained roads. The data were acquired by conducting interviews with household representatives about their households travel behaviour. Interviews were conducted in seventeen villages, nine of which are located on maintained roads. In every village between 14 and 22 respondents have been interviewed. The analysis of the average number of trips made to district and regional hospital has been supported by data from patient registration records.

Results of the field studies

The field studies have produced the following results

Main results from the field studies

- **Linear relationships with distance to trunk road have been found for producer prices and sales production.**
- **The relationships for maintained roads diverge from the relationships for unmaintained roads.**
- **Producer prices and sales production are significantly higher on maintained roads.**
- **The operation of the industial and tourist sectors is not influence by road maintenance.**
- **The number of trips made by households shows no different patterns between maintained and unmaintained roads.**
- **Of all the villages from which patients were registered 64% have active bus services. Of all villages connected by bus services 76% recorded registered patients.**

Main conclusions

The results from the field studies have lead to the following main conclusions:

Main conclusions on the economic effects of road maintenance

- **Road maintenance has enormous effect on income per capita from agricultural production.** The drop in income recorded in the midland zone is up to 55,000 Tsh (65 U$) per person and up to 95% of total income.
- The loss of income per kilometre caused by lack of maintenance much higher than the rise in transport cost. **Basing the economic evaluation of road maintenance solely on transport costs would underestimate the effect for the midland zone by a factor of 15.**
- **Road maintenance has a strong positive effect on sales production.** The sales production was found to be substantially higher on maintained roads than on unmaintained roads.
- **Road maintenance has a strong positive effect on producer prices.** Producer prices decline 50% faster on unmaintained roads than on maintained roads.
- **The effect of road maintenance on the industrial and tourist sectors is reduction of transport costs.**

Main conclusion on the social effects of road maintenance

- **Road maintenance does not have any direct effect on market access, government and healthcare.**
- **Market access and healthcare are depending on the presence of transport services**
- **It could not be established whether road maintenance has any effect education**

Shortcomings of the research

Lack of maintained roads and the lack of appropriate sample groups have seriously hampered the field studies. As problems have resulted in the following shortcomings:

Shortcomings of the research

- **The behaviour of producer prices and sales production on unmaintained roads connected by maintained roads could not be established.**
- **The input-functions can not be generalised to other areas**

General recommendations

The results of the case study show that road maintenance has a very strong positive effect on the income of rural agricultural communities. Other research has shown that smallholder farming is one of Tanzania's comparative advantages and that increments to rural income have very strong multiplier effects. Considering that most of the road network in Tanzania is in very poor condition, especially in rural areas, road maintenance can provide a very strong impulse for economic growth and raising the income per capita. Since the latter is the most important long-term development goal the following recommendation is made:

In order to excellerate economic growth and increase the income per capita strong emphasis must be placed on maintenance of the road network

Most methods for the appraisal of investments in road infrastructure base the economic benefits on the reduction of transport costs that result from the investment. However, the results of the case study show that the reduction of transport costs resulting from road maintenance underestimate the economic effects by a factor up to 15. Furthermore, the effect on income is shown to vary between the agro-ecological zones in the research area. Reduction of transport costs per tonkilometre may be expected to be roughly the same for all areas. So, apart from underestimating the effect on income, the reduction of transport costs does not present an accurate picture of the economic effects of road maintenance. For these reasons the following recommendation is made:

Appraisal of investments in road infrastructure must be based on the effects on income in order to achieve an appropriate picture of the economic benefits of the investment

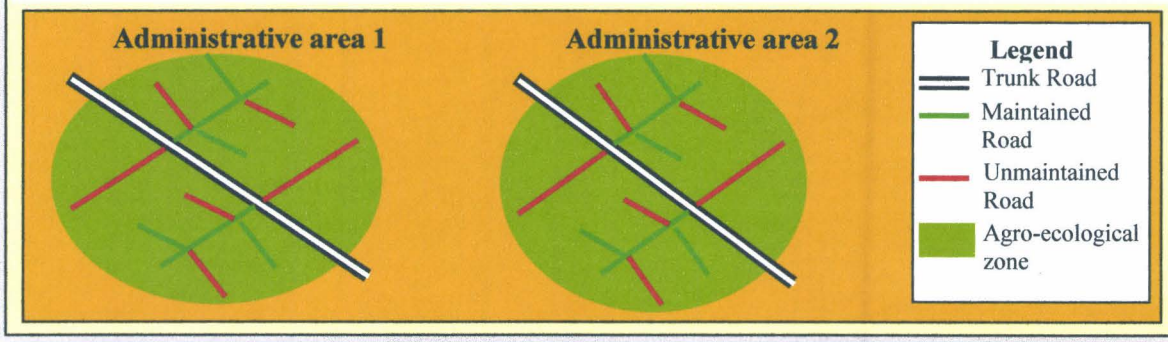
Recommendations for further research

The general recommendations made in the previous paragraph strongly underline the necessity for basing road maintenance on the effect on income per capita. In order to achieve input-functions that can be widely applied further research is recommended. In order to achieve this the research must meet the following requirements:

Prerequisites for further research

- **The research must compare the income per capita on roads that have recieved scheduled maintenace for a substantial period of time with roads that have not.**
- **The maintenance programme must follow the same standards for every road selected for the research.**
- **The research must focus on a limited number of agro-ecological zones with specific levels of productivity in terms of yield per hectare in order to determine the effect of productivity.**
- **In order to exclude the influence of local habits or government directives the research must take place in at least two different administrative areas for each agro-ecological zone.**
- **For a proper comparison each of the two areas requires:**
  - **Good connection by a trunk road.**
  - **At least two unmaintained roads.**
  - **At least two maintained roads that connect to a number of maintained and unmaintained roads that twine of at different distances from the trunk road.**
- **The proposed layout for a single agro-ecological zone is visualised in the figure below.**

'Proposed Layout of research area'



Preface

This paper presents the final report of my M.Sc. Thesis research for the Technology and Development Studies at the Eindhoven University of Technology. The research has taken place in the United Republic of Tanzania in co-operation with the National Construction Council.

I would hereby like to thank everyone who has helped me in any way during the long and tedious process of compiling my research and writing my report. First of all I want to thank my supervisors, Drs. H.A. Gaillard, Drs.W. Ruiter and Dr. H.A. Romijn for their endless patience in waiting for this report to arrive on their desk. Secondly I would like to thank Mr. Msita, Ms. Kinasha and Mr. Mamiro from the National Construction Council for hosting my research and providing me with the proper contacts to get me started. Furthermore, my translator, Godfrey Mtweve, who travelled with me over all the 'kipeche' road to help me with my interviews.

I have met many people during my stay in Tanzania, but I have to thank some people without whom my stay would not nearly as pleasant and comfortable. First of all my thanks goes out to John van Rijn who has let me stay with him during the first months of my presence and introduced me to many fruitful contacts. Just a pity he supports the wrong team. Also I am much obliged to all the people from SPW Tanzania for the unforgettable games of 'goody', the 'kiti moto', things would have been quite boring without you. Last of all is send my gratitude to father Joseph Konda, for all the meals I had at his house.

Last but not least I would like to thank my parents and grandmother for their moral and not in the least financial support during my research. Without you it would not have been possible.

Table of contents

Chapter 1 Introduction

1.1 Background

One of the most pressing problems and an often-cited constraint for economic development in developing countries, especially Sub-Saharan Africa is the poor state of the road infrastructure. The results of the poor condition of the roads are manifold; High transportation costs, vast parts of countries being disconnected from the outside world and markets, poor access to social institutions like schools and health care facilities for a major part of the community and poor access to markets for agricultural and industrial output resulting in low producer prices.

In recent years the poor state of the road networks in developing countries has been recognised by the international donor organisations and governments of developing countries as being on of the major constraints for socio-economic development and poverty eradication. In the recent past there has been a very distinct shift from investments in new infrastructure towards rehabilitation and maintenance of existing structures.

In most of sub-Saharan Africa the budgets for road maintenance do not meet the requirements. It is not uncommon to find that the available budget for roads or road maintenance sufficient to maintain only half or one third of the roads in the country.

The budgetary insufficiency to meet the requirements to maintain a countries entire road network and the resulting effects on a countries socio-economic development presses for accurate planning and allocation of the available funds in a way that the road network supports a country's goals as good as possible. Planning network maintenance under these severe budget constraints basically means scaling down a country's road network to a so-called core network.

1.2 Scientific relevancy

At present only a few core network approaches are available but deciding which roads are part of the core network and which are not is a problem that still persists. The most widely used model for investment or maintenance appraisal for roads are the Highway Design Standards and Maintenance Model HDM-III. HDM-III is developed under supervision of the World Bank and is now in the hands of an organisation called Piarc who are developing version 4 of the model.

For planning core networks the existing models have a few shortcomings. Firstly, most models used for planning or prioritising road works only evaluate individual road section without looking at its relation with and function within the road network.

The second shortcoming is that most models in used base investment decisions on reduction in transport costs that result from the investment. Using the reduction in transport costs causes a few problems. One problem is that it is based on the traffic flow that a road carries. Data on traffic flow in developing countries are usually rare and inaccurate. Furthermore, impact studies on road rehabilitation projects often show a strong increase in traffic once a road has been rehabilitated. This means that traffic flows before rehabilitation or maintenance provide an inapt picture of a roads importance in terms of traffic flow. More importantly, the reduction of transport costs may well underestimate the socio-economic effects of road maintenance. Several studies on the role of road networks in developing countries show a tremendous impact on amongst others rural income, agricultural production and access to important places such as markets, schools and health facilities.

The **scientific relevancy** of this research lies in its aim to assess the socio-economic impact of road maintenance in a way that it can be used for the planning of maintainable core networks. The research contributes to the insight in the mechanisms at work that determine the socio-economic effects of road maintenance.

1.3 Social relevancy

Assessing the socio-economic impacts of road maintenance and its underlying mechanisms is the first step towards a planning methodology for road maintenance at network level based on the socio-economic benefits of road maintenance. Although this research is only a exploratory pilot study, the ultimate goal is to develop a methodology for planning maintainable core-networks that support a country's socio-economic development goals as efficient as possible.

1.4 Organisational setting

The research has been conducted in co-operation with the NCC, the National Construction Council *(Baraza la Taifa la Ujenzi)* of the United Republic of Tanzania. The NCC is a parastatal organisation that provides information, training and support for the construction sector in Tanzania. It provides information, training and support on planning, design, budgeting, project management, research, construction methods and labour based technologies. The work field of the NCC comprises all construction works including roads, bridges and buildings. These services are provided to contractors, government institutions and other organisations. In order to achieve its goals the NCC keeps close contacts with all actors in the Tanzanian construction sector, including road authorities, road contractors and the Ministry of Works.

The research has been treated as an independent research within the NCC under supervision of the director, Mr. K.M. Msita, and chief consultant, Ms. E.K. Kinasha. They have provided the researcher with the necessary contacts and information.

1.5 Report set-up

The main report of this research is set up in three parts. Part one discusses the set-up of the research. Part two presents the results of the studies undertaken in this research. Part three contains the final conclusions and recommendations.

Part one, the research set-up, contains three chapters. Chapter 2 deals with the background of the research. It provides the information on which the research questions and theoretical framework are based. These are discussed in chapter 3 along with the research aim and problem definition. Chapter 4 describes the research methodologies used for the research.

Part two, the result of the partial studies, is divided into three sections. Section A contains a base-line study for location background (chapter 4) and for the classification of roads for research purposes (chapter 5). Section B discusses the economic effects of road maintenance based on field data Chapter 6 to 9). The results of the study of the social impact of road maintenance are presented in section C (Chapter 10).

Part three discusses the final conclusions of the research, the general recommendations and the recommendations for further research (Chapter 11).

Part One

Research set-up

Chapter 2 Theoretical background

This chapter describes, in short, the theoretical background of the research. The aim is to determine what elements need to be researched in order to establish the input-functions for calculations of maintainable core-networks. Paragraph 2.1 discusses the causes and effects of poor road quality. The properties of maintainable core-networks are explained in 2.2. Paragraph 2.3 discusses the input-functions for the selection of roads for maintainable core-networks. All paragraphs lead to the conclusions with regard to the elements that need to be researched, which are presented in 2.4.

2.1 Causes and effects of poor road quality

One of the most pressing problems and an often-cited constraint for economic development in developing countries, especially Sub-Saharan Africa is the poor state of the road infrastructure. It is not uncommon that most of the roads in these countries are in very poor condition, in many cases making them impassable. Table 2.1 shows the road condition in some Sub-Saharan countries in 1990.

Table 2.1: 'Road condition. 1990'

Country	Paved roads		Unpaved roads	
	Good	Fair/ poor	Good	Fair/ poor
Tanzania	24%	76%	10%	90%
Zambia	40%	60%	30%	70%
Kenya	32%	68%	66%	34%
Malawi	50%	50%	30%	70%
Zimbabwe	70%	30%	50%	50%

Scource: World Bank, The United Republic of Tanzania, Integrated Roads Project, Staff Apraisal Report, 1990

The poor state of the road infrastructure in many developing countries is a result of poor construction, overloaded vehicles, severe weather conditions and lack of maintenance culture resulting in poor organisational structure, planning methods and lack of funds allocated for road maintenance. The lack of maintenance funding is generally regarded as the main cause of the poor road condition in developing countries. Up until about a decade ago investments in road infrastructure focussed primarily on the constructions of new roads. Road maintenance was widely neglected. In recent years the focus has changed dramatically towards road maintenance for the existing road networks.

The effects of the poor condition of the roads are manifold. **There are two main mechanisms at work that determine the effects of poor road quality**.

The **first effect** of poor road quality is that it causes a strong **increase in vehicle operation costs**[1] or transport costs. The rise of transport costs can result in lower producer prices obtained by villagers for their agricultural output. This, in turn, may cause production levels to drop causing a massive decrease in income[2]. The decreased income can bear heavy social effects of all kinds. It can result in lesser visits to health facilities, markets schools etc.

The **second effect** of poor road quality that is widespread in developing countries **is poor access**. Poor road quality may cause roads to become impassable or at least not economically viable for the operation of transport services. This leaves many communities without or poor and expensive access to the outside world, health facilities, markets and schools and the makes villages inaccessible for traders[3,4]. This also leads to lower production and decreased income.

2.2 Maintainable core-networks

Even though road maintenance is now recognised as one of the most pressing problems in developing countries, most countries have not yet been able to establish proper funding. In most of sub-Saharan

[1] Molenaar, prof.dr.ir.A.A.A., Structural Design of Pavements, Part II: Design of Earth and Gravel Roads, Lecturnotes CTVb4860, Delft, January 1999

[2] Gaviria, J, Rural Transport and agricultural Performance in SSA: 6 County Case Studies, World Bank, May 1991

[3] Howe, J.D., Various publications

[4] Edmonds, G, Wasted Time: The Price of Poor Access, RATP No. 3, ILO, Geneva, 1998

Africa the budgets for road maintenance still do not meet the requirements. For instance in Tanzania, where a road fund has recently been established (see appendix 1) the available budget for roads or road maintenance sufficient to maintain only half or one third of the roads in the country.

The absence of proper planning tools and capabilities enhances the problem because in general road maintenance programs focus on maintenance of parts of the entire existing network. In many cases little coherence can be found between the projects. This results in parts of the network being rehabilitated and/ or maintained that are not connected with one another. Network-based planning is seen as the correct response to this situation. This approach is currently advocated by the international agencies as the World Bank and UK Transport and Road research Laboratory. **A maintainable core-network can be defined as follows:**

> *'A maintainable core-network is a coherent and interconnected network of roads that consists of a selection of roads from a larger network and that can be maintained with the available funds for road maintenance.'*

The available maintenance budget and the costs of road maintenance determine the size of the maintainable core-network. The network is coherent and interconnected, meaning that every maintained road section in the core-network is connected to each other, be it directly or by other maintained road sections of the core-network.

2.3 Prerequisites for selecting roads for core-networks

2.3.1 Road maintenance programmes

In order to determine the size of the selection of roads for the maintainable network it is necessary to have good insight in the costs of road maintenance over a longer period of time. Considering the often-weak organisational structure of the road authorities in developing countries, the cost of road maintenance can only be based on scheduled maintenance programmes. Scheduled maintenance programmes consist of repetitive cycles of routine and recurrent maintenance that together keep roads in maintained condition. Road authorities in developing countries do not have the funds, equipment and organisational framework to plan and execute maintenance as a response to road condition. Due to lack of funding there is no experience with responsive maintenance programmes on which maintenance costs can be based. As a result, **maintainable core-networks can only be based on scheduled maintenance programmes.**

2.3.2 Prioritising roads for selection

Within an existing road network, a maintainable core-network can take many shapes. Selecting roads for the core-network is therefor a matter of prioritisation. Prioritisation of roads for investments such as road maintenance is done on basis of the expected benefits derived from the investment. Most existing models for evaluation of investments in road infrastructure use the reduction of transport costs as the benefits of the investment. However, in developing countries road maintenance or lack thereof has effects on socio-economic scale that stretch beyond the effect on transport costs, as is explained in paragraph 2.1.

Furthermore, the function of road infrastructure is to support and enhance a country's or regions social and economic structure. Therefor, **prioritisation of roads can best be done on basis of the socio-economic effects expected from the investment.** In the case of developing countries the socio-economic development goals can be taken as a guideline for the selection of the socio-economic effects on which prioritisation can be based.

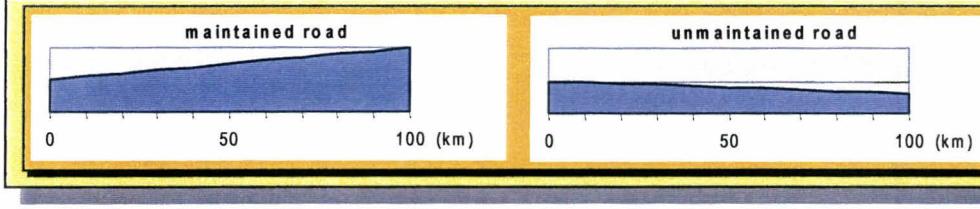
2.3.3 Quantifying the socio-economic effects of road maintenance

Many of the socio-economic effects of road maintenance are in some way related to the reducing effect on transport costs caused by road maintenance. Transport costs become higher when the distances to be

travelled gets longer. It is therefor likely that the socio-economic effects resulting from the reduced transport costs also have a relationship with distance. For example if the distance over which agricultural produce needs to be transported to the market is longer, the costs for transporting the goods becomes higher. However, the sales prices for agricultural at the market are fixed. Therefor, the price a trader can afford to pay for produce in villages far away from the market is lower than in villages located close to the market. If the costs of transport are high due to the lack of road maintenance the prices will decline more rapidly. This behaviour may be expected for the other socio-economic effects as well. Linear relationships between school attendance and hospital visits have been found in a case study in India[5].

The socio-economic factors affected by road maintenance are likely to have a relationship with distance to the place that needs to be accessed. In case of healthcare the place to be accessed is a hospital. The relationships for producer prices and agricultural production are related to the distance to the market. However, it must be noted that the main destination for agricultural products may be located outside the area for which the core network is designed. For rural areas the relationship can then be related to the most important transport route.

Figure 2.1 'Effect of maintenance; example'

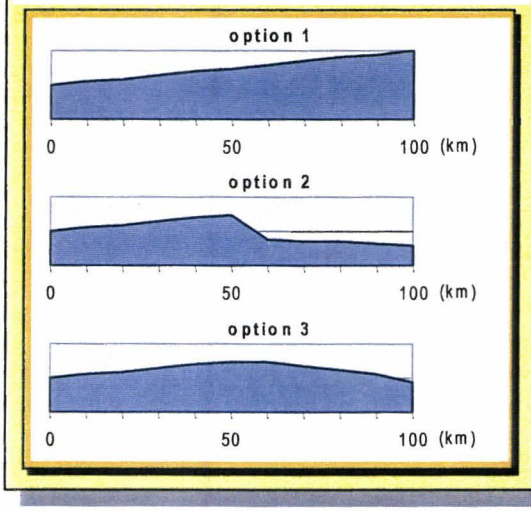


In case the socio-economic factor has a linear relationship with distance, the effects takes the shape of the example shown in figure 2.1. The example shown in the figure is a purely hypothetical case of two relationships for maintained and unmaintained roads. The relationships with distances have slopes with different directions. **The effect of road maintenance is then expressed by the difference between the relationship with distance for maintained and unmaintained roads.**

Knowing the difference between the relationships for maintained and unmaintained roads does not suffice for prioritising road sections for maintainable core-networks. Because the core-network is part of a bigger network it is likely that only the first section of a road is selected for the core-network. Maintenance of the first section can then still have an effect on the following unmaintained sections. The effect on unmaintained sections connected by maintained sections can take several shapes. The following three options are most likely to occur:

1. The socio-economic factor behaves as if the entire road is maintained
2. The socio-economic factor behaves as if the entire road is unmaintained
3. The socio-economic factor behaves as a combination of the two

Figure 2.2 'Effect of maintenance; options'



The three options are visualised in figure 2.2 for an example of a road that is being maintained for the first 50 kilometres and unmaintained for the last 50 kilometres.

[5] Kumar, A., Tillotson, H.T., A comprehensive planning methodology for rural roads in India, New Delhi, 1990

In order to assess the effect of maintaining a section of road it is necessary to include the effects on unmaintained sections of road that are connected by the maintained section.

The relationships found for the selected socio-economic factors serve as the input-functions for the calculation of the optimum maintainable core-network.

2.4 Method of calculating the optimum core-network

Once the input-functions calculations of core network are known the optimum maintainable network can be calculated. The method of calculation is as simple as it is complex. The size of the network is determined by the available maintenance budget and the maintenance costs for each individual link in the network. Based on the budget and costs a number of core networks can be designed The optimum maintainable core-network is the one that produces the highest output based on the input-functions.

2.5 Conclusions

With regard to the explorative research into the input-functions for calculation of maintainable core-networks the following conclusions can be drawn:

- **Maintainable core-networks can only be based on scheduled maintenance programmes.**
- **Prioritisation of roads can best be done on basis of the socio-economic effects expected from the investment.** The socio-economic development goals can be taken as a guideline for the selection of the socio–economic effects on which prioritisation can be based.
- **The socio-economic factors affected by road maintenance are likely to have a relationship with distance to the place that needs to be accessed.** The effect of road maintenance is then expressed by the difference between the relationship with distance for maintained and unmaintained roads.
- **In order to assess the effect of maintaining a section of road it is necessary to include the effects on unmaintained sections of road that are connected by the maintained section.** The following three options are most likely to occur:
  1. The socio-economic factor behaves as if the entire road is maintained
  2. The socio-economic factor behaves as if the entire road is unmaintained
  3. The socio-economic factor behaves as a combination of the two

Chapter 3 Research design

This chapter describes the way in which the research has been set up. Paragraph 3.1 discusses the theoretical issues of the research set-up. These comprise the research aim, the problem definition, the research questions and the conceptual model. Paragraph 3.2 explains the empirical issues regarding the research. In this part the research instruments, data acquisition, sampling procedures and method of data analysis is worked out for each partial study undertaken in this research.

3.1 Theoretical issues

This chapter discusses the theoretical issues of the research. Paragraph 3.1.1 presents the aim of the research. Paragraph 3.1.2 defines the scope and boundaries of the research. The problem definition is discussed in 3.1.3. The problem definition is split up in several research questions, which are presented in 3.1.4. Paragraph 3.1.5 elaborates on the conceptual model applied for the research.

3.1.1 Research aim

The aim of this research is defined as follows:

> *'To explore the input-functions for the calculation of maintainable core-networks of roads in the United Republic of Tanzania based on the socio-economic effects of road maintenance and their underlying mechanisms'*

3.1.2 Scope of the research

The research is an explorative pilot study into the input-functions for the calculation maintainable core-networks of roads based on the socio-economic effects of road maintenance and their underlying mechanisms. The research presented in this paper has been executed in Iringa Rural and Mufindi districts in the United Republic of Tanzania. Due to limits in time and budget the research has not been conducted on a larger scale. This meant that the research was restricted to the availability of suitable roads in these two districts. This has resulted in a limited set of data and a relatively small sample of roads. The results of the study as well as the input-functions for the model can therefor not automatically be generalised nor be copied to a different location.

3.1.3 Problem definition

In order to explore the input-functions for the calculation of core networks based on the socio-economic effects of road maintenance, these effects need to be analysed. Therefor the problem definition for this research is:

> *'What are the socio-economic effects of road maintenance and their underlying mechanisms in Iringa Rural and Mufindi Districts in the United Republic of Tanzania?'*

3.1.4 Research questions

The problem definition can be split up in two main questions. Based on the United Republic of Tanzania national setting and the local setting in the research area as presented in chapter 3 these two questions are divided in seven sub-questions. With regard to the effects of road maintenance on the agricultural sector three more sub-questions are posed. The research questions posed are the following:

1. **'What are the economic effects of road maintenance?'**
   - a. 'What are the effects of road maintenance on the agricultural sector?'
     - *i* *'What is the effect of road maintenance on producer prices?'*
     - *ii* *'What is the effect of road maintenance on agricultural production?'*
     - *iii* *'What is the effect of road maintenance on rural income per capita?'*
   - b. 'What are the effects of road maintenance on the industrial sector?'
   - c. 'What are the effects of road maintenance on the tourist sector?'

2. **'What are the social effects of road maintenance?'**
   a. 'What is the effect of road maintenance on market access?'
   b. 'What is the effect of road maintenance on government?'
   c. 'What is the effect of road maintenance on education?'
   d. 'What is the effect of road maintenance on healthcare?

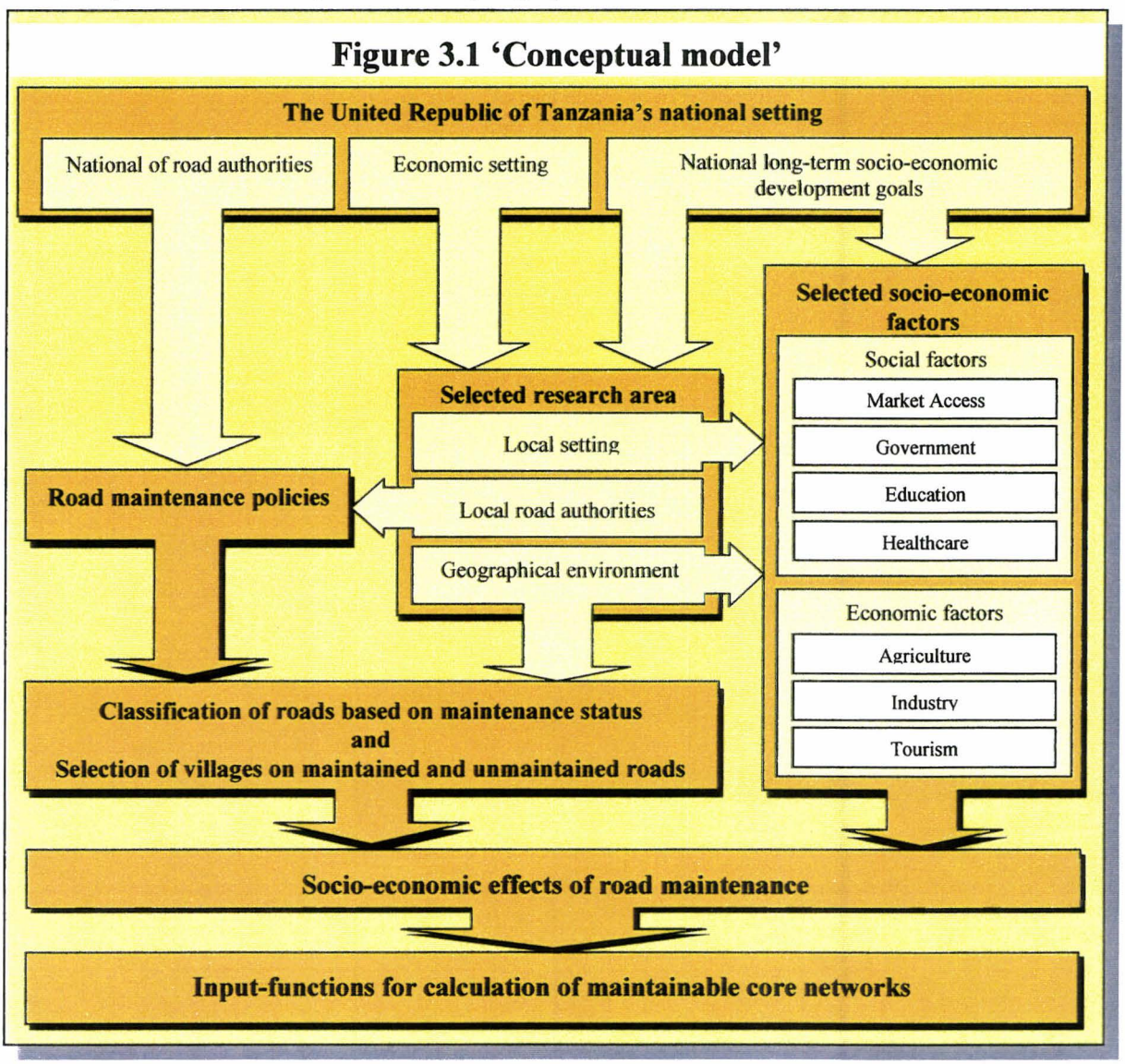
In order to derive input-functions for the calculation of maintainable core networks all research questions have to be answered for both entirely maintained routes and for unmaintained roads that are connected by maintained roads. The reasons for this are discussed in the theoretical background in chapter 2.

Furthermore, the questions have to be answered separately for the four agro-ecological zones present in the research area since they may have strong influences on the outcomes.

3.1.5 Conceptual model

Figure 3.1 shows the conceptual model used in the research. The darker shaded boxes form the main elements of the conceptual model. The lighter boxes within draw a more detailed picture of the most important sub-elements of which the main elements consist. These sub-elements are selected by the baseline study concerning the location setting of the research presented in chapter 4. The elements of the conceptual model are explained in the paragraphs that follow below.

Figure 3.1 'Conceptual model'



3.1.5.1 United Republic of Tanzania's national setting

The United Republic of Tanzania's national setting is of great influence for the set-up of the research. The most elements of the national setting that are most relevant to the research are the institutional setting of the road authorities, the economic setting and the national long-term development goals.

The **national road authorities** are responsible for road maintenance in the country. The institutional setting determines the policies and funding for road maintenance. It has great influence on the methods applied for road maintenance.

The **economic setting** defines the structure of the Tanzanian economy. It determines the relative importance of the sectors of the economy.

The **national long-term development goals** deal with the development targets set for 2025. The long term-development goals comprise a range of socio-economic elements towards which the development of policies and the allocation of funds by the government are targeted. The goals and the elements most relevant for this research are described in the base-line study regarding the location background presented in chapter 4.

3.1.5.2 Selected socio-economic factors

The selected socio-economic factors are the elements of the national long-term development goals and local government policies that are expected to be influenced by road maintenance. The selection of these socio-economic factors is discussed in chapter 4. The effect of road maintenance is analysed for all selected socio-economic factors. The socio-economic factors correspond with the sub-questions posed in paragraph 3.1.4.

3.1.5.3 Selected research area

The selected research area for consists of Iringa Rural and Mufindi Districts. The selection of the area is based on the long-term development goals and the economic setting of the United Republic of Tanzania. Assuming that the situation for the social development goals does not differ strongly between regions and districts the selection of the research area is based on the economic goals. Taking into account the structure of the Tanzanian economy, an area has been selected that shows characteristics that are suitable for analysing the economic effects of road maintenance. This selection is discussed in more detail in chapter 4.

The **local setting** concerns the local situation with regard to the socio-economic criteria based on the national long-term development goals. The local setting influences socio-economic factors selected for the research. It furthermore determines the selection of the research units necessary and available for the analyses of the socio-economic effects of road maintenance in the research area.

The **local road authorities** are responsible for planning and executing maintenance of the road network in the research area. The local road authorities determine the allocation of maintenance funding to individual road section and the methods and programmes applied in the research area.

The **geographical environment** determines the terrain characteristics relevant for the research. It is of great importance for the productivity of the agricultural sector and the soil and terrain characteristics that determine the rate of road deterioration. Four agro-ecological zones are distinguished that have specific different characteristics relevant fir the research.

3.1.5.4 Road maintenance policies

The road maintenance policies determine the methods used for road maintenance and set the limits for deterioration and frequency of maintenance cycles. They are determined by the institutional setting of the national road authorities and the regional and district maintenance policies.

3.1.5.5 Classification of roads and selection of villages

The classification of roads classifies roads as being in maintained or unmaintained condition. Based on this classification villages can be selected that are suitable for the analysis of the effects of road maintenance. The classification of roads is determined by the road maintenance policies and the geographical environment of the research area. The classification of roads is dealt with in chapter 5.

3.1.5.6 Socio-economic effects of road maintenance

The socio-economic effects answer the problem definition expressed in paragraph 3.1.3. The answer is determined by analysing the differences in selected socio-economic factors for selected villages located on maintained and unmaintained roads. The analyses of the effects of road maintenance on the selected socio-economic factors are discussed in sections B and C of the results of the research.

3.1.5.7 Input-functions for the calculation of maintainable core-networks

The input-functions for the calculation of maintainable core-networks form the inputs for a calculation methodology and the conditions to which the calculation methodology must comply. They are based on the mechanisms that describe the socio-economic effects of road maintenance. The input-functions are dicussed in the conclusions and recommendations in chapter 11.

3.2 Empirical issues

3.2.1 Division in partial studies

The research has been split up into seven partial studies. The partial studies deal with individual parts of the conceptual model. Each partial study is presented in separate chapters of this report.

3.2.2 Study 1: Baseline study into location background

The baseline study about the location background aims to determine the basic parameters for the research. The baseline study consists of two parts both presented in chapter 4. The first part describes the United Republic of Tanzania's national setting. It deals with the selection of the socio-economic factors relevant for the research, the selection of the research area and the maintenance policies relevant for the classification of roads. The second part concerns the context of the research area, Iringa Rural and Mufindi Districts. It presents all relevant information about the research area.

The information presented in the baseline study is derived from various sources such as policy reports, research reports, statistical data and data from government institutions. The actual sources of the data are mentioned where necessary.

3.2.3 Study 2: Classification of roads and selection of villages

The classification of roads and the selection of villages is presented in chapter 5. The classification is based on the policies for and methods of road maintenance applied in the research area. These policies and methods are described in chapter 4. Calculations have been made using the deterioration models for unpaved roads from the Highway Design and Maintenance Standards Models (HDM-II) developed by the World Bank. The input data for the models are derived from local government institutions. All data are presented in appendix 3.

The selection of villages is done according to the prerequisites for selection for each partial study as presented in the paragraphs below.

3.2.3.1 Study 3: Effect of road maintenance on producer prices

3.2.3.2 Research instrument

The effect of road maintenance on producer prices is analysed by comparing the producer prices of the main agricultural products on maintained roads with those on unmaintained roads.

3.2.3.3 Sampling procedure

Data have been taken from villages located on maintained and unmaintained routes in three of the four distinguished agro-ecological zones. The villages are the same as those for the analyses of the social effects of road maintenance (see paragraph 3.2.8) with the addition of several other villages that have been visited for other purposes. The villages from which data have been collected are depicted in Map 3. Data have been taken from 24 villages in total.

3.2.3.4 Data acquisition

The data on producer prices have been gathered from the local village officials. Data have been taken for producer prices during the harvesting season, during which the bulk of the produce is sold and the producer prices are at their lowest point.

3.2.3.5 Method of analysis

The data are analysed by using linear regression analyses. By doing this the relationships between distance and producer prices have been established for maintained and unmaintained roads for each individual product.

3.2.4 Study 4: Effect of road maintenance on agricultural production

3.2.4.1 Research instrument

The effect of road maintenance on agricultural production is analysed by comparing the production for sales in hectares per person in villages on maintained roads with the production in villages on unmaintained roads. The comparisons are made, if possible, for each agro-ecological zone. The effect on unmaintained roads that are connected by maintained roads is done by comparison of the production data with the expected production based on the three options described in chapter 2.

3.2.4.2 Sampling procedure

Roads have been classified on basis of their maintenance condition as 'maintained', 'unmaintained' or 'indiscriminate'. Villages are grouped for each agro-ecological zone based on the following principles:

- Villages are grouped according to the classification of the road on which they are located.
- Villages are selected for the 'maintained' or 'unmaintained' sample groups only if the entire route to the trunk road is classified as either 'maintained' or 'unmaintained'.
- Only villages located on surveyed roads are included since villages found to be located away from any of the surveyed roads may in fact be connected by unclassified road. The maintenance condition of these roads is then unknown and may lead to distortions.

Separate selections have been made to assess the effects on unmaintained roads that are preceded by maintained roads.

3.2.4.3 Data acquisition

All data on agricultural production have been gathered from Divisional Extension Officers (DEO's). The data represent the total agricultural production during the 1999-2000 season of each village in hectare for all products that are grown in each village. The data are produced by the DEO's by sampling. They measure the size of land used for each product for a limited number of households per village. The average from this sample is then used to calculate the production of the entire village.

3.2.4.4 Method of analysis

The effect of road maintenance is analysed by performing linear regression analyses. This results in linear relationships between distance and the level of production. These relationships are then compared with each other for each agro-ecological zone. The analysis of the data for unmaintained roads that are connected by maintained roads are compared with the expected values based on the linear relationships found for maintained and unmaintained roads.

3.2.5 Study 5: Effect of road maintenance on rural income

3.2.5.1 Research instrument

The effect of road maintenance on rural income is calculated by the combination of the effects on producer prices and the effect on production. In order to determine the effect on income the income form direct sales on the central markets which is not affected by road maintenance, is subtracted. The sales on the central markets is determined by the average number of trips to the market with the purpose of selling produce and the average quantity of produce sold.

3.2.5.2 Data acquisition

The data for the analysis of the quantity of produce sold on the market is gathered by interviews. Respondents are asked the number of trips to the central market for selling produce and the quantity of produce sold per trip. The questions are incorporated in the social impact survey described in paragraph 3.2.8.

3.2.5.3 Sampling procedure

The selection of villages and sampling procedure for respondents is the same as for the social impact survey described in paragraph 3.2.8.

3.2.5.4 Method of analysis

The quantity of produce sold is analysed by comparing the averages on maintained roads with those on unmaintained roads. The averages are then subtracted from the total sales production in order to determine the effect of road maintenance on rural income.

3.2.6 Study 6: Effect of road maintenance on the industrial and tourist sector

3.2.6.1 Research instrument

The effect of road maintenance on the industrial and tourist sectors is analysed by looking at the individual companies in the sectors and their relationship with transport. The results of this study are summarised in chapter 9.

3.2.6.2 Population and research unit

The population consists of all industrial and tourist companies active in Iringa Rural District. In total five industrial companies and one tourist attraction are present in the area. The research unit is the individual company.

3.2.6.3 Data acquisition

Data are gathered from key-informants. The information is gathered by unstructured interviews.

3.2.6.4 Method of analysis

The basic information on the individual companies is reviewed in order to see whether road maintenance has any other effect than reduction of transport costs. The effect on transport costs is analysed by the quantity of transported goods.

3.2.7 Study 7: Effect of road maintenance on social factors

3.2.7.1 Research instrument

The effects of road maintenance on the selected social factors are analysed by the number of trips made by village households to the centres that provide the social services. The average number of trips for maintained roads is compared to the averages for unmaintained roads. The results of the analyses are elaborated on in chapter 10.

3.2.7.2 Data acquisition

The data are acquired by means of structured interviews. The interviews consist of 18 questions concerning the number of trips per year to the social service centres and the means of transportation. The questionnaires are shown in overview 1 of appendix 5.

3.2.7.3 Population and research unit

The population for the interviews is the entire population of each of the selected villages. The research units are village households. The interviews are conducted with household representatives.

3.2.7.4 Sampling procedure

Due to limitations in time and budget only a very small sample of the population has been taken. In each of the selected villages between 14 and 22 household representatives have been interviewed. The number is based on a minimum of 2% of all households in the village. The size of the samples is generally considered to be too small to be considered a probability sample. Therefor only the simplest of analyses can be performed with the sample data.

All interviews are conducted in the vicinity of the village headquarters, which is located in the centre of the village. Because the villages stretch out quite far, up to 20 kilometres, the distance to the villages centre can be of influence on travel behaviour. In order to avoid this influence, household representatives have been selected that live close to the village headquarters. By doing this the effect of household location can be assumed to be equal in all selected villages.

3.2.7.5 Selection of villages

The objective here is to compare travel behaviour of households from villages along roads in 'maintained' condition with the behaviour of households in villages along 'unmaintained' roads. For each zone one road in maintained and one road in unmaintained condition are selected. For the selection of roads and villages the following assumptions are made:

- The livelihood of village households relies on agricultural surplus production.
- There is an abundance of uncultivated arable land available in all villages.
- The flow of agricultural products is targeted towards the central market places in Iringa and Mafinga where the regional and district hospitals are located as well as the regional and district head quarters.

In order to make for a clean comparison between roads in 'maintained' and 'unmaintained' condition roads and villages are selected that comply with the following guidelines:

- Selected villages are located at intervals of roughly 20 km. from each other Transport costs towards central markets are as equal as possible for villages at equal distances to eliminate the effect of transport costs on travel behaviour.
- No shortcuts are available to the central markets or to the trunk roads.
- Selected routes are the dominant transport routes into the specific area.

The actual selection of villages for the interviews is presented in chapter 5.

3.2.7.6 Method of analysis

Since the size of the samples taken in the selected villages is very small only very simple analyses can be performed. The analyses use only the average number of trips to the selected social service centres. Based on the averages it is analysed whether patterns can be found that distinguish between maintained and unmaintained roads.

3.2.7.7 Support data

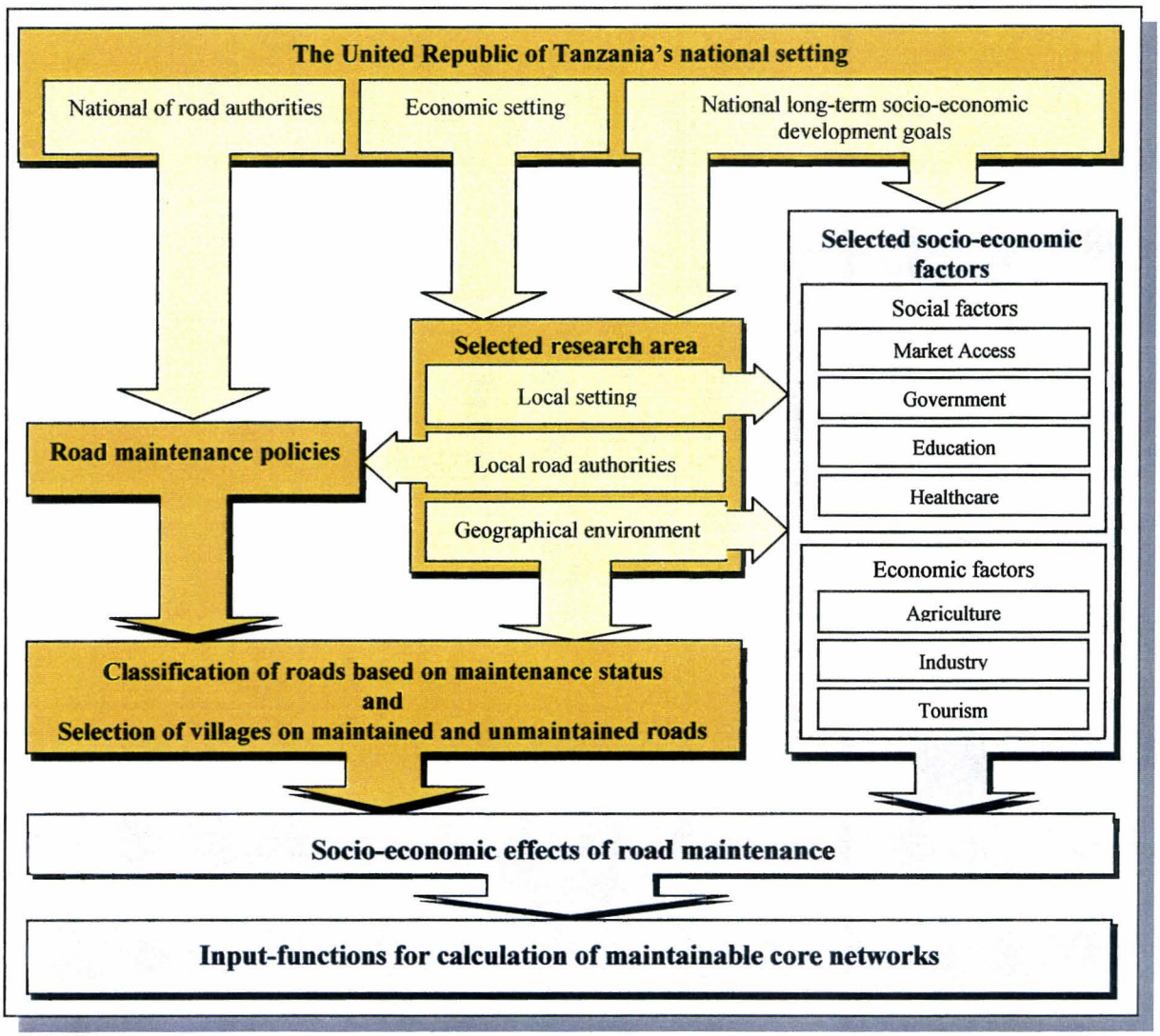
Records in the village of origin have been taken from the patient registrations from the district and regional hospitals. These data are analysed in support of the data from the interviews. The number of registered patients per 1000 people is compared for villages on maintained and unmaintained roads.

Part Two

Results of partial studies

Section A

Baseline studies



Chapter 4 Baseline study: location background

The baseline study is divided into three parts. Part one, presented in paragraph 4.1 deals with the national setting of the United Republic of Tanzania. It discusses the sub-elements shown in the conceptual model and the results for the selection of the research area and the socio-economic of the research. Paragraph 4.2 deals with the local setting in the selected research area. It discusses the sub-elements shown in the conceptual model and the selection of socio-economic research units available in the area.

The national setting and the local setting in the selected research area have led to the selection of socio-economic factors that need to be taken into account in the analysis of the effects of road maintenance. Paragraph 4.3.1 shows the conclusions with regard to the selection of the research area. The conclusions with regard to the selected factors are shown in 4.3.2. The conclusions with regard to the road maintenance policies are presented in 4.3.3. Paragraph 4.3.4 contains the conclusions with regard to the classification of roads. These paragraphs correspond with the arrows in the conceptual model pointing out from the boxes represented by paragraphs 4.1 and 4.2.

4.1 The United Republic of Tanzania's national setting

4.1.1 General information

The United republic of Tanzania is located on the coast of East Africa, bordered by Kenya in the north and Mozambique in the south. In the East Tanzania is bordered by the land-locked countries of Malawi and Zambia in the south, Uganda in the north and the Republic of Congo in the middle.

The United republic of Tanzania consists of the islands of Zanzibar in the Indian Ocean and the mainland formerly known as Tanganyika. The official capital of Tanzania is Dodoma, which centrally located in the middle of Tanzania. However the bulk of the countries ministries as well as the Presidents and Prime Ministers Offices are still located in Tanzania's major city and former capital Dar Es Salaam which is located at the coast. Dar es Salaam also holds the countries major seaport and international airport making it the centre of the country's economic activity. Most of the country's in- and exports go through Dar es Salaam, which also serves as a port of entry for most imports and exports to and from Malawi and Zambia. It serves as the major market in the country where agricultural and industrial output is traded.

Figure 4.1: 'Map of Tanzania'

Source: Newafrica.com

4.1.2 Economic setting

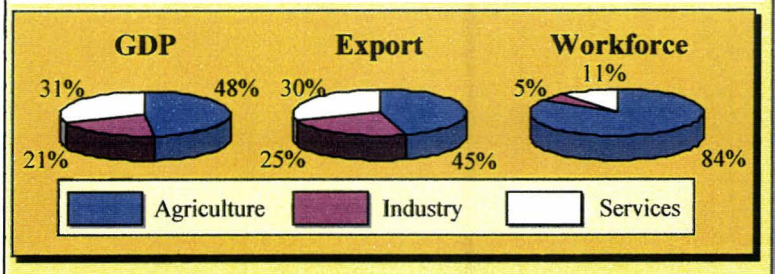
When it comes to socio-economic performance the country finds itself back close to the bottom. Tanzania is often grouped as a low-income county or a Sub-Saharan African country. In many aspects Tanzania's performance is much lower than the averages in these groups. The Gross National Product per Capita at international U$ (1997 prices) was 620 U$ in 1997 which is the fourth lowest in the world. It is not even half of the group averages, 1.460 U$ and 1.400 U$ respectively and 35 times less than that of a western European country like the Netherlands, which has 21.300 U$ per capita. The

annual GNP growth rate of 3,9 percent is higher than that of the average for Sub-Saharan Africa, but lower than average for a low-income country.

The Tanzanian economy is heavily relying on the agricultural sector. The agricultural sector accounts for roughly 50% of the nation's GDP and employs 84% of the total workforce (See figure 4.2).

Agriculture also accounts for 45% of export revenues. Agricultural output is mainly produced by smallholder farming especially when it comes to staple food products such as maize, beans and paddy rice. Export crops as coffee, tea and tobacco are often produced in large estates often owned by foreign settlers.

Figure 4.2 'Contribution per economic sector'



Source: World Development Indicators, World Bank, 1999

Since about 80% of the population lives in rural areas where there is very little, if any at all, job opportunity in the other sectors of the economy, rural communities completely rely their agricultural output as their only source of income.

Services account for 30% of the nations GDP and employs 10% of the work force. The most profitable segment of the services sector is international tourism. In 1997/98, tourism contributed 15.8% to the GDP and is responsible for 30% of Tanzania's export revenues. The industrial sector is heavily depending on the agricultural sector. Most industries in Tanzania either produce inputs for the agricultural sector or process food and cash crops for sales and exports. Industry accounts for around 5% of the total workforce and 21% of GDP. The contribution of industry to export revenues is 25%.

Apart from being the strongest economic sector in terms of contribution to GDP, Export revenues and workforce, **the agricultural sector is found to offer the best opportunities to create economic growth**. According to research conducted by FAO shows that smallholder farming of exportable crops, such as maize, is among the countries strongest and robust comparative advantages. It therefor offers a strong opportunity to raise export revenues. It was also found that increments to household income from agricultural production have the strongest links for the rest of the economy, resulting in a multiplier effect of 2,78 for rural households. This was found to be higher than multiplier effects from other sectors. **Small-holder farming is one of the coutry's strongest comparative advantages, especiallly for the production of maize**.

The study by the FAO also recognised the necessity for good access to external markets. It was found out that maize, the most important agricultural product, reacted as a non-tradable in market areas that were not properly connected to the market in Dar es Salaam. The agricultural produce in such areas would then not have any effect on the economy. **A good road connection to outside markets such as Dar es Salaam is an absolute necessity**.

4.1.3 Long-term development goals

The **main long term-development goal for 2025 is** to raise the standard of living of the people to the level of a typical medium development country by **raising the per capita income to U$ 3000** (current prices). This policy is guided by national policy stances as elaborated below:

i. Appropriate macro-economic policies
ii. Good governance and deepening democracy
iii. Peace, stability and unity
iv. Existence of well educated, learning, healthy and informed society
v. Commitment to develop infrastructure to level of middle income country

A more detailed description of the long-term development goal and its their relationships with road maintenance is discussed in appendix 1 'The United Republic of Tanzania's national setting'.

4.1.4 Institutional setting of the national road authorities

The national road authorities are responsible for the countries roads network. The roads network in Tanzania has a total length of 88,000 kilometres of which 10,200 kilometres are classified as trunk roads, 18,500 kilometres as regional roads and the remaining 49,300 are classified as district or feeder roads. Only 4,100 kilometres of trunk roads are paved. The roads network is in appalling condition due to the complete lack of maintenance over a long period of time. A survey done in 1990 by the World Bank found that only 24% of the paved roads and 10% of the unpaved roads were in good condition.[6] Very little has changed since then. The Tanzanian trunk roads network is shown in map 1 at the end of this report.

The institutional setting was undergoing radical changes during the period in which the research has taken place. In recent years the government of Tanzania has established the Tanzanian Roads Fund which is governed by the Roads Fund Board which is responsible for allocating budgets for maintenance of the road network. The Road Fund receives funds that originate from fuel taxes (0,10 U$ per litre fuel) that are solely dedicated to the maintenance of the road network. It is estimated that the available funds suffice to maintain one quarter to one third of the entire road network. Before the reorganisation funds for road maintenance were practically non-existent.

The Road Fund disburses the money either to TANROADS or to the Ministry of Regional Administration and Local Government (MRALG). TANROADS is an organisation formally established in July 2000, which is responsible for maintaining and upgrading all trunk and regional roads and the development of maintenance policies and planning mechanisms. The MRALG in turn disburses funds to District Engineers Offices (DEO) that are responsible for feeder and district roads.

During the research The Roads Fund Board was working on a new system for allocating funds for the district and feeder roads. However, this system focuses solely on the distribution of funds between all the districts and does not provide any protocols for the prioritisation of individual road. At the time of the research TANROADS had not yet established a system for the prioritisation regional roads. Due to lack of funds for road maintenance over a long period of time the United Republic of Tanzania has not yet developed standardised maintenance programmes or methods for regional or district roads. There are no technical standards that can determine whether a road requires maintenance or not. **In conclusion, at national level there are no standardised guidelines for the prioritisation of roads, maintenance programmes and methods for routine and recurrent maintenance or prescribed limits to road deterioration.**

4.1.5 Selection of socio-economic factors

Based on the long-term development goals and the guiding policy stances it becomes apparent that raising the income per capita is the most important goal. **The most important sectors of the economy that may be affected by road maintenance are agriculture, industry and tourism.** These factors have to be taken into account when analysing the socio-economic impact of road maintenance.

The social factors are determined by the guiding policy stances. **The social factors that are affected by road maintenance are government, education and healthcare.** These factors have to be taken into account in the analysis of the effect of road maintenance. The effect of road maintenance on the selected factors is likely to be expressed in the number of trips made to government headquarters, health facilities and the number of pupils that attend schools. The effect can be caused either by better transport opportunities or by higher income on maintained roads or a combination of the two.

[6] World Bank, The United Republic of Tanzania, Integrated Roads Project, Staff Appraisal Report, Washington D.C., 1990

4.1.6 Selection of research area

The selection of the research area is based on the long-term development goals and the national economic setting. The most important goal set by the Tanzanian government is raising the per capita income to 3000 U$ in the year 2025. It has been shown that agriculture is the economic sector that is most capable of rising the per capita income. In order to contribute substantially to the main development goal **the research area has to meet the following requirements**:

- **the area relies on smallholder farming for the local economy**
- **has an important place in the agricultural performance of Tanzania as a whole**
- **a good roads connection to the outside market, i.e. Dar Es Salaam**

It is assumed that situation with regard to the social factors selected to analyse the effect of road maintenance is fairly in all areas of the country.

Iringa Rural district and Mufindi district in Iringa Region meet these requirements. Iringa Region is located in the Southern Highlands, accommodating some of the most productive areas in the country. It produces 19% of the maize sold to Dar Es Salaam and is one of the six regions that together account for 95% of Dar Es Salaam's beans supply. The production comes entirely from smallholder farming. It has excellent connection to the major market and export port in Dar Es Salaam, both by road and by rail. The major markets, Iringa Town and Mafinga, are located on the T1, or Tanzam highway, which is one of the best roads in Tanzania. Furthermore, a number of industrial companies and the Ruaha National Park are located in the research area enabling analysis of the effect of road maintenance on industry and tourism.

4.2 Iringa Rural and Mufindi Districts

4.2.1 Local setting

Iringa Rural and Mufindi Districts are the two most northern districts in the Iringa Region. Iringa Region is located in the south west of Tanzania in the Southern Highlands. It is bordered by Morogoro Region in the east, Dodoma Region in the north and Mbeya region in the west (see figure 1). The Region is connected to the outside markets of Dar es Salaam and Zambia and Malawi by the most important route in the country, the T1 Trunk road. It is furthermore connected to the nations capital by the T4 trunk road.

Iringa Rural District consists of 9 divisions and has 178 villages. Iringa town is the district and regional capital. Mufindi district has 5 divisions and 131 villages. Its district capital is Mafinga. The district capitals that serve as central markets from where produce are being transported to Dar es Salaam and other countries. These capitals, Iringa Town and Mafinga also host the district headquarters, hospitals and are the main. For more information see Map 2 'Iringa Rural and Mufindi districts base map'.

4.2.1.1 Economy

The local economy in the area is largely depending on **the agricultural sector**. The livelihood of virtually all households outside Iringa Town depends on growing and selling food crops. The most important crops are maize, beans, sunflower, Irish and sweet potatoes and wheat. **The effect on agriculture is expressed by the effect on producer prices and the effect on production. Combined these two effects determine the effect on rural income** (see chapter 2).

According to the Iringa Rural District Agricultural and Livestock Officer (DALDO) there are two ways in which villagers can market their crops. The first is selling their produce directly from their village to traders who transport and sell the produce to the outside markets such as Dar es Salaam. The second way is to bring the goods to the markets in Iringa or Mafinga themselves where they can get better prices. These markets are also the main markets for household products and farm implements. **Market**

access is considered to be of vital importance for rural households and has to be included in the analysis of the social impact of road maintenance.

Agricultural produce is either sold to the central markets in Iringa and Mafinga or to traders who transport the goods directly to the outside markets. This means that the central markets may not serve as the origin for the relationships between distance and producer prices or level of production as described in chapter 2. Since much produce is exported from the research area, the trunk roads may be more important. Therefor **it must be analysed whether producer prices and production levels are related to the distance to the market or to the distance to the trunk road.**

The industrial sector in Iringa Rural and Mufindi District is very small. There are five medium scale industries in Iringa Rural District; Dabaga Fruit and Vegetables Cannery Ltd, Asas Dairy Farms Ltd, Green Highland Ltd, Maji Africa Mineral Water Company and a conglomeration of tobacco farmers. These companies can be used to analyse the effect of road maintenance on the industrial sector.

The tourist sector has in Iringa Rural District has one major attraction; The Ruaha National Park. The park can be used to analyse the effect of road maintenance on tourism.

4.2.1.2 Government

In principle, each administrative level of government has its own headquarters. Road maintenance may affect the number of trips made to these headquarters. **The most relevant headquarters for the analysis of the number of trips are at the ward and the district/ regional level.** Divisional headquarters do exist, but the divisional government officials usually travel around in stead of receiving people.

4.2.1.3 Education

Each village in Iringa Rural and Mufindi districts has at least one primary school. Primary school attendance is obligatory and free of costs. Therefor, road maintenance is unlikely to affect primary school attendance. Tertiary education is very expensive and only attended by a very small fraction of the population. It is unlikely that in rural areas road maintenance will have any significant effect on tertiary school attendance. **In order to analyse the effect of road maintenance on education only secondary school attendance needs to be taken into account.**

4.2.1.4 Healthcare

There are four levels of health facilities in the research area that offer treatment for different kinds of ailments. The system is structured much according with the governmental structure. In principle each ward has at least one dispensary offering the most basic services. Every division has a divisional health centre offering a slightly wider range of treatments. There is one district hospital for every district, which in this case are located in Mafinga and Tosamaganga, just outside of Iringa Town and one regional hospital in the regional capital of Iringa Town. Road maintenance may affect the number of trips to all types of health facilities. **In order to analyse the effect of road maintenance the number of trips has to be analysed for dispensaries, divisional health centres and district and regional hospitals.**

4.2.2 Local road authorities

There are three local road authorities, which are responsible for planning and executing road maintenance. The Regional Engineers office is responsible for the trunk and regional roads. There are 3 trunk roads in the research area with a total length of 408 kilometres. The 8 regional roads in the area have a total length of 472 kilometres. The District Engineers Office in Iringa Rural District is responsible for 1,284 kilometres of district and feeder roads. The length of roads under the jurisdiction of the District Engineers Office in Mufindi District is 625 kilometres. The roads network is shown in Map 3 'Iringa a Rural and Mufindi district: Roads network'.

Over the last years only the trunk roads have received routine and recurrent maintenance. No maintenance records were found for routine and recurrent maintenance executed by the local road authorities on any of the regional, district or feeder roads. Due to the almost complete lack of funding these roads have only received emergency maintenance to prevent roads from becoming impassable. However, especially in Mufindi District a number of roads have been maintained by local entrepreneurs. No records were available on their maintenance activities. **Since there is no maintenance history available for most of the roads network roads can not be classified on basis of the maintenance undergone in recent years.** A different approach has to be used to classify the roads based on their maintenance condition. This issue is dealt with in chapter 5.

Because there has been very little funding in the past the **local road authorities have not developed any policies with regard to prioritisation of roads or programmes for routine and recurrent maintenance.** The only information available concerns the method by which road maintenance is executed. **Maintenance operations on unpaved roads, that can be considered suitable for routine maintenance consists mainly of deep grading whereby the road surface and profile are reshaped as if the were newly constructed.**

4.2.3 Geographical environment

Four distinctly different agro-ecological zones can be distinguished in Iringa Rural and Mufindi Districts; a Lowland zone, a midland zone, a highland zone and the Mufindi Plateau. The four agro-ecological zones show very different rainfall patterns, soil characteristics, terrain characteristics and productivity of the land. Map 4 shows the soil types found in the research area.

The differences in rainfall patterns, soil characteristics and terrain characteristics between the agro-ecological zones have severe effects on the rate of deterioration of the roads in each zone. **The different characteristics for each agro-ecological zone have to be taken into account when calculating road deterioration.**

The differences between the zones in agricultural productivity of the land can have serious effect on the quantity of output produced in each zone. The differences in terrain characteristics may influence transport costs and as a result also the producer prices. The combined effect on production and producer prices can produce different patterns of rural income for the zones. This, in turn, can have an effect on school attendance and the number of trips made to markets, health facilities and government headquarters. Therefor, **it is necessary that the analysis of the socio-economic effects of road maintenance is executed separately for each agro-ecological zone.**

4.3 Conclusions

4.3.1.1 Conclusions with regard to the selected research area

- Based on the long-term development goals and the economic setting of the United Republic of Tanzania **two districts have been selected for the research: Iringa Rural District and Mufindi District.** Both are located in Iringa Region.
- **The research area comprises four different agro-ecological zones**: the Highland zone, Midland zone, the Lowland zone and the Mufindi Plateau

4.3.1.3 Conclusions with regard to the selection of socio-economic factors

- The **social factors** that have been selected **are market access, government, education and healthcare.**
  - The **effect on market access** is expressed by the number of trips to the central markets for buying things and for selling produce.
  - The **effect on government** is expressed by the number of trips to ward and to district or regional headquarters.
  - The **effect on education** is expressed by the number secondary school students per household.
  - The **effect on healthcare** is expressed by the number of trips to dispensaries, divisional health facilities and to district or regional hospitals.

- The **economic factors** that have been selected **are agriculture, industry and tourism.**
  - With regard to **agriculture** the following conclusions are drawn:
    - The **effect on agriculture** is expressed by the effect on producer prices and the effect on production.
    - In order to determine **the effect on income**, the portion of production sold on the markets in Iringa and Mafinga Towns must be established. Income derived from these sales is not affected by road maintenance.
    - The effects on agriculture have to be analysed individually for all four agro ecological zones in the research area.
    - It has to be established whether producer prices and production levels are related to the distance to the market or to the distance to the trunk road.
  - The **effect on industry** is expressed by the effect on five companies selected in Iringa Rural District.
  - The **effect on tourism** is expressed by the effect on the Ruaha National Park .

4.3.1.5 Conclusions with regard to road maintenance policies

- **There are no records of any maintenance history for regional, district and feeder roads.**
- **There are no standardised programmes for routine and recurrent maintenance**
- **Routine maintenance operations on unpaved roads consists of deep grading whereby the road surface and profile are reshaped as if the were newly constructed.**

4.3.1.6 Conclusions with regard to the classification of roads

- **The classification of roads can not be done on basis of maintenance history.**
- **The four agro-ecological zones have different characteristics that determine the rate of road deterioration. These have to be taken into account when calculating deterioration.**

Chapter 5 Road classification of roads

In order to asses the effects of road maintenance on the selected socio-economic parameters it is necessary to classify the roads in the research area as being in 'maintained' or 'unmaintained' condition. Ideally, this classification should be made based on the maintenance history of the road network. However, there were no records of any structural routine and recurrent maintenance in the recent past on the regional, district and feeder roads in Iringa Rural and Mufindi Districts. It was therefore not possible to classify roads as being in 'maintained' or 'unmaintained' condition based on maintenance records. The methodology used to classify the roads is presented in paragraph 5.1.

Paragraph 5.2 discusses the selection of roads and villages for the social impact surveys. Paragraph 5.3 contains the conclusive comments on the classification methodology. All subjects in this chapter are discussed in more detail in appendix 3.

5.1 Methodology of road classification

With the lack of any maintenance history, classification of roads on basis of their maintenance condition could only be done on basis of the current quality of the roads. Paragraph 5.1.1 explains the methodology that was used for surveying the road quality in the area under study.

In order to classify the roads the current road quality needs to be compared to the quality that is expected at the end of a roads maintenance cycle. To be able to make the comparison the format of data must be the same for both types of data. The methodology used to generate those data on the expected road quality is presented in paragraph 5.1.2.

Apart from the lack of a maintenance history, there are no predetermined maintenance cycles for routine and recurrent maintenance being applied in Tanzania. The prerequisites for such maintenance schemes that have been developed for this research are presented in paragraph 5.1.3.

Paragraph 5.1.4 presents the classification criteria derived from the calculations. Some comments on the model applied for the calculations are discussed in paragraph 5.1.5.

5.1.1 Methodology of road quality surveys

The quality of the roads in Iringa Rural and Mufindi Districts has been surveyed using the methodology applied by COWI Tanzania Consulting Engineers and Planners Ltd. COWI Tanzania have surveyed all district and feeder roads in the districts. The regional roads have been surveyed by the researcher, using the same methodology.

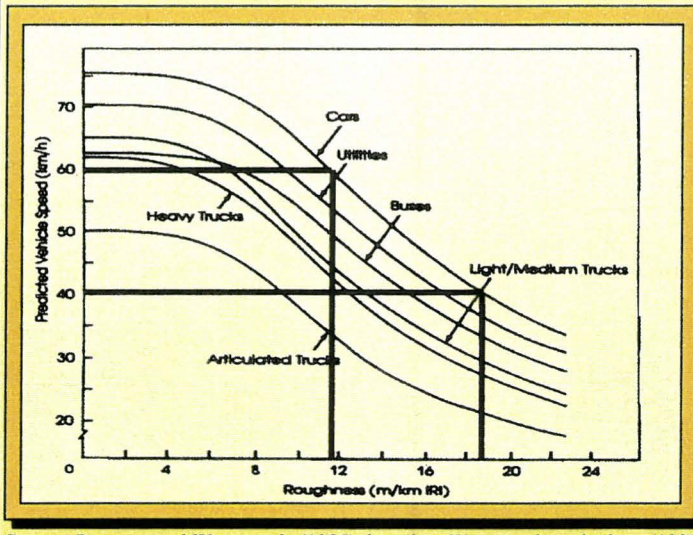
The methodology uses applied comfortable driving speed as an indicator for road quality. The comfortable driving speed is defined as being that speed at which a section of road can be passed safely and comfortably for both the driver and the passengers. In the survey by COWI limits have been set at 60 km/h and 40 km/h in a way that roads are considered to be in;

- **good** condition if the comfortable driving speed exceeds 60 km/h,
- **fair** condition if the comfortable driving speed is between 60 km/h and 40 km/h, and
- **poor** condition if the comfortable driving speed is less than 40 km/h.

Using figure 5.1 'Comfortable driving speed and road roughness' it becomes apparent that for cars the limits of 60 km/h and 40 km/h roughly correspond with IRI's of 12 and 18 m/km. Although the limits used by COWI only correspond roughly to limits of 12 and 18 km/m IRI that are generally applied to classify roads, these figures can be translated to percentages of road being in good, fair or poor condition in terms of road roughness. The result of the surveys can be found in overview 4 of appendix 3.

The applied method of surveying is indirect, in the sense that road roughness is not measured directly. The applied method is also a subjective measure since it is based on a subjective parameter; 'comfortable driving speed'. Because of the indirect and subjective method of surveying the boundaries do not provide a very distinct demarcation between good, fair and poor quality in terms of road roughness. Furthermore it must be noted that the vehicle used for the survey of the district and feeder roads is different from the one used on the regional roads. It is assumed that the difference in vehicles used for the surveys is of little influence on the outcome.

Figure 5.1 'Comfortable driving speed and road roughness'



Source: Paterson and Watanatada (1985), based on Watanatada and others (1987)

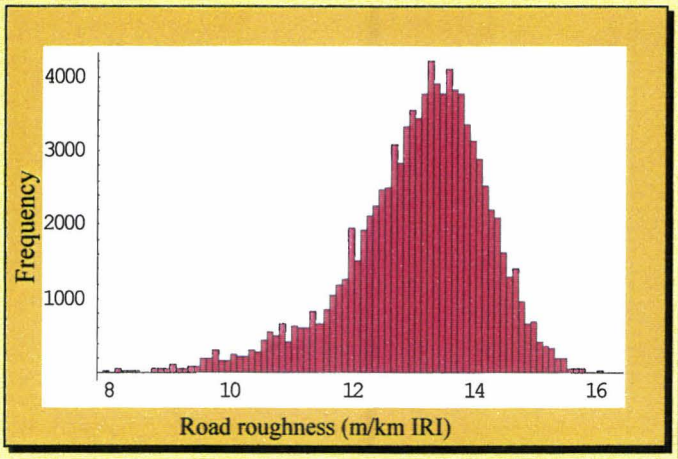
5.1.2 Calculation methodology for expected road quality

Roads can be classified as being in maintained or unmaintained condition by comparing the data on road quality to the road quality that is expected at the end of a maintenance cycle. In order to do so the expected road quality need to have the same format as the data on road quality derived from the surveys. The limits between good and fair and between fair and poor defined for the road quality surveys can be translated to road roughness of 12 m/km IRI and 18 m/km IRI respectively.

The same format of data was achieved using the HDM-III models for roughness progression. By incorporating the individual distributions of the input parameters into the HDM-III model and iterating the calculations a large number of times, the road quality after a set period of time is determined in the form of a distribution of road roughness. An example of such a distribution of road roughness is shown in figure 5.2. From this distribution the percentages of a road with a roughness smaller than 12 m/km IRI and larger than 18 m/km IRI can be derived. These percentages then fit the format of the data from the road quality survey.

The calculations have been performed for all agro-ecological zones for several traffic intensities. The distributions of the input data for rainfall and soil characteristics have been determined based on distribution of fit test of field data. In some cases only very few data were available. The distributions may therefor not be fully representative for the actual distributions. Default values for terrain characteristics have been used under the assumption that they fit a standard normal distribution. The fact that the applied input data may not be representative in all cases can have an effect on the distributions of road roughness found by the calculations.

Figure 5.2 'Example of road roughness distribution'



This, in turn, can affect the percentages of road expected to be in good, fair or poor condition. It is assumed that these effects will not be of dramatic influence. However, it must be kept in mind that the percentages found may not be 100% accurate.

5.1.3 Selection of maintenance schemes

The calculations are made to determine the distribution of road quality at the end of a maintenance cycle. However, there are no guidelines for maintenance cycles for unpaved roads that are applied or prescribed in Tanzania. Therefore suitable maintenance cycles had to be designed first. For routine maintenance, cycles were selected that show an average roughness at the end of the maintenance cycle that is closest to 12 m/km IRI. For recurrent maintenance on gravel roads the cycles were determined by the time elapsed when material loss has reached 100 mm. Only maintenance cycles for routine maintenance of 0.5, 1, 2, 3 or 4 years have been considered to eliminate the seasonal effects on road deterioration. The selected maintenance schemes are presented in table 5.1.

Table 5.1 'Selected maintenance schemes'

		Highland zone			Midland zone			Lowland zone			Mufindi Plateau		
	ADT	Years		IRI mean	Years		IRI mean	Years		IRI mean	Years		IRI mean
Earth	25	3		12.33	2		11.34	2		11.02	2		11.18
	50	2		11.58	2		13.04				2		12.79
	100				1		11.45	1		11.12	1		11.19
	200				0.5		10.56						
		routine	recurrent	IRI mean	routine	recurrent	IRI mean	routine	recurrent	IRI mean	routine	recurrent	IRI mean
Gravel	25	3	6	12.27	2	6	11.11				3	6	13.09
	50				2	5	12.79						
	100												
	200				1	2	10.55						

5.1.4 Classification criteria

For the classification of roads as being in 'maintained' or in 'unmaintained' condition, two criteria have been selected. A road can be classified as being in a 'maintained' condition when the percentage in 'good' condition (IRI≤ 12 m/km) is higher than the percentage that is expected at the end of its maintenance scheme.

Table 5.2 'Classification criteria'

		Criterion 1	criterion 2			Criterion 1	criterion 2	
Agro-ecological zone	ADT	percentage of IRI ≤12 ≥	percentage of IRI ≤12 ≤ or	percentage of IRI ≥18 ≥	ADT	percentage of IRI ≤12 ≥	percentage of IRI ≤12 ≤ or	percentage of IRI ≥18 ≥
		Earth roads				Gravel roads		
Highland zone	25	43%	24%	7%	25	43%	27%	7%
	50	56%	26%	6%				
Midland zone	25	77%	9%	5%	25	81%	16%	5%
	50	16%	2%	5%	50	23%	6%	5%
	100	70%	2%	5%				
	200	98%	5%	5%	200	98%	5%	5%
Lowland zone	25	98%	6%	5%				
	100	96%	1%	5%				
Mufindi Plateau	25	84%	11%	5%	25	19%	7%	5%
	50	21%	3%	5%				
	100	81%	3%	5%				

Because the methodology of the road quality surveys does not provide very exact data in terms of road roughness and because some input data for the calculations could not be gathered from the field, it is

impossible for a single value to clearly distinguish between 'maintained' and 'unmaintained' condition. Therefore a second criterion has been introduced to classify roads as being in 'unmaintained' condition. A road can be classified as 'unmaintained' when its percentage in 'good' condition (IRI 12 m/km) is lower or when its percentage in 'poor' condition (IRI 18) is higher than the expected percentage one year or one maintenance cycle after maintenance should have been executed according to the maintenance scheme for that type of road. Roads that fall between the two criteria are classified as 'indiscriminate'. The resulting classification criteria for all types of roads in the area are presented in table 5.2. The classification of roads based on the road quality is presented in overview 4 of appendix 3. The classification has been visualised in Map 4 'Road classification'.

5.1.5 Comments on HDM-III models

By introducing two criteria to distinguish between 'maintained' and 'unmaintained' condition a quite robust methodology has been developed that accounts for inaccuracy of the available data. It must be noted, however, that the HDM-III model for roughness progression produced some surprising results that are in conflict with what is generally expected. This has raised some questions that cast doubt on the correctness of the model. These questions are discussed more elaborately in appendix 3. This can have great effect on the classification of roads and on the maintenance schemes selected for the research. The objective of the research, however, is not to formulate or investigate new models to describe deterioration patterns of unpaved roads. The HDM-III models are therefore assumed to be correct.

5.2 Selection of roads and villages

5.2.1 Selection for study of social effects

The classification of roads described in the previous paragraphs can be used directly for the analysis of economic impact, i.e. agricultural production, and analysis of support data for education and health care. However, since both time and budget were constraint for the research a selection had to be made for villages and roads along which interviews were conducted for the social impact analysis. The selection of villages for the intervies is done according to the prerequisites laid down in paragraph 3.2.7.

The selection of **routes and villages for the highland zone** encountered no problems. The routes selected as being in 'maintained' condition consists of the villages of Kinyanyembo, Ihalimba, Ugesa, Kibengu and Mapanda, all located in Mufindi District The villages are located on the Kinyanyembo – Ihalimba road and the connecting D3398 Mtili – Mapanda road. For the 'unmaintained' route the villages of Tagamenda, Ndwili, Kilolo and Kidabaga on the R628 Iringa – Idete regional road and Bomalang'ombe on the D3420 Kidabaga – Bomalang'ombe road. The bus fare to the last villages in on both selected routes is 2500 Tsh.

The selection of **routes into the lowland zone** was problematic. There are no routes available that can be classified as being 'maintained' except for the T4 Iringa – Dodoma trunk road. In stead the Lugalo - Ilula – Uhominyi – Ibumu route was selected. The first two villages are located on the T1 trunk road. Under the third assumption posed above, this should not be of much influence. The other two villages are located on the D3411 Ilula - Ibumu road. This road was expected to be entirely in 'maintained'condition based on initial information. However, it turned out that the section from Uhominyi to Ibumu could not be classified as such. It is classified as 'unmainatained'. Data from this village are therefore not representative for maintained roads.

The route selected as 'unmaintained' follows the R621 Iringa – Msembe regional road on which the villages of Kalenga, Kidamali, Malinzanga and Idodi have been selected for the surveys. Bus fares for Idodi and Ibumu are the same at 1500 Tsh. It has to be noted that the village of Kidamaili does not comply with the first assumption. The are some large tobacco farms located in the village as well as the Maji Africa Mineral water plant. These companies raise average houshold income with 20,000 Tsh per month.

The selected roads and villages are visualised in Map 4. The distances from the villages to the markets are shown in table 5.3.

Table 5.3 'Disitancesfrom selected villages to central markets'

Into Highland zone				Into Lowland zone			
Maintained route		Unmaintained route		Maintained route		Unmaintained route	
Villages	Km.	Villages	Km.	Villages	Km.	Villages	Km.
Kinyanyambo	4	Tagamenda	6				
Ihalimba	23	Ndwili	23	Lugalo	22	Kalenga	17
Ugesa	41	Kilolo	39	Ilula	40	Kidamali	37
Kibengu	57	Kidabaga	56	Uhominyi	57	Malinzanga	56
Mapanda	80	Bomalang'ombe	75	Ibumu	72	Idodi	85

5.2.2 Selection of villages study of the effect on production

Villages have been selected according to the prerequisites presented in paragraph 3.2.4. The selection of villages on maintained and unmaintained routes in the four agro-ecological zones is presented in overview 5 of apppendix 4. Except for the T1 and T4 trunk roads no roads were found for the lowland zone and the Mufindi Plateau that are classified as maintained.

For the analysis of the effect on unmaintained roads that are connected by maintained roads only two roads are found to be suitable: The road from F7443 from Kipanga to Uhafiwa in the highland zone and the Uhominyi – Ibumu section of the Ilula- Ibumu road in the midland zone.

5.3 Conclusive comments

Because of the lack of any maintenance history, roads had to be classified as being in 'maintained' or 'unmaintained' condition based on a comparison of current road quality and the expected quality at the end of a maintenance cycle. The indirect method of road classification can only be regarded as a proxy for the actual maintenance condition. It can not be said that roads, classified as 'maintained' actually receive maintenance on a structural basis. It may well be possible that structural road maintenance has psychological effects that do not occur on 'maintained' roads in the research area. If a road is actively being maintained it might give a strong incentive for the population to produce more agricultural surplus.

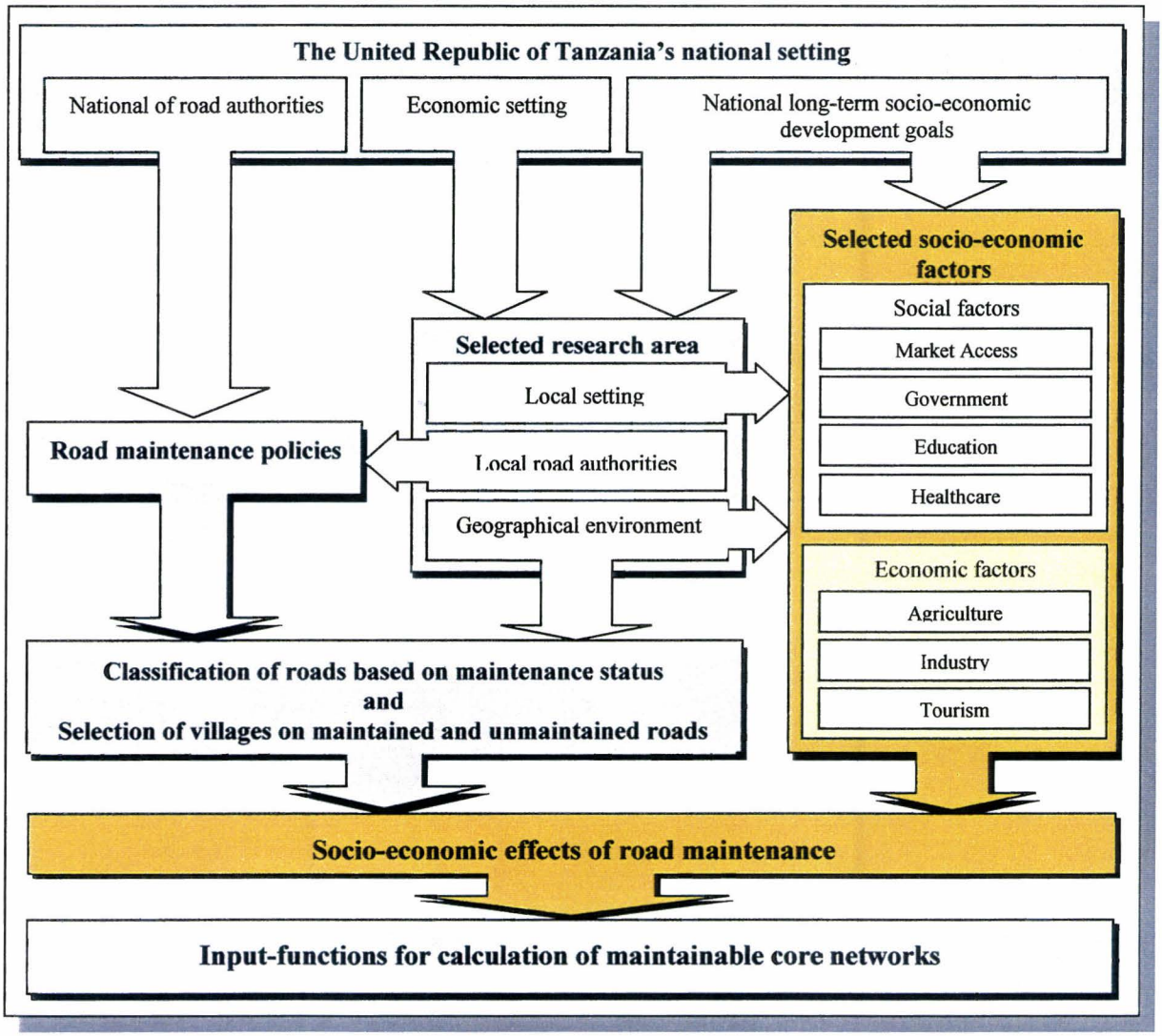
Since there are no maintenance schemes actively being applied in Tanzania, maintenance schemes had to be selected by the researcher himself. Because there is hardly any information to provide a solid basis for such the selection of maintenance schemes, this has been done rather arbitrarily. If road authorities decide to apply other prerequisites than the ones that are used here, the classification applied for this research may not be valid. As a result the effects of road maintenance that will be found will not be suitable for other maintenance schemes.

Because the classification is not based on actual maintenance history the classification of roads on maintenance condition has become somewhat hypothetical. The results of the research can therefore not be generalised or applied to other areas or other maintenance schemes.

For **further research** it is advisable to select roads that either are being maintained or have not received maintenance for a long period of time. Initial information provided by the Ministry of Works indicated that this would be the case in the selected research area, but this proved to be not so. If no maintenance history exists, it would be advisable to select an area where there are predetermined standard programmes for routine and recurrent maintenance on which calculations can be based.

Section B

Economic effects of road maintenance



Chapter 6 The effect of road maintenance on producer prices

This chapter presents the analysis of the effects of road maintenance on producer prices. it answers the following research question:

'What is the effect of road maintenance on producer prices?'

The effect of road maintenance on producer prices is measured by assessing the prices obtained by villagers from merchants for their agricultural products. The villages from which data were taken are grouped on basis of the maintenance condition of the road that connects them and on basis of the agro-ecological zone in which they are located. The grouping can be found in appendix 4. The data from the villages is then used to analyse the effect of road maintenance on producer prices for each specific agro-ecological zone. The method of data acquisition is discussed in paragraph 6.1.

Firstly, the relationships between producer prices and the distance to the market and the distance to the trunk road have been assessed in order to determine which of the two distances is most significant. The results are presented in paragraph 6.2. Subsequently the producer prices have been analysed separately for each agro-ecological zone. The results are presented in 6.3. The conclusions from the analysis of producer prices are discussed in 6.4.

6.1 Data acquisition

The data for analysis of the impact on producer prices were gathered at the same villages as where the survey for the social impact analysis was conducted and in a couple of other villages that were visited for other purposes. The prices for the main crops sold in each of the villages are shown in table 1 of appendix 4. The data were gathered from the local village officials.

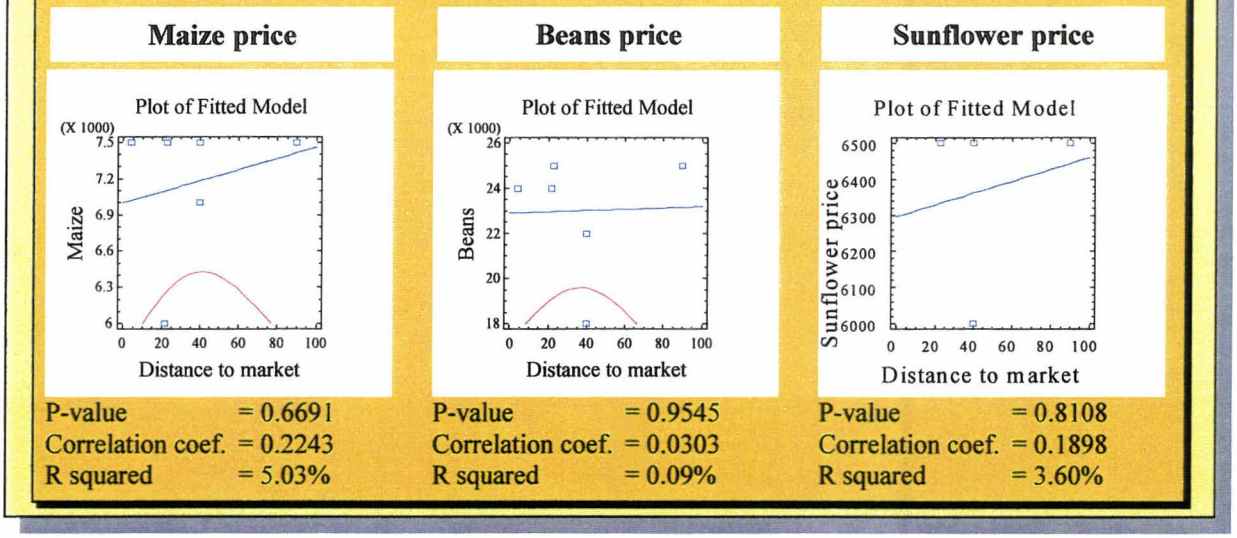
The producer prices vary throughout the year depending on the mechanism of supply and demand. However, according to the district agricultural livestock officers (DALDO) in both Iringa Rural and Mufindi Districts, virtually the entire agricultural surplus is sold directly after harvesting, mainly because there are no storage facilities present in the villages. At this time the prices villagers get for their products are at their lowest point. Because virtually all the produce is sold at this time producer prices during the harvesting season have been used for this research. Producer prices have been acquired for: maize, beans, sunflower, sweet potatoes, Irish potatoes and wheat.

6.2 Producer prices on trunk road

Traders sell agricultural produce bought from villager communities either on the markets in Dar Es Salaam or Dodoma or on more local central market places like Iringa Town and Mafinga. It is, however unknown which market attracts the most produce. If local markets are more important a strong relationship may be expected between the producer prices and the distance to that local market. If the destination for most of the produce is located further outside the research area, producer prices can be expected to show little variation along the trunk roads and a high correlation with the distance to the trunk roads. In order to determine to which of the two distances producer prices are related strongest a linear regression analysis has been performed on the producer prices in villages along the T1 trunk road and the distance to the local markets.

Producer prices were taken from six villages along the T1 trunk road. Maize and beans were the only products sold in all villages. Sunflower is sold in four out of six villages. As depicted in figure 6.1, none of the three products show a statistical relationship with the distance to the market. The P-values of all regression analyses are very high indicating that the confidence levels for the models determined by the regression analyses are very low. The R-squared statistics, which represents the percentage of the variability that can be explained by the models, are all far lower than 10%. **It can therefor be concluded that producer prices for the three crops have no relationship with the distance to the market.**

Figure 6.1 'Linear regression producer prices on trunk road'



Further regression analyses are made incorporating data from villages not located on the trunk roads, which are shown in overview 1B in appendix. The analyses again show no relationship between producer prices and distance to the market for both maize and sunflower. The price for beans however showed a statistical relationship at a confidence level of 90%.

The prices for maize and sunflower appear to be rather constant along the trunk road. For maize a price of 7,500 Tsh per 100-kg bag was recorded four out of six times. With no evidence found for a relationship with the distance to the market, a price of 7,500 Tsh per bag may be assumed to be the predominant price on the T1 Trunk road. The same can be said for a standard price of 6,500 Tsh per bag of sunflower, which occurs in three out of four villages. The evidence for these assumptions may not considered to be very strong, mainly due to the relatively small number of data used for the analysis. **On basis of the constant prices for maize and sunflower it assumed that prices for other products behave in the same fashion.**

The price of beans does not show any predominant value and is ranging from 18,000 to 25,000 Tsh per bag. This wide variance can be explained by the fact that beans are generally not sold in standard quantities of 100 kg. as opposed to the other products. Households usually sell beans in much smaller poorly defined quantities such as buckets, basket, bowl or jug. The price per bag is derived from prices obtained for these smaller measures that carry quantities that are often open for discussion. The prices per bag may vary strongly accordingly. The relationship between beans price and distance to the market is likely to be purely coincidental.

6.3 Producer prices away from the trunk road

It has been concluded in the previous paragraph that producer prices are not related to the distance to the market and that prices are constant along the trunk road. In this paragraph the relationship between producer prices and distance to the trunk road is analysed. Linear regression analyses and in few cases polynomial regression analyses are performed to determine the relationship between the two variables. Separate analyses have been made for each product for each agro-agricultural zone for both maintained and unmaintained roads.

For some cases there were no data included for prices on the trunk road. The estimated constant prices on the trunk road have been included in the analyses. The prices for maize and sunflower were found to be 7,500 Tsh and 6,500 Tsh respectively. From the few available data for other products the following prices are assumed to be the standard on the trunk road: Sweet potato 5,000 Tsh, Irish potato 4,500 Tsh and wheat 14,000 Tsh.

6.3.1 Maintained and unmaintained routes

Relatively strong relationships with the distance to trunk roads have been found for both maintained and unmaintained roads for the prices of maize, Irish potatoes and wheat. Furthermore relationships were established for sweet potato on maintained roads and sunflower for unmaintained roads. Separate relationships for maize price were found for both the highland and the midland zone. . The data for maize prices were best fitted by a second order polynomial model. However, for planning purposes the linear models are preferred. **Comparing the data from the midland zone with the models that were found for the highland zone suggests that both sets of data fit the same model.** Therefore one single model has been developed for maize prices that applies to both zones Insufficient data were available to do similar analyses for other products and/ or other agro-ecological zone. The data on the price of beans turned out to be very unreliable. As a result no relationship with distance to trunk road could be found. The linear relationships found are summarised in table 5.1 below

Table 5.1 shows that the slopes of the linear functions differ quite strongly between the products. In a linear model for product prices as a function of distance to trunk road the slope can be regarded as the cost of transport in Tsh per 100 kg per kilometre. If transport costs would be the only agent determining the price of products along a route the one would expect the transport costs per kilometre (i.e. the slope of the function) to be the same for every product. This is clearly not the case. The slopes in term of transport costs on maintained roads vary from 202 Tsh/tkm for Irish potato to 426 Tsh/tkm for wheat. On unmaintained roads these costs are 315 and 637 Tsh/tkm. These differences in cost clearly point out that there is no direct relationship between transport costs and producer prices. This is underlined by the fact that maize prices have a strong second order relationship with distance to trunk road. This means that transport costs decline as the distance increases. Factors other than transport costs must be involved in determining producer prices for agricultural products.One factor that may be of extreme influence is price control by monopolistic traders that are active in the area.

Table 6.1 'Linear models for producer prices and distance to trunk road'

		Maintained roads			Unmaintained roads			
Product	Estimated price at trunk road	Intercept*	slope*	slope / trunk price	Intercept*	slope*	slope / trunk price	decrease in slope
Maize	7,500	7,066.12	-35.528	-0.0050	6,904.83	-51.400	-0.0069	45%
Sunflower	6,500				6,402.22	-62.010	-0.0095	
Irish potato	4,500	4,290.24	-20.159	-0.0045	4,463.12	-31.485	-0.0070	56%
Wheat	14,000	14,134.90	-42.612	-0.0030	14,114.60	-63.692	-0.0045	49%
Sweet potato	5,000	4,657.35	-24.329	-0.0049				

* Intercept and slope of linear function: Product price = Intercept + Slope* Distance to trunk road

One of the most striking features in table 6.1 is the percentual change in slope between maintained and unmaintained roads. For the three products for which relationships were found for both types of road the slope for unmaintained roads is close to 50% higher than the slope for maintained roads. This similarity between different products may be expected when producer prices depend on transport costs only. Since the transport costs appear to differ strongly between different products the similarity in change of slope is quite surprising. There is no simple explanation for this phenomenon. Since a very similar relationship is found between the slopes for maintained and unmaintained roads in all cases where relationships were found for both types of roads it is safe to assume that the change in slope is similar for other products as well.

6.3.2 Unmaintained rods connected by maintained roads

For the last section of the Ilula – Ibumu route data are only available for maize, beans and sunflower in the village of Ibumu. The maize price was quoted to be 7000 Tsh. This is higher than may be expected on maintained routes according to the relationships found in previous paragraphs. It is most likely an odd value. The price of sunflower in Ibumu was 5000 Tsh. This is close to the expected value on unmaintained roads, which is 5058 Tsh.

This one value is not sufficient to draw any conclusions. **There is insufficient data to analyse the behaviour of producer prices on unmaintained roads that are connected to the trunk road by maintained roads.** However, increase in transport cost is the only maintenance-related issue that should affect producer prices. It seems quite logical that producer prices should roughly follow the behaviour of transport costs. It can therefor logically be assumed that producer prices follow the rate of decline according to the maintenance condition of the road. **It may logically be assumed that on maintained roads producer prices follow the rate of decline for maintained roads. Consequently, on the connecting unmaintained section they would follow the rate of decline for unmaintained roads starting from the value found at the end of the maintained section.**

6.4 Conclusions and comments

From the analysis of the effect of road maintenance on producer prices the following can be concluded:

1. **Prices for agricultural products appear to be constant along the trunk road.** This conclusion is based on the prices found in villages on the trunk road for maize and sunflower. The prices were found to be constant at values of 7,500 Tsh and 6,500 Tsh per 100kg. bag respectively. Although only few values were found for other products it is assumed that they are constant along the trunk road as well. The following prices per 100 kg. are adopted: Irish potato 4,500 Tsh, Sweet potato 5,000 Tsh and wheat 14,000 Tsh. The fact that prices are found to be constant on along the trunk road indicates that the main destination of the products lies outside the research area.

2. **Relatively strong linear relationships were found to exist between producer prices and distance to trunk road for all products.** The data for maize prices were best fitted by a second order polynomial function. Data for beans were very unreliable as a result of which no relationships with distance to trunk road could be discovered.

3. **There appears to be no difference between agro-ecological zones with regard to the relationships between producer prices and distance to trunk road.**

4. **The transport costs per tonkilometre differs strongly between different products.** This can be seen from the differing slopes in the linear relationships between producer prices and distance to trunk road. Differences up to 200% were encountered. The fact that data on maize prices best fit second order relationships underlines that there is no direct relationship with transport costs. This indicates that factors other than transport costs are involved in determining producer prices. Price control by monopolistic traders may play an important role.

5. **Producer prices decline 50% faster on unmaintained roads than on maintained roads.** The change of the slope between maintained and unmaintained roads was around 50% for all products for which relationships were found for both types of roads. Other products are assumed to behave similarly.

6. **It may logically be assumed that on maintained roads producer prices follow the rate of decline for maintained roads. Consequently, on the connecting unmaintained section they would follow the rate of decline for unmaintained roads starting from the value found at the end of the maintained section.** There is not enough data available to underpin this assumption.

The following comments on the conclusions must be noted:

1. All data in villages on the trunk road were gathered on the T1 Iringa – Dar Es Salaam trunk road. There is no proof that producer prices are also constant on the T4 Iringa – Dodoma trunk road.

2. Data were taken in a limited number of villages especially at distances to the trunk road greater than 40 km. This can have implications on the relationships found for some products.

3. There were no comparable data available for the lowland zone and the Mufindi plateau. Data for the midland zone did not surpass 40 km. distances from the trunk road. This made it impossible to prove similarity between relationships for all products and all agro-ecological zones.

It furthermore must be noted that the conclusion that producer prices are constant along the trunk road causes that the selection of the Lugalo – Ilula – Uhominyi – Ibumu route may not be suitable for the comparison with the Kalenga – Kidamali – Malinzanga – Idodi route. This first route was selected under the assumption that Iringa town serves as the main destination for agricultural produce. Accordingly, producer prices and impact on income as well as income related effects were expected to be related to the distance to Iringa rather than to the trunk road. Lugalo and Ilula are both located on the trunk road.

Chapter 7 Effects on agricultural production

7.1 Data acquisition

For Iringa Rural District production data were retrieved for all divisions except for Mahenge division. For the Pawaga division only data for the production targets set for 1998-1999 and 1999-2000 were found. Generally the actual production differs a lot from the intended targets. The data for Pawaga division could therefore not be used for the analysis. For Mufindi District data at village level were only available for three out of five divisions: Kibengu, Sadani and Malangali.

7.2 Selection of villages

The selection of villages has taken place according to the prerequisites presented in paragraph 3.2.4 the exact selection of the villages is presented in overview 5 of appendix 4.

7.3 Calculating sales production

The agricultural production data at village level represent the total production. That includes own consumption. In order to analyse the effect of road maintenance on rural income, it is necessary to subtract consumption from the total production.

The food consumption is estimated at 300 kg. of maize and 100 kg. of beans per person per year. These amounts are used by the District Agriculture and Livestock Officers to calculate food balances for the districts. It is based roughly on a food supply of 2000 kcal per person per day. The area of land needed for food production depends on the yield per hectare, which vary for each agro-ecological zone. The calculation of sales production is described in more detail in appendix 4.

7.4 Effect of road maintenance on total sales production

7.4.1 Distance to trunk road versus distance to market

In order to determine the effect of road maintenance in the form of relationships on which road maintenance can be planned it has to be determined whether sales production is related strongest to the distance to the trunk road or distance to the market. Table 7.1 shows the correlation coefficients between sales production and the distances to the market and to the trunk road. The correlation coefficients have been calculated for all sample groups for maintained and unmaintained roads for all four agro-ecological zones. **Table 7.1 shows that the correlation coefficient is stronger for distance to trunk road than for distance to the market in 4 out of the 6 groups.**

The only group that shows a coefficient that is much stronger for distance to market is the Mufindi Plateau. This is caused by data stemming from two different divisions and does not bear any relationship with distance to the market.

Table 7.1 'Correlation coefficients'

	highland zone		midland zone		lowland	mufindi
	maintained	unmaintained	maintained	unmaintained	unmaintained	unmaintained
distance to market	0.17	0.43	0.42	-0.06	-0.27	-0.59
distance to trunk	0.18	0.61	0.36	-0.30	-0.67	0.01

It can be concluded that **sales production has a stronger relationship with distance to the trunk road than with distance to the market**. This complies with the earlier findings for producer prices. In the further analyses relationships with distance to trunk road will be analysed.

7.4.2 Maintained and unmaintained routes

Applying linear regression anlyses, relationships between total sales production and distance to trunk road could be established. **Linear relationships have been found for unmaintained routes in all**

agro-ecological zones. Due to lack of roads that can be classified as being in maintained condition in the lowland zone and the Mufindi plateau it was not possible to establish relationships for maintained roads in these two agro-ecological zones.**The following relationships have been established:**

Highland zone:
Maintained roads: Total sales in ha p.p. = 0.251+0.0055*Distance to trunk
Unmaintained roads: Total sales in ha p.p. = 0.190+0.0026*Distance to trunk

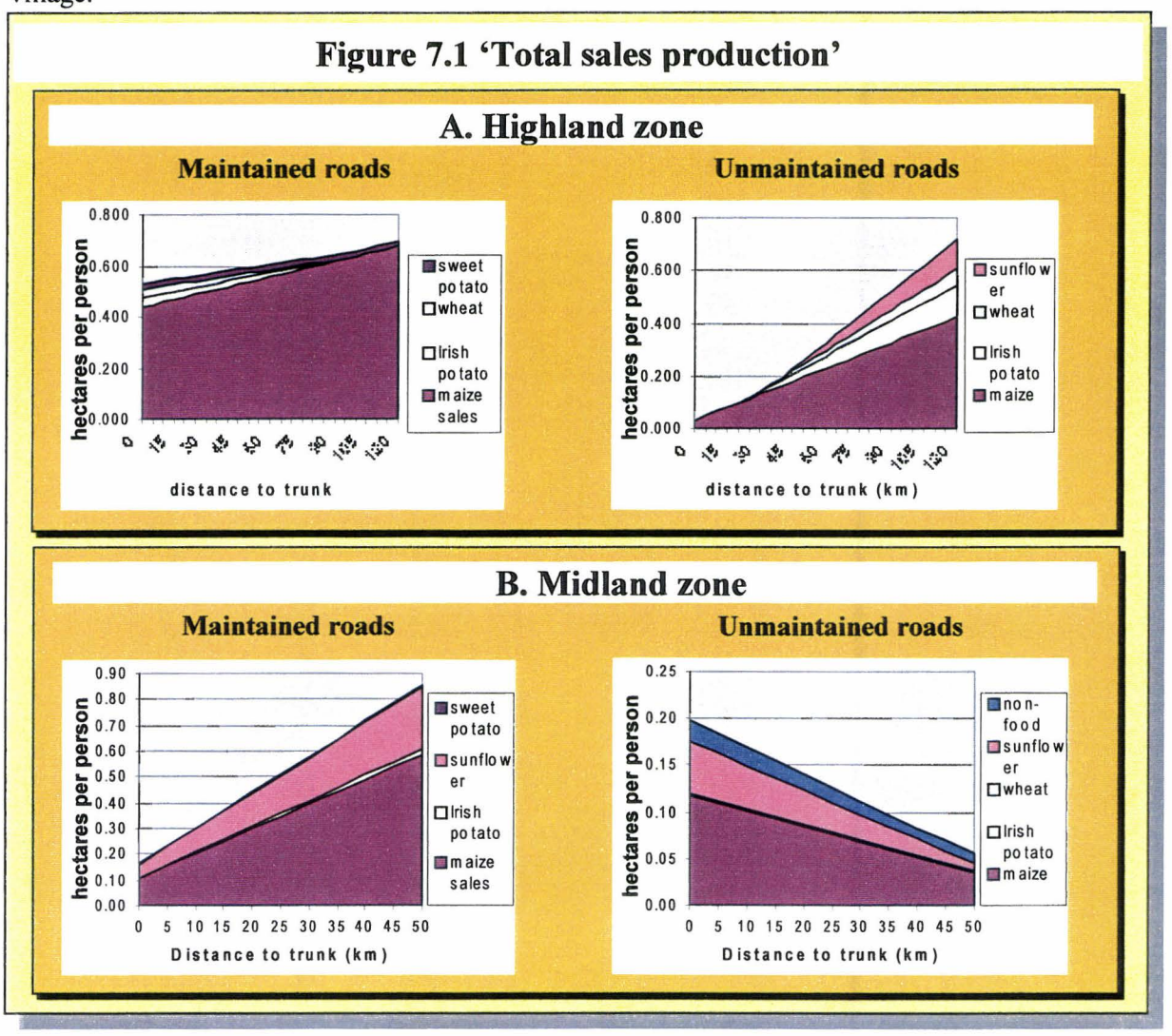
Midland zone:
Maintained roads: Total sales in ha p.p. = 0.184 + 0.0127*Distance to trunk
Unmaintained roads: Total sales in ha p.p. = 0.200 - 0.0024*Distance to trunk

Lowland zone:
Unmaintained roads: Total sales in ha p.p. = 0.159 - 0.0011*Distance to trunk

Mufindi Plateau:
Unmaintained roads: Total sales in ha p.p. = 0.232 + 0.00003*Distance to trunk

The data on total sales production show a great variance that can only partly be explained by the relationships with distance to trunk road. This results in relatively low R-squared statistics, between 44% and 3.2%. The correlation coefficients are also relatively low, between 0.67 and 0.18. Relationships have been found that are not statistically significant in cases where the number of data is limited. It is clear that there are other factors at work that determine the total sales production for each village.

Figure 7.1 'Total sales production'



As stated before, relationships for both maintained and unmaintained roads have only been found for the midland and highland zones. The total sales production as a function of distance to trunk road are visualised in figure 7.1. The figures are based on linear relationships found for individual products. Together they form a good proximation for the relationships presented above.

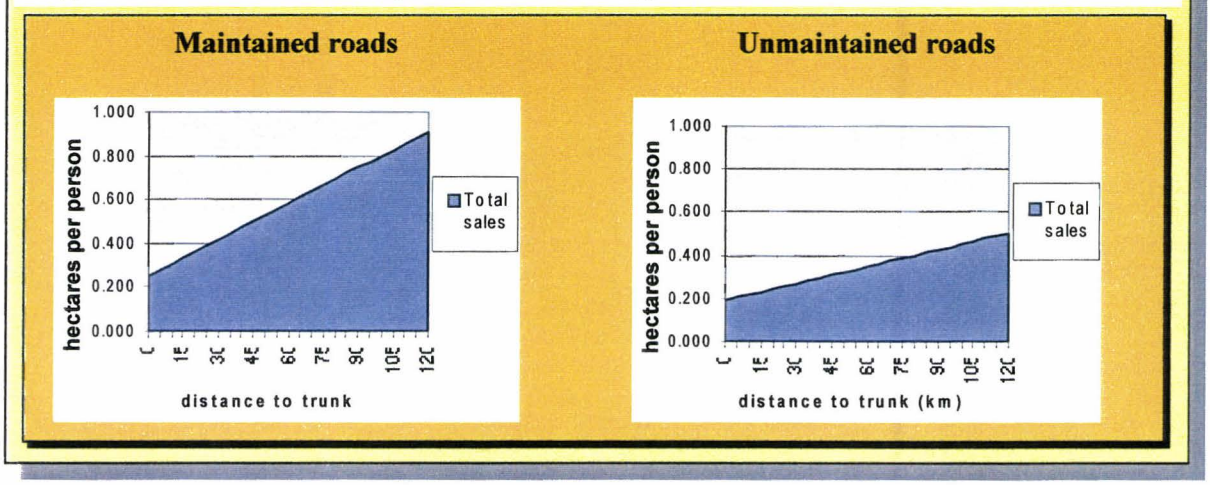
The **most prominent feature** in the figure is the totally different shapes of the graphs. The total sales production in the midland zone starts out at the same level on the trunk road and diverges with distance to the trunk road. The fuctions for the highland zone have different intercepts at the trunk road of 0.519 and –0.068 for maintained and unmaintained roads respectively. The two fuctions converge to equilibrium at 115 kilometres from the trunk road. This situation is very unlikely to occur in reality.

This effect is caused by the absence of villages that are located on or close to the trunk road. **Introducing an estimate for the average sales production on the trunk road for the highland zone presents an entirely different picture.** An average sales production on the trunk road of 0.225 hectares per person has been selected. It is the mean between the intercepts of the relationships found for the highland zone. Since there is no evidence at all that this value is correct the relationships found when incorporating this value may only be regarded as an example and can not be used for planning purposes. Incorporating the estimate for sales production on the trunk road the following relationships have been found for the highland zone:

Maintained roads: Total sales in ha p.p. = 0.251+0.0055*Distance to trunk
Unmaintained roads: Total sales in ha p.p. = 0.190+0.0026*Distance to trunk

These relationships are visualised in figure 7.2. The figure shows that the functions roughly have an equal intercept at the trunk road and diverge with distance to trunk road. The two diverging functions present a picture that is very similar to the one found for the midland zone. Based on this example it can be concluded that **sales production on maintained roads and unmaintained roads diverge with distance to trunk road.** Due to lack of data from villages in the highland zone located on or close to the trunk road the relationships found previously are not representative for the effect of road maintenance on sales production.

Figure 7.2 'Total sales production – highland zone inc. trunk estimates'



The relationships found on basis of production data show that **total sales production is significantly higher on maintained roads than on unmaintained roads**. For the midland zone the adjusted averages for sales production are 0.45 hectares per person for maintained and 0.17 for unmaintained roads adjusted for an average distance of 20.95 kilometres. For the highland zone the average production on maintained roads adjusted for the average distance to the trunk road at 50.67 kilometres is expected to be 0.59 hectares per person as opposed to 0.27 hectares per person on maintained roads. For the example including sales production estimates of 0.225 on the trunk road these values are 0.53 and 0.32 respectively.

The relationships found by the linear regression analyses show great differences between the agro-ecological zones. Therefor, it is impossible to make any inferences on the relationships for maintained roads for the lowland zone and Mufindi Plateau based on the relationships found for the other zones. The differences in sales production are probably related to differences in productiviy of the land. **The substantial differences between agro-ecological zones shows that productivity plays an important role that can not be neglected when analysing the effect of road maintenance on agricultural production**.

- **Due to the lack of 'maintained' roads in the lowland zone and Mufindi Plateau and the lack of villages in the highland zone that are located on or close to the trunk road, the effect of land productivity on sales production could not be analysed.**

7.4.3 Unmaintained roads connected by maintained roads

Apart from the effect of road maintenance on the sales production in villages located on the road itself, road maintenance can affect the sales production on unmaintained roads connected to the maintained road. in order to analyse the effect three options have been calculated: the expected sales on basis of the relationship found for maintained roads, on basis of the relationship for unmaintained roads and one on basis of a combination of the two. For the latter option it is assumed that sales production follows the relationship for maintained roads on the maintained section. It then continues following the slope of the relationship for unmaintained roads taking the level of production at the end of the maintained section as a starting point.

Only very few data are available for the analysis. The most suitable data for the analysis come from villages located in the highland zone. In the previous paragraph it was found that the relationships for the highland zone are not representative due to the absence of villages located on or close to the trunk road. In the midland zone only the villages of Lyasa, Kilala and Ibumu were found suitable for the analysis.

Table 7.2 shows the production data in the selected villages in the midland zone along with the expected values for the three options described above.

The production data from villages in the midland located on unmaintained roads that are connected to the trunk road by maintained roads shows that **the level of sales production is closer to the expected level on unmaintained roads than to the expected value on maintained roads**.

Table 7.2 'Unmaintained roads connected by maintained roads –Midland zone'

			Expected sales production		
			Maintained	Unmaintaine	Combined
Kilala	28	**0.15**	0.13	0.54	0.37
Ibumu	32	**0.19**	0.12	0.59	0.36
Lyasa	23	**0.35**	0.14	0.47	0.38

Table 7.3 shows the production data and the expected values for the three options described above. The expected values are based on the relationships found for the highland zone incorporating an estimated sales production on the trunk road of 0.225. These relationships are preferred over the relationships that were originally found because they provide a more realistic picture of the effect of road maintenance. It must be noted that they can not be regarded to be representative. They can merely serve as an example.

Table 7.3 'Unmaintained roads connected by maintained roads – Highland zone'

			Expected sales production		
			Maintained	Unmaintaine	Combined
Igolombe	73	**0.54**	0.65	0.38	**0.59**
Kipanga	89	**0.16**	0.74	0.42	**0.64**
Ukami	109	**0.59**	0.85	0.47	**0.69**
Uhafiwa	105	**0.64**	0.83	0.46	**0.68**
Ihimbo	101	**0.61**	0.81	0.45	**0.67**

The data from the highland zone show a better fit to a combination of relationships for maintained and unmaintained roads

It must be noted that the data on sales production showed very high variances. As a result the standard error of the estimates are very high. It can therefor not be excluded that the production levels found on the unmaintained roads that are connected by maintained comply with the expected values for maintained roads.

Because the sample is very small and the result are contradicting eachother and it can not be excluded that the values found do not comply with the other analysed options, **it is impossible to draw a valid conclusion.**

7.4.4 Conclusions

- **Due to lack of roads that can be classified as being in maintained condition in the lowland zone and the Mufindi plateau it was not possible to analyse the effect of road maintenance on agricultural production for these two agro-ecological zones.**
- **Valid relationships could not be established for roads in the highland zone due to the absence of data on or close to the trunk road.**
- **Road maintenance has a strong positive effect on sales production. The sales production was found to be substantially higher on maintained roads than on unmaintained roads.**
- **Sales production on maintained and unmaintained roads diverge with distance to trunk road.**
- **With regard to the behaviour of sales production on maintained roads connected to the trunk road by maintained roads no conclusion can be drawn on basis of the available information.**

7.5 The effect on the composition of sales production

The effect of road maintenance on the composition of sales production has been analysed by determinating linear relationships between the production of individual products and the distance to the trunk road. The relationships have been determined by linear regression analyses for each product on maintained and unmaintained roads in all the agro-ecological zones. Due to lack of roads that can be classified as being in maintained condition in the lowland zone and the Mufindi plateau it was not possible to analyse the effect of road maintenance on the composition of production for these two agro-ecological zones.

Figure 7.2 in the previous paragraph show the sales production for each individual product in the highland and the midland zones. The figure shows that **in the highland zone the composition of surplus production found for maintained roads deviates strongly from the composition on maintained roads.** The data samples for maintained and unmaintained roads stem from different administrative area, that are located in different districts. **In the midland zone the composition of sales production shows little difference between maintained and unmaintained roads.** This difference lies only in the absence of 'other non-food' products in the data sample for unmaintained roads.

The observed difference in the composition of sales production in the highland zone may be related to relative changes in producer prices between the individual products. In order to assess whether this relationship exists, the revenue per hectare for each individual product as a proportion of maize revenue per hectare has been plotted against the land use for each individual product as a portion of land use for maize. If a strong relationship between the relative producer prices and the area of land

used for each individual product exists, the relationships should be similar for maintained and unmaintained roads. It turned out that the relationships found for maintained and unmaintained roads differ strongly both in direction of the slope as in the shape of the relationship. Because the relationships differ strongly it can be concluded that **the difference in composition of sales production between maintained and unmaintained roads has no relationship with the relative change of producer prices.**

The difference in the composition of sales production found for the highland zone may well be caused by the fact that the data stem from two different adminstrative areas that are located in different districts. This pattern can be underpinned by the data from the other agro-ecological zones. The data for the lowland zone and the Mufindi Plateau show a distinct difference in composition between the divisions included in the sample. The small differences in composition between maintained and unmaintained roads in the midland zone appears to be caused by the fact that the small number of data comes from those few wards where no production of 'other non-foods' was recorded on both maintained and unmaintained roads. Furthermore, the data sample for unmaintained roads connected to the trunk road by maintained roads in the highland zone show the exact same composition as the villages from the same ward that are in the sample for maintained roads.

7.5.1 Conclusions

Since clear variations are found between administrative areas and only small variations within administrative areas and because the changes in composition between maintained and unmaintained roads are not related to changes in producer prices, the following **conclusions** can be drawn:

- **The composition of sales production is subordinate to the administrative area in which it is located.** It is likely that differences between administrative areas are caused by differences in government directives and/or local farming tradition.
- **As a result, the composition of sales production is unlikely to be affected by road maintenance or lack thereof.**
- Since the data for maintained and unmaintained roads in the highland zone were taken from very different administrative **areas it is very unlikely that production in villages located on unmaintained roads will adapt the composition found on the maintained roads in case the roads were to be maintained.** This must be kept in mind in further calculations.
- Because the composition of the sales production is not affected by road maintenance it is possible to calculate relationships for average revenue per hectare.

7.6 Relationship between sales production and producer prices

In order to assess whether a relationship between producer prices and production exists or not, the relationships between average revenue per hectare and sales production have been calculated. The average revenue per hectare has been calculated for all agro-ecological zones for both maintained and unmaintained roads if possible. The average is based on the compositions of sales production found in the previous paragraphs and the expected producer prices found in paragraph 5.2. Applying linear regression analysis **the following relationships for average revenue per hectare have been found:**

Highland zone

Maintained	Average revenue	= 208,860 – 1,008*Distance to trunk
Unmaintained	Average revenue	= 204,155 – 1,613*Distance to trunk

Midland zone

Maintained	Average revenue	= 87,172 – 408*Distance to trunk
Unmaintained	Average revenue	= 82,923 – 556*Distance to trunk

Lowland zone
Unmaintained Average revenue = 45,467 – 286*Distance to trunk

Mufindi Plateau
Unmaintained Average revenue = 118,745 – 1045*Distance to trunk

The resulting functions for average revenue per hectare have then been plotted against the relationships found for total sales production for maintained and unmaintained roads in all agro-ecological zones in order to determine the relationship between the two. The relationships between sales production and average revenue per hectare are as follows:

Highland zone[7]
Maintained total sales = 1.057 – 0.00350 * revenue (1000 Tsh)
Unmaintained total sales = 0.408 - 0.00094 * revenue (1000 Tsh)

Midland zone
Maintained Total sales = 2.89 – 0.03103*revenue (1000 Tsh)
Unmaintained Total sales = -0.153 + 0.00426*revenue (1000 Tsh)

Lowland zone
Unmaintained Total sales = -0.015 – 0.00384*revenue (1000 Tsh)

Mufindi Plateau
Unmaintained Total sales = 0.159– 0.00000*revenue (1000 Tsh)

The relationships between total sales and average revenue per hectare do not show any similarity amongst eachother. The slopes of the functions differ considerably. In one case the direction is different from the others. However, a clear difference has been found in total sales production between maintained and unmaintained roads for the highland and midland zones.

7.6.1 Conclusions

- Since the relationships between total sales and revenue per hectare do not show any strong similarities it may be concluded that **the difference in sales production between maintained and unmaintained roads can not fully be explained by changes in producer prices.**
- Because there is no clear relationship between average revenue and total sales production that is valid for all maintained and unmaintained roads in all of the agro-ecological zones it is not possible to derive any relationships between total sales production and distance to trunk road for maintained roads in the lowland and midland zone.
- **Since there is no relationship between producer prices and sales production the effect of road maintenance on these two factors must be treated as two individual independent relationships.**

7.7 Effect on food shortages

Food shortages are recorded in a significant number of villages, especially in the midland and lowland zones. These are the two least productive zones in the research area.

Shortage of maize on **maintained roads in the midland zone** in villages away from the trunk road occurred one out of seven times, shortage of beans occurs three times. Relationships have been found that show a decline in food shortage with growing distance from the trunk road. However, the

[7] Based on relationships including an estimate sales production on the trunk road of 0.225 hectares per person

relationships have very high p-values, meaning they are not statistically significant at 90% confidence levels. **The Relationships are very weak and it is questionable whether they are representative.** For maize only one village recorded shortage. The relationship is mainly determined by the occurrences of maize shortages on the trunk road. The negative relationship for beans shortage is due to zero shortages at longer distances.

On **unmaintained roads** shortage of maize occurs 8 out of 38 times. Shortage of beans is rife on unmaintained roads. Only one village recorded no shortage of beans. For both maize and beans the shortage appears to be relatively steady at all distances from the trunk road. **The severity of maize shortage, when occurring, is higher on unmaintained roads than on maintained roads.** The shortage of maize recorded on unmaintained roads is up to 0.2 hectares per person. The maize shortage recorded on maintained roads was 0.02 hectares per person. The severity of recorded beans shortages on maintained roads is slightly higher (0.4 hectares per person) than the average on maintained roads. **There are no data available for maintained roads in the lowland zone. It can therefore not be assessed whether road maintenance has any effect on food shortages.**

7.7.1 Conclusions

Based on the available data the following conclusions can be drawn:

- **Road maintenance in the midland zone appears to have a reducing effect on food shortages.** The extent of the effect is hard to determine.
- **The relationships found between food shortages and distance to trunk road are very weak and it is questionable whether the relationships are representative.**
- Since there is a positive relation found between sales production and distance to trunk road for maintained roads that has a much steeper slope than those found for food **shortages it may be assumed that the effect on sales production covers the effect on food shortages quite well.**

7.8 Conclusions

From the previous paragraphs the following main conclusions on the effect of road maintenance on agricultural production can be drawn:

- **Due to lack of roads that can be classified as being in maintained condition in the lowland zone and the Mufindi plateau it was not possible to analyse the effect of road maintenance on agricultural production for these two agro-ecological zones.**
- **Valid relationships could not be established for roads in the highland zone due to the absence of data on or close to the trunk road.**
- **Sales production shows a stronger relationship with the distance to the trunk road than with distance to the market.**
- **Road maintenance has a strong positive effect on sales production. The sales production was found to be substantially higher on maintained roads than on unmaintained roads.**
- **Sales production on maintained and unmaintained roads diverge with distance to trunk road**

- **The effects on producer prices can not explain the positive effect of road maintenance on sales production.** The effects of road maintenance on producer prices and on sales production have to be treated as two different independent functions.

- The relationships between sales production and distance to trunk road show strong differences between the agro-ecological zones, which are related to the differences in productivity of the land. **The productivity of the land can not be neglected in the assessment of the effects of road maintenance.** The effect of land productivity could not be abalysed due to lack of data.

- **The composition of sales production is not affected by road maintenance. It is more likely to be determined by government directives and local farming tradition.**

- **With regard to the behaviour of sales production on maintained roads connected to the trunk road by maintained roads no conclusion can be drawn on basis of the available information.**

- **Road maintenance appears to have a reducing effect on food shortages.** However, there were insufficient data available to properly quantify the effect. **It is assumed that the effect on sales production represents the reduction of food shortages.**

7.9 comments

With regard to the conclusions presented above the following comments must be made:

- **The relationships found are generally very weak.** Only in a few cases the relationships were found to be statistically significant. The r-squared statistics are usually very low. This indicates that there are other forces at work that determine the level of sales production.

- **The data for maintained and unmaintained roads in the highland zone used in the analyses originate from two different administrative areas.** It has already been pointed out that this has great effect on the composition of sales production. However, this can also bear strong influence on the total sales production found in the two areas. **The relationships found for maintained roads may therefore not present an accurate description fitting the data sample for unmaintained roads in case they were to be maintained.**

With regard to the **extend to which the research findings can be generalised** the following must be noted:

The analyses show that the composition of sales production is largely depending on local government directives and local farming tradition. The data samples taken in this research are rather small and in some cases incorporate only one division or district. The outcome may therefore be very case specific.

The analyses show that the composition of sales production is largely depending on local government directives and local farming tradition Therefor the relationships found in this research can not be used as quantifications for other divisions, districts, regions or countries.

Chapter 8 The effect on rural income

This chapter discusses the analysis of the effect of road maintenace on rural income. It answers the following research question:

'What is the effect of road maintenance on rural income per capita?'

For the analysis on rural income it is assumed that all income derives from the sales of agricultural produce. As was discussed before, there are two ways in which rural households can sell their produce. The first way is to sell produce to traders that come to the villages to buy up produce and sell it in major market, mostly in Dar Es Salaam. In this case village households will receive the producer prices as described in chapter 2. The second way is to travel to the central markets of Iringa and Mafinga Town to sell produce there. The prices at these markets are higher than those paid in the villages.

In order to assess the effect road maintenance has on rural income, the quantity of produce sold on the central markets needs to be assessed first. The effect of road maintenance on the quantity of produce sold in the central markets is analysed in paragraph 8.1. Paragraph 8.2 discussses the effect of road maintenance on rural income based on the relationships found in chapter 7 combined with the results of paragraph 8.1. The conclusions with regard to the effect of road maintenance on rural income are presented in paragraph 8.3.

8.1 Sales on the central markets

This paragraph assesses the quantity of produce sold at the central markets of Iringa and Mafinga towns. The direct sales on these markets form the portion of income that is not affected by changes in producer prices cause by road maintenance or lack thereof. The direct sales on the central markets is discussed in more detail in chapter 4 of appendix 4.

8.1.1 Data acquisition

In order to assess the direct sales on the central markets data have been gathered on the number of trips with the objective to sell produce on the markets made by rural households. Accordingly the quantity of produce sold at per trip has been assessed as well. The data have been gathered during the social impact surveys executed in pre-selected villages. The selection of these villages has been discussed in chapter 4

In the social impact survey household representatives from the rural villages have been asked the number of times people from their household travel to the central market to sell produce and the quantity of produce they sell at a single trip. The responses of each individual respondent are presented in overview 3 of appendix 5 'Social impact survey'.

8.1.2 Local traders

The responses given by the respondents show great variances. Many heads of households stated that they never travel to the central market to sell produce, whereas a small number of respondents reported up to 180 trips for this purpose. **In virtually all cases where the number of trips for selling produce exceeded 12 trips per year the respondent, or one of his household members, was reported to be a trader by profession.** Local traders buy up produce from the villagers for the same price as traders from outside do. Sales on the central market by the local traders do therefore not contribute to extra income of village households. There is no information available on the profits made by the local traders. Since no quota sampling has been applied, the number of traders in the samples is very likely not representative for the village samples. For these reasons **the responses from traders have been excluded from the analysis.**

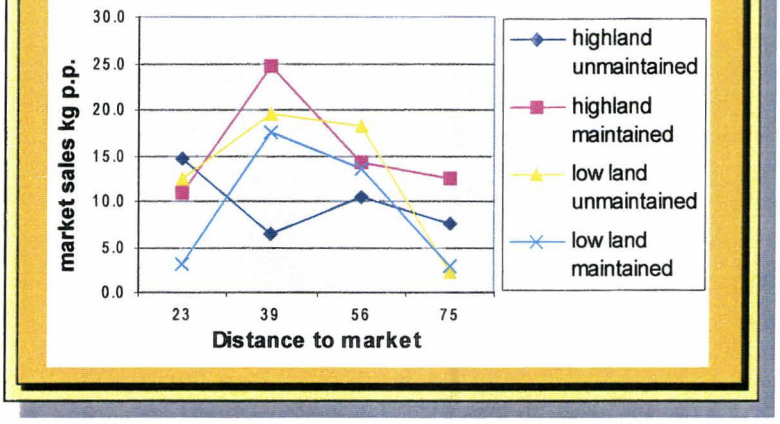
8.1.3 Quantity of produce sold at the market

The quantity of produce sold at the market is determined by the average weight sold per trip and the number of trips made by a household to sell the produce. **The average quantity of produce sold per trip to the central market is around 50 kg. The main product sold on the central markets is maize. The average number of trips per household varies between 0.07 and 6.1 trips per year per household**. Figure 8.1 shows the average quantity of produce sold per year per household in the selected villages based on the responses by respondents.

The figure shows that there are no patterns that clearly distinguish between maintained and unmaintained roads. This maens that **road maintenance does not have any significant effect on the quantity of produce sold on the central market.**

Linear regression analyses have been performed to see whether a relationship exists between market sales and distance to trunk road. **No statistically significant relationship was found between market sales and distance to trunk road**.

Figure 8 'Central market sales vs distance'



In order to determine the effect of market sales on rural income, the average quantity sold can be used. **The average quantity of produce sold on the central market is roughly 11.9 kilogram per person for each village**. The standard deviation of the average is 6.4. In terms of land use, market sales of 11,9 kilograms is equal to 0.004 hectares for the highland zone, 0.008 hectares for the midland zone and 0.012 and 0.006 hectares for the lowland zone and Mufindi Plateau respectively.

The quantity of produce sold on the central markets shows no relationship at all with the expected extra revenue in comparison with sales at the village. Furthermore it was found **that direct sales on the central market only form a substantial part of the total sales production for villages with low productivity and low production levels.** In these cases market sales also contribute strongly to rural income.

8.1.4 Conclusions

From the previous the following main conclusions can be drawn:

- **The amount of produce per person sold on the central market does not show any distinct differences between maintained and unmaintained routes or between routes in the highland and the lowland zones**.
- **The average quantity of produce sold on the central market is roughly 11.9 kilogram per person for each village**. In terms of land use, this is equal to 0.004 hectares for the highland zone, 0.008 hectares for the midland zone and 0.012 and 0.006 hectares for the lowland zone and Mufindi Plateau respectively.

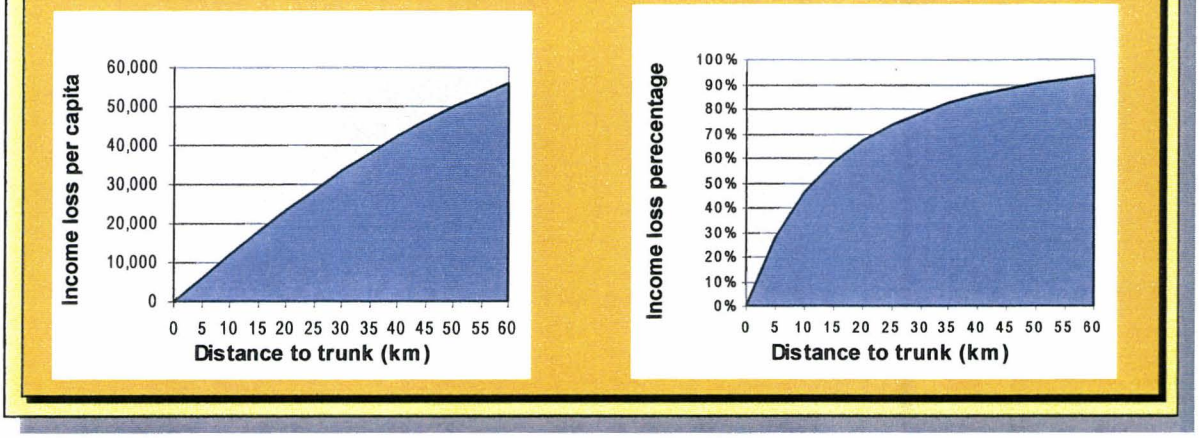
8.2 Effect on rural income

Based on the relationships found in the previous chapters the effect of road maintenance on the income per capita can be calculated. Because only the relationships found for the midland zone are representative the income effect can only properly be assessed for this zone. In order to gain some insight in the effects of road maintenance the income effect is assessed for the highland zone as well. The relationships from the exemplary analysis, whereby estimates for sales production on the trunk road have been included have been applied for the calculations.

8.2.1 Effect on income per capita in the midland zone

Figure 8.2 shows the loss in income per capita for the midland zone in monetary terms (Tsh) as well as in percentages of income. The income loss in percentages is based on the expected income on maintained roads. The income per capita is calculated using the relationships between distance to trunk road and sales production and the relationship between distance to trunk road and average revenue per hectare. The revenues from direct sales are based on sales of 11.9 kg per person at a price of 8500 Tsh.

Figure 8.2 'Effect on income – Midland zone'

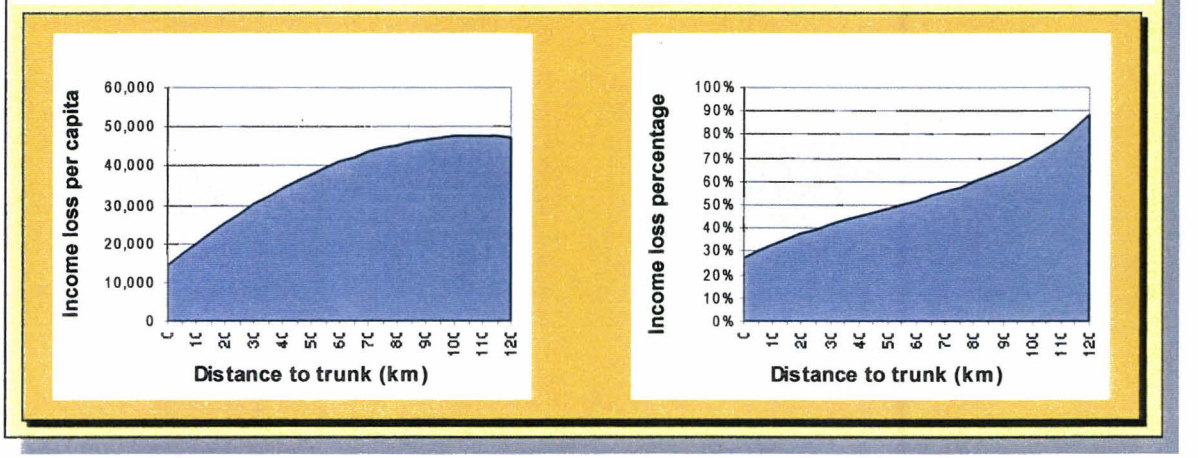


The figure shows that **road maintenance has a dramatic effect on income per capita. At a distance of 60 kilometres from the trunk road the income per head has dropped 95% with 55,000 Tsh.** The figure shows there is a rapid drop in income even at short distances to the trunk. At 10 kilometres the income has dropped 50%. **On average the drop of income per kilometre is roughly 1000Tsh.**

8.2.2 Effect on income per capita for the exaple for the highland zone

Figure 8.3 shows the loss of income in the highland zone caused by the absence of road maintenance both in monetary terms and in percentages. The relationships are based on the example whereby estimates for sales production on the trunk road have been included. There are no data available on which the estimates could be based. Therefor, **the picture drawn here for the effect on income in the highland zone can not be used as quantification for network calculation purposes.** It can only be used to gain insight in the mechanisms of the effect of road maintenance.

Figure 8.3 'Effect on income – Highland zone Example'



The loss of income varies between 15,000 Tsh and 48,000 Tsh. At a distance of 60 kilometres the loss of income is 40,000 Tsh. In the midland zone a loss of 55,000 Tsh was recorded at this point. **The absolute loss of income appears to be somewhat smaller than the loss registered in the midland**

zone. This may be caused by the fact the relationships for the highland zone can not be considered representative. Other values for sales production on the trunk road will certainly change the magnitude of the effect on income per capita.

The loss of income in the highland zone has a more parabolic shape then the income loss in the midland zone. This is mainly due to longer distance at which villages are located in the highland zone. In the first 60 kilometres the average loss of income per capita per kilometre is roughly in the order of 500Tsh. **The shape of the curves for income loss per person is roughly the same for both the highland and the midland zone.** However, there is not enough information available for proper comparison between the two zones, let alone for a comparison with the lowland zone and the Mufindi Plateau.

8.3 Comparison with transport costs

For the first 60 kilometres an average drop in income per kilometre was found of 1,000 Tsh in the midland zone and 500 Tsh for the highland zone. There are no data available for the actual raise in transport costs. However from the effects on producer prices estimates for transport costs can be derived. Since the bulk of the sales production consists of maize, the difference in transport costs for maize between maintained and unmaintained roads will probably be the most representative. Using the relationships producer prices for maize the extra transport costs caused by the absence of road maintenance is estimated at 150 Tsh per tonkilometre.

The average weight of produce sold on maintained roads in the midland is 0.464 metric tonne. The extra transport cost of the absence of road maintenance would then be 69.6 Tsh per kilometre per person. This is roughly 15 times less than the loss of income recorded in the midland zone. It does not even account for the loss in sales production. **The loss of income per kilometre caused by lack of maintenance much higher than the rise in transport cost. Basing the economic evaluation of road maintenance solely on transport costs would underestimate the effect for the midland zone by a factor of 15.**

8.4 Unmaintained roads connected by maintained roads

It has proved impossible to properly determine the effect of road maintenance on succeding unmaintained roads. It is therefor not possible to determine the behaviour of income per capita on such roads.

8.5 Conclusions

- **Road maintenance has enormous effect on income per capita from agricultural production.** The drop in income recorded in the midland zone is up to 55,000 Tsh (65 U$) per person and up to 95% of total income.
- **The effect of income appears to be different for each agro-ecological zone.** There is no information available to make proper comparison between the agro-ecological zones.
- **The loss of income per kilometre caused by lack of maintenance much higher than the rise in transport cost. Basing the economic evaluation of road maintenance solely on transport costs would underestimate the effect for the midland zone by a factor of 15.**
- **Because transport costs alone strongly underestimate the economic effect it is very relevant to take the loss of income into account when assessing the economic effect of road maintenance.**
- **The effects on income per capita could not be established for unmaintained roads connected by maintained roads.**

Chapter 9 Effect on industry and tourism

This chapter discusses the effects of road maintenance on the industial and tourist sector. The chapter answers the following research questions:

'What are the effects of road maintenance on the industrial sector?'
'What are the effects of road maintenance on the tourist sector?'

The effects on the industrial sector are discussed in paragraph 9.1. The effects on the tourist sector are presented in paragraph 9.2. The conclusions are summarised in paragraph 9.3.

9.1 The effect of road maintenance on the industrial sector

The five companies active in Iringa Rural District are Dabaga Fruit and Vegetables Cannery Ltd, Asas Dairy Farms Ltd, Green Highland Ltd, Maji Africa Mineral Water Company and a conglomeration of tobacco farmers.

Of these five companies **the Dabaga Fruit and Vegetables Cannery Ltd and the Asas Dairy Farms Ltd** are both located on the trunk road. Both companies produce their inputs at the plant site. Both companies have no need for transportation of inputs over the rural road network of Iringa Rural District. The end products of the companies are sold nation wide and in the neighbouring regions respectively. The products are mainly sold in the major cities, from where they may be distributed further. Transport takes place on the maintained trunk roads. Therefor **road maintenance on the rural roads in Iringa Rural Districts has no effect on the Dabaga Fruit and Vegetables Cannery Ltd and the Asas Dairy Farms Ltd.**

The Green Highland Ltd. is located in the village of Bomalang'ombe in the highland division of Kilolo. The company is connected to the T1 trunk road by unmaintained roads. This leads to higher transport cost. This has had a strong effect on the construction costs of the plants. Since the plants are not fully operational produce is sold on very small scale mainly in Iringa Town and other nearby cities. Only a limited number of people were employed at the production plant at the time of the research. Local farmers grow the inputs for the products. At the time of the research the company was still working out its marketing plan. It could therefor not be said how much produce they expect to sell when the company is fully operational. Therefor **the impact of road maintenance on the Green Highland ltd can not be determined.**

The **Maji Africa Mineral Water Ltd**. is located in the village of Kidamali some 10 kilometres off the Iringa – Msembe regional road. The CEO of the company could not be contacted to provide any information about the company. Therefor, **no conclusions can be drawn about the effect of road maintenance for the Maji Africa mineral Water Ltd.**

There are several **tobacco farms** in Iringa Rural District, all located in the Nzihi ward in Kalenga division. The farms are located in Kidamali, Nzihi, Nyamihuu and Kipera. The companies consist of large tobacco plantations and a processing plant in Kidamali. The bad quality of the roads connecting these villages to Iringa Town and the trunk roads lead up to high transport costs. This in turn damages the profitability of the company because prices are set on the international market. Therefor they can not calculate their high transport costs into their sales prices. **Road maintenance would increase the profitability of the tobacco farms by reducing transport costs**. It is not know whether the extra profits in case the roads were to be maintained would have any distribution effects. They would in any way depend on the reduction in transport costs.

The total production of the tobacco farms in 2000 was 9,497 tonnes on all four farms together. Since the central processing plant is located at Kidamali it may be assumed that all transport starts from here. **The economic effect of maintenance of the Iringa – Kidamali section of the Iringa – Msembe**

road would be 1.425 million Tsh per kilometre based on additional transport costs of 150 Tsh per tonkilometre.

9.2 Effect of road maintenance on the tourist sector

9.2.1 Effect on visitor nights

Table 7 shows the number of visitor nights for the last couple of years. The table shows that the number of visitors has increased strongly over the last years. Since the road to the park has not been maintained for some time the quality of the road has worsened over the same period.

Table 7 'Vistor nights Ruaha National Park'

Year	1993	1994	1995	1996	1997	1998	1999
Fee paying	2404	2690	2600	2761	2859	2957	10301
Total	3099	4416	4269	5098	5683	6268	10938

Therefor **it can not be concluded that road maintenance has affected the number of visitor nights in the park in a negative way.** It is impossible to assess whether more people would have visited the park if the road had been maintained.

9.2.2 Effect on transport costs

The poor condition of the road leads to higher transport costs for getting all the necessary food and beverages for the visitors and the personnel to the park. The park warden estimated an average of roughly 50 kg per visitor night is needed. This includes food and drinks for visitors and personnel as well as replacement parts for vehicles and camps. This requires a total annual transport of roughly 550 tonnes. **At an additional transport cost of 150 Tsh per tonkilometre the additional benefit of road maintenance from the park is 82,500 Tsh per kilometre for the entire Iringa – Msembe road.**

9.2.3 Future plans

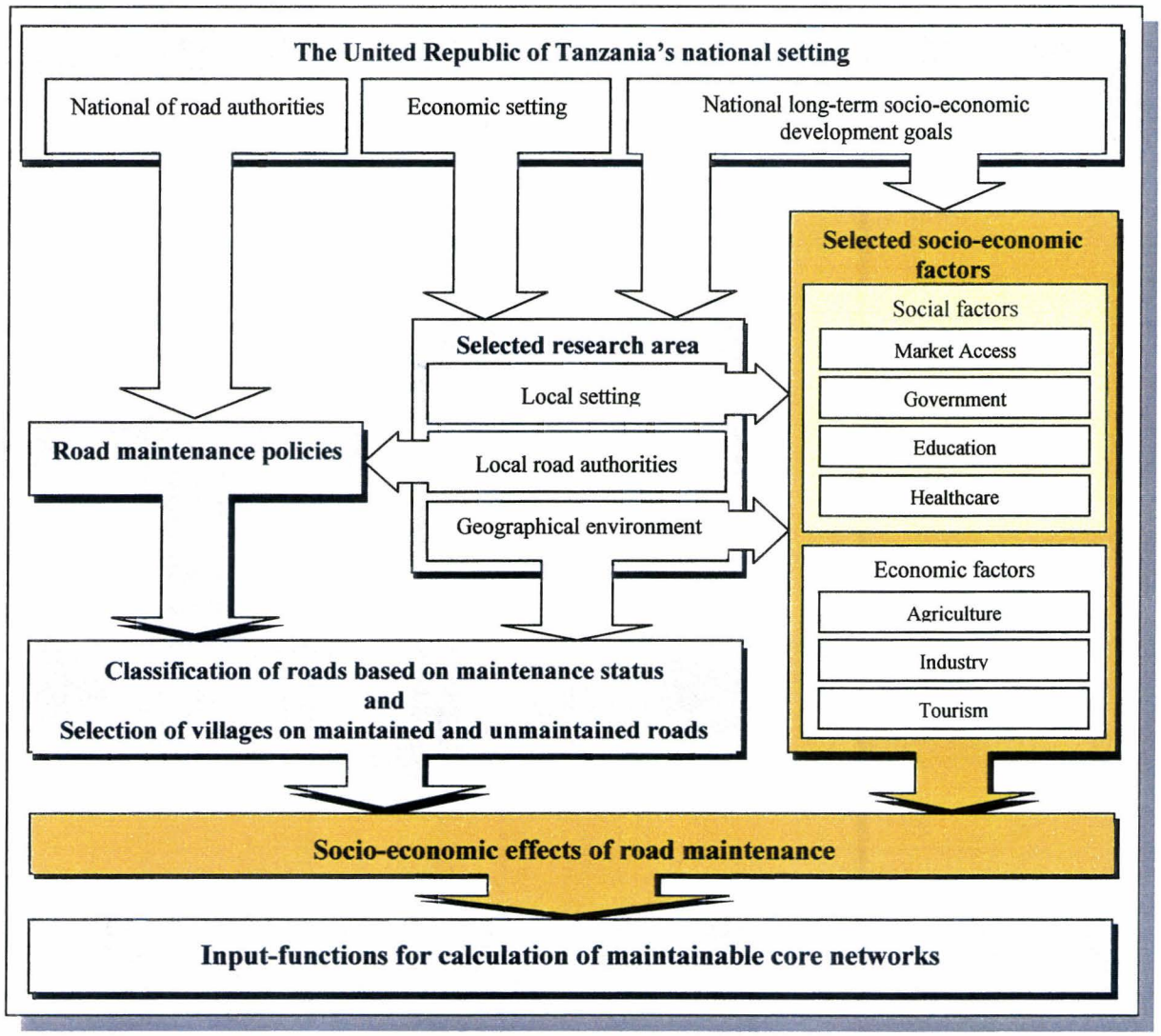
The Tanzanian government has serious plans to further develop the Ruaha National Park over the next few years. Plans are being made for two new lodges adding 300 beds to the park. This would more than double the parks capacity. Building these new lodges would bring about enormous extra transport costs if the road as not being maintained. It is however at this stage not know how high those costs would be.

9.3 Conclusions

- **The only effect road maintenance has on the industrial companies is reduction of transport costs.** There is no evidence for any further economic consequences.
- **The lack of road maintenance has not influenced the number of visitors to Ruaha National Park over the last few years**
- Maintenance of the R621 Iringa – Msembe regional road will result in reduction of transport costs for the ruaha National park and the tobacco farms. **The reduction of transport costs are estimated at a total of 1.508 million Tsh per kilometre for maintenance of the Iringa – Kidamali section. The reduction of transport cost on the Kidamali – Msembe section will be 82,500 Tsh per kilometre.**

Section C

Social effects of road maintenance



Chapter 10 Social effects of road maintenance

This chapter describes the analysis of the social effects of road maintenance. The chapter answers the following research questions:

'What is the effect of road maintenance on market access?'
'What is the effect of road maintenance on government?'
'What is the effect of road maintenance on education?'
'What is the effect of road maintenance on healthcare?

Paragraph 1 discusses the data acquisition. Paragraphs 2 to 5 elaborate on the respective questions. paragraph 6 discusses the conclusions regarding the impact of road maintenance on the selected social parameters.

10.1 Data acquisition

Most of the data analysed here come from the interviews held with household representatives in 17 selected villages. Between 14 and 22 respondents per village have been interviewed, depending on the population of the village. The method of data acquisition and the selection of respondents are discussed in chapter 3 of the main report. The selected villages ar roughly located at distances of 20, 40 60 and 80 kilometres from the district capitals of Iringa and Mafinga Towns. Although the actual distances on the selected routes may differ slightly, all figures in this chapter depict the results at these distances. The number of trips presented in this chapter are all in number of trips per year.

The questionnaires used for the interviews are shown in overview 1. The results of the interviews in average for each specific question are presented in overview 2. Overview 3 shows the response sheets for all the interviews that have been conducted. Overview 4 contains the data taken from hospital admittance records from the district and regional hospitals. All overviews are presented in appendix 5.

10.2 The effect of road maintenance on market access

The effect of road maintanenance on market access has been analysed by comparing the average number of trips per household to the markets. Household representatives have been asked the number of trip their household members make to the central markets in Iringa and Mafinga towns and the number of trips made to possible local markets. The trips to the central markets have been divided in two purposes. One purpose is to sell produce, the second purpose is to by household necessities and farming equipment. Furthermore, the respondents have been asked about the mode of transportation used for the trips and the quantity of produce sold on the central market per trip. **For the analysis it is assumed that households are the determinative unit for the number of trips to the market.**

10.2.1 Adjusting data for salesmen and businessmen

In some of the villages a number of respondents were found to be salesman or businessman by profession. Salesman buy up produce locally to sell on the central markets. They usually pay the same producer prices as the traders that come from outside to buy the produce. It is assumed that for this reason the sales on the market by local salesmen does not contribute to the income of the households. Salesmen make more trips to the central market for selling produce than the average household. Businessmen are usually local shop owners. They regularly travel to the central markets to buy stock.

Because quota sampling has not been applied for the selection of respondents, the number of sales- and businessmen is not likely to be representative for the village population. Therefor, **the responses from salesmen and businessmen have been excluded from the analysis.**

10.2.2 Trips to markets

The average number of **trips to the central markets** varies considerably between villages regardless of their location. The average number of trips to the central market for selling produce varies strongly

between 0.1 time per year to 6.2 time per year.The average number of trips for buying things varies between 0.6 and 8.8 times per year. The village of Tagamenda recorded a very high number of trips: 30.6 and 47.5 per household per year respectively for selling produce and buying things. This is probably due to the short distance to the central market. From the responses given by household representatives **no patterns that clearly distinguish between maintained and unmaintained roads regarding the number of trips to the market for selling produce as well as for the purpose of buying things can be found.**

As has already been discussed in chapter 8, road maintenance has no significant effect on the quantity of produce sold on the central markets. The average quantity was found to be 11.9 kilo per person.

With regard to the number of trips to **local markets** it was found that most of the selected villages are visted once a month by travelling markets. These markets travel around, visiting one village per day. Households can buy necessities and farming equipment at these markets. The travelling markets are visited every month by the local population. Local permanent markets were foundin the villages of Kalenga and Ilula. These markets are visited virtually every workday by the local population.

10.2.3 Mode of transportation

All trips made to the local markets are made on foot. The trips to the central markets are all mede by bus with the exception of the villages of Kalenga and tagamenda. These villages are located at walking distance from the central markets. These villages recorded a large number of trips made on foot.

10.2.4 Conclusions

The analysis of the number of trips to the central markets of Iringa and Mafinga town for both selling produce and buying goods shows that there are no distinctly different patterns have been found for maintained and unmaintained roads. The quantity of produce sold at the central markets is not influenced by road maintenance. Furthermore. Travelling markets visit each village one time per month, providing easy access to household appliances and farming equipment. Based on these findings the following **conclusion** can be drawn:

- **Road maintenance does not affect market access in any significant way**

10.3 The effect of road maintenance on government

The effect of road maintenance on the functioning of the governments is analysed by the number of trips made by household members to governmnet headquartes at ward and district/ regional level. Respondents have also been asked the mode of transportation used to the government headquarters.

10.3.1 Adjusting data for government officials

In most of the villages a number of respondents said to be government officials. **The number of trips made by government officials is largely depending on obligations related to their functions.** This is usually once per year for hamlet officials, once or twice per month for village officials and once a week for ward officials. Virtually all answers by government officials comply with this number of trips made to the ward headquarters. Since no quota sampling has been applied it is likely that the number of governmnet officials in the sample is not representative for thhe village population. Therefor, **the responses from government officials have been excluded from the analysis.** Seperate analysis on the travel behaviour of village officials could not be performed.

10.3.2 Trips to ward headquarters

The average number of trips to the ward headquarters varies from 0 to 3.5 times per year. The average number of trips shows a strong reltionshhip with the distance to the ward headquarters. Villages in which the headquarters are located reported averages between 0.3 and 3.5 trips per year. Villages located more than 5 kilometres away all score less than 0.2 trips per year. Furthermore, the analysis

shows that **there are no patterns that clearly distinguish between maintained and unmaintained roads regarding the number of trips to the ward head quarters.**

10.3.3 Trips to district/ regional headquartes

The number of trips to the district and/ or regional headquarters recorded in the villages is very low. For most villages the average number of trips is once per ten years. Only two villages recorded a higher number of trips, around 0.7 times per year. The number of trips is very low, both on maintained and unmaintained roads. **It can be concluded that road maintenance has no effect on the number of trips made to district and regional head quarters.**

10.3.4 Mode of transportation

For trips to the ward head quarters 100% of all respondents stating to make trips to the ward headquarters indicated that they make these trips on foot. This is mainly because the ward headquarters are within 20 kilometres of all selected villages. All reported trips to the district or regional headquarters are made by car.

10.3.5 Conclusions

The analysis of the number of trips to the ward and district or regional headquarters shows that there are no distinctly different patterns have been found for maintained and unmaintained roads. The number of trips to the ward headquarters is strongly related to the distance to the headquartes. The average number of trips to the district or regional headquarters is very small. The number of trips by government officials is mostly determined by obligations related to their function. Based on the findings the following **conclusion** can be drawn:

- **The effectivity of the government structure is not influenced by road maintenance.**

10.4 The effect of road maintenance on education

The effect of road maintenance on education is measured by the average number of students per household that attend secondary school.

The population sample was too small to analyse the effect of road maintenance on secondary school attendance. Nationally less than 5% of all children eligible to go to secondary school actually attend school. It is well known that the percentage in cities is much higher than in rural areas. It is possible that a sample of 2% of the population is too small to estimate the actual number of students that attend secondary school.

Unfortunately there was no data available from village governments on the number of secondary school students from each selected village. Therefor, **it could not be established whether road maintenance has any effect on secondary school attendance**. It is, however, quite likely that secondary school attendance is related to income.

10.5 The effect of road maintenance on healthcare

The effect of road maintenance on healthcare is measured by the number of trips made to health facilities at different levels. These levels are dispensaries, divisional health centres and the district and regional hospitals. For the analysis it is assumed that the individual person is the determinative unit for the number of trips to health facilities.

10.5.1 Trips to health facilities

The number of trips to the three levels of health facilities showed a high correlation with the distance to the health facilities. The number of trips to dispensaries was clearly highest in villages where dispensaries are located. A similar pattern was found for divisional health centres. Divisional health centres take over the role of dispensaries in the villages where they are located. The villages that are located on the unmaintained route into the lowland zone reported a relatively high number of trips to

the district and regional hospitals. The high number of trips in the first village on the route, Kalenga, may be explained by the short distance to the district hospital in Tosamaganga. This district hospital is located at only 6 kilometres from Kalenga. The villages with high numbers of trips to the hospitals also show a low number of trips to other facilities. A similar pattern can be seen in the village of Tagamenda, which is located close to the regional hospital in Iringa Town. This shows that **the location and distance to health facilities has a great influence on the number of trips to the different levels of health facilities.** All selected villages have a health facility within 20 kilometres.

The total number of trips per person to health facilities varies between 2 and 10 times per year. Based on the answers given by the respondents shows **no patterns that clearly discriminate between maintained and unmaintained roads**.

Based on the responses given by the household representatives the following **conclusion** can be drawn

- **Road maintenance does not have a significant effect on access to healthcare facilities.**

10.5.2 Patient admittance registrations from district and regional hospitals

Patient admittance registers were taken from the district hospital in Tosamaganga and the regional hospital in Iringa Town. Data could not be obtained from the district hospital in Mafinga. **The data gathered are the village of village of residence from the hospital admittance records for January 2001**. Data for other periods could not be obtained. Due to the lack of data from the Mufindi District Hospital a proper comparison could not be made between maintained and unmaintained roads in the highland zone.

Of the 686 patients registered in January 2001 a total of 87 patients could not be attributed to specific villages. The data can therefor not be used for full analyses of the effect of road maintenance on the number of patients registered at the hospital.

10.5.2.1 Data analysis

Table 1 in appendix 5 presents a summary of the data taken from the hospital admittance records. The table shows that, when taking all villages into account the average number of patients registered on the trunk road is highest. The results show that **the average number of registered patients does not show different patterns for maintained and unmaintained roads**.

From the analysis of the patient admittance registers it becomes clear that the presence of bus services in the villages is of great consequence to the number of patients registered in the hospital. 44% of all villages are connected bus services. **Of all the villages from which patients were registered 64% have active bus services. Of all villages connected by bus services 76% recorded registered patients. The number of registered patients per 1000 people is significantly higher for villages connected with bus services than the overall averages**.

The coefficients of the correlation between bus fare and number of registered patients show great differences between the selected groups. This strongly indicates that there is no evident relationship between the two. The data shown above clearly show that **the number of registered patients depends heavily on the presence of bus services in the village of origin.**

Although the data indicate otherwise, there is no direct relationship between road maintenance and the presence of bus services. However, from the impact studies from, a/o. the rehabilitation project on the Ilula – Ibumu road it becomes evident that road maintenance or rehabilitation can provide incentives for entrepenuers to start bus services. As a result **road maintenance can affect access to district and regional hospitals in an indirect way.** The magnitude of the effect can therefor not be quantified.

10.5.3 Conclusions

Based on the available information the following conclusions can be drawn:

- **Road maintenance does not have any significant effect on visits to healthcare facilities.**
- A strong relationship was found between the presence of bus service in a village and visits to the district and regional hospitals by villagers from a village. It is concluded that **the number of registered patients depends heavily on the presence of bus services in the village of origin.**
- There is no direct relationship between road maintenance and the presence of bus services. However, impact studies on rehabilitation projects show that road maintenance can provide a strong incentive for new bus services. Therefor, **road maintenance can affect access to district and regional hospitals in an indirect way.** The magnitude of the effect can therefor not be quantified

10.6 Conclusions and comments on the social impact of road maintenance

10.6.1 Conclusions

- **Road maintenance does not have any significant effect on market access, government and healthcare.**
- **It could not be established whether road maintenance has any effect on secondary school attendance.**
- It is concluded that **the number of registered patients depends heavily on the presence of bus services in the village of origin.**

10.6.2 Comments on conclusions

The finding that the number of registered patients depends heavily on the presence of bus services in the village of origin has some serious consequences for the social impact of road maintenance.

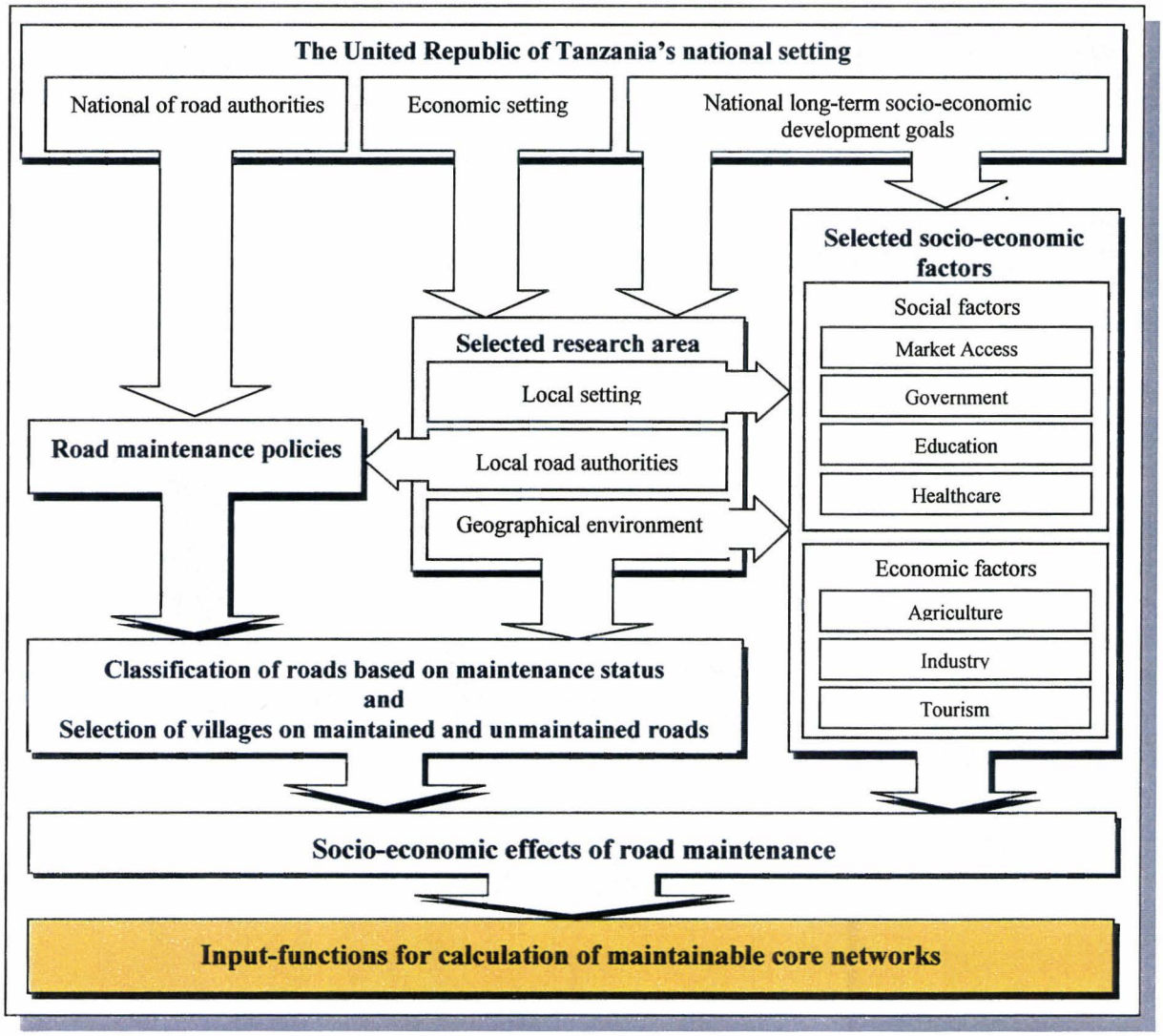
First of all **it has to be noted that several respondents indicated that trips to capitals of Iringa and Mafinga Towns often have more than one purpose.** For example, household member may decide to travel to these towns to go to the hospital. They would then take with them a small quantity of produce to sell on the market in order to obtain money to buy some necessities and to pay for the bus fare. **In short purposes of travel that have been singled out in the interviews are often combined into one single trip.**

Furthermore it was found that trips longer than 20 kilometres are mostly undertaken by motorised transport (bus services). It is very likely that these trips are also heavily depending on the presence of bus services. These trips mainly concern trips to the central market, district headquarters, district and regional hospitals and in some cases divisional health centres. Since visits to the district and regional headquarters are very rare it is probably not affected strongly by the presence of bus services. However, it is likely that **market access is affected by the presence of bus services much in the same way as hospital visits are affected.**

Furthermore it must be noted that all villages selected for the social impact survey are connected by bus services. **With all selected villages having bus services the effect of the presence of bus services could not be assessed.**

Part Three

Conclusions and Recommendations



Chapter 11 Conclusions

The conclusions with regard to the research are divided into five paragraphs. Paragraph 11.1 presents the main conclusions with regard to the socio-economic effects of road maintenance. 11.2 describes the conclusions on the input-functions found in the case studies. The shortcomings of the case study and their consequences are discussed in paragraph 11.3. The limits of generalisation are discussed in paragraph 11.4. In conclusion paragraph 11.5 presents the prerequisites for extending the results of the case study to other areas.

11.1 Main conclusions

The main conclusions concern the general effects of road maintenance on the socio-economic factors selected for the research. They provide the crude answers to the to the following research questions:

With regard to the economic effects:

- *'What is the effect of road maintenance on rural income per capita?'*
- *'What is the effect of road maintenance on producer prices?'*
- *'What is the effect of road maintenance on agricultural production?'*
- *'What are the effects of road maintenance on the industrial sector?'*
- *'What are the effects of road maintenance on the tourist sector?'*

With regard to the social effects:

- *'What are the social effects of road maintenance?'*
- *'What is the effect of road maintenance on market access?'*
- *'What is the effect of road maintenance on government?'*
- *'What is the effect of road maintenance on education?'*
- *What is the effect of road maintenance on healthcare?*

The conclusions for the economic effects and the social effects are presented in the boxes below.

Main conclusions on the economic effects of road maintenance

- **Road maintenance has enormous effect on income per capita from agricultural production.** The drop in income recorded in the midland zone is up to 55,000 Tsh (65 U$) per person and up to 95% of total income.
- The loss of income per kilometre caused by lack of maintenance much higher than the rise in transport cost. **Basing the economic evaluation of road maintenance solely on transport costs would underestimate the effect for the midland zone by a factor of 15.**
- **Road maintenance has a strong positive effect on sales production.** The sales production was found to be substantially higher on maintained roads than on unmaintained roads.
- **Road maintenance has a strong positive effect on producer prices.** Producer prices decline 50% faster on unmaintained roads than on maintained roads.
- **The effect of road maintenance on the industrial and tourist sectors is reduction of transport costs.**

Main conclusion on the social effects of road maintenance

- **Road maintenance does not have any direct effect on market access, government and healthcare.**
- **Market access and healthcare are depending on the presence of transport services**
- **It could not be established whether road maintenance has any effect education**

11.2 Conclusions with regard to input-functions

As stated in the previous paragraph, the results of the case study shows that road maintenance does not have a direct effect on the social factors selected for the research. Input functions have been found for the economic effects only. Therefor the following can be concluded:

The case study has resulted in input-functions for:

- **Market prices for individual products**
- **Sales production for each agro ecological zone**
- **Reduction of transport costs for individual companies**

The conclusions with regard to the input-functions are presented in the following three boxes

Conclusions with regard to the input-functions for producer prices

- **Linear relationships have been found between distance and producer prices for individual products**
- **The relationships are related to the distance to the trunk road**
- **The relationships are expressed by the following input-functions:**

Maize

Maintained roads	Price (Tsh/100kg) = 7,066 – 35.5 * Distance to trunk road
Unmaintained roads	Price (Tsh/100kg) = 6,904 – 51.4 * Distance to trunk road

Irish Potato

Maintained roads	Price (Tsh/100kg) = 4,290 – 20.2 * Distance to trunk road
Unmaintained roads	Price (Tsh/100kg) = 4,463 – 31.5 * Distance to trunk road

Wheat

Maintained roads	Price (Tsh/100kg) = 14,134 – 42.6 * Distance to trunk road
Unmaintained roads	Price (Tsh/100kg) = 14,114 – 63.7 * Distance to trunk road

Sweet potato

Maintained roads	Price (Tsh/100kg) = 4,657 – 24.3 * Distance to trunk road

Sunflower

Unmaintained roads	Price (Tsh100kg) = 6,402 – 62.1 * Distance to trunk road

- **The input-functions are the same for all agro-ecological zones.**
- **Because the slopes of the functions are different for each product it is concluded that producer prices are not directly related to transport costs.**

Conclusions with regard to the input-functions for sales production

- **Linear relationships have been found between distance and sales production for each agro ecological zone**
- **The relationships are related to the distance to the trunk road**
- **The relationships are expressed by the following input-functions:**

Midland zone:
Maintained roads: Total sales in ha p.p. = 0.184 + 0.0127*Distance to trunk
Unmaintained roads: Total sales in ha p.p. = 0.200 - 0.0024*Distance to trunk

Lowland zone:
Unmaintained roads: Total sales in ha p.p. = 0.159 - 0.0011*Distance to trunk

Mufindi Plateau:
Unmaintained roads: Total sales in ha p.p. = 0.232 + 0.00003*Distance to trunk

The following functions were found for the highland zone usng an estimate for sales production on the trunk road:

Maintained roads: Total sales in ha p.p. = 0.251+0.0055*Distance to trunk
Unmaintained roads: Total sales in ha p.p. = 0.190+0.0026*Distance to trunk

- **The input-functions differ strongly between the agro-ecological zones.**
- **The effect of road maintenance on sales production has no direct relationship with th effects on producer prices**
- **The composition of sales production depends on local tradition and government directives and is not affected by road maintenance.**

Conclusions with regard to the input-functions for industry and tourism

- **The following input function has been found:**

  Maintenance of the R621 Iringa – Msembe regional road will result in reduction of transport costs of
  - **1.508 million Tsh per kilometre for the Iringa – Kidamali**
  - **82,500 Tsh per kilometre for the Kidamali – Msembe section**

- **The input-functions are based on**
  - **Reduction in transport costs per tonkilometre**
  - **Quantity of goods transported on the road by individual companies**

11.3 Shortcomings of the case study

The case study has been seriously hampered by a number of factors. The factors and the results they have had on the research are discussed in the box below.

Shortcommings of the case study

The research has been seriously hampered by:

- The absence of maintained roads in the lowland zone and Mufindi Plateau
- The absence of data from villages in the hihgland zone located on or close to the trunk road
- The complete absence of maintenance history
- The absence of standardised programmes for scheduled maintenace
- The absence of standardised specifications for road quality

These problems have resulted in the following shortcommings:

1. **The behaviour of producer prices and sales production on unmaintained roads connected by maintained roads could not be established.**

   As a result calculations for a maintainable core-network can not be made

2. **Input-functions could not be established for:**
   - **Maintained roads in the lowland zone and the Mufindi Plateau**
   - **Maintained and unmaintained roads in the highland zone with a satisfying degree of reliability**

   As a result the effect of road maintenance on rural income
   - **could not be established for the lowland zone and the Mufindi Plateau**
   - **be roughly estimated for the highland zone**

   This, in turn, makes it impossible to find any analogy between the agro-ecological zones.

3. **The classification of roads has not been done on basis of actual road maintenance or existing maintenance programmes.**

   As a result the classification has become rather hypothetical

11.4 Limits of generalisation

The shortcomings of the case study have implications on the extent to which the results of the study can be generalised. The limitations are strengthened by some of the finding of the case study itself. The limits of generalisation concern each of the input-functions described in paragraph 11.2.1. They are depicted individually in the next three paragraphs.

11.4.1 Limits of generalisation for producer prices

With regard to the input functions for producer prices it was found that:

- The input-functions are the same for all agro-ecological zones.
- The producer prices are constant on the trunk road.

This suggests that the input-functions can be applied in any other region. However, it is very unlikely that producer prices on the trunk road are the same for areas close to the main national market in Dar es Salaam, which is 600 kilometres from the research area.

. **It is unlikely that the input-functions for producer prices can be used in other areas.**

11.4.2 Limits of generalisation for sales production

The analyses show that the composition of sales production is largely depending on local government directives and local farming tradition. The data samples taken in this research are rather small and in some cases incorporate only one division or district. The outcome may therefore be very case specific.

The analyses show that the composition of sales production is largely depending on local government directives and local farming tradition **Therefor the input-functions for sales production found in this case study can not be used as quantifications for other divisions, districts, regions or countries.**

Due to the shortcomings discussed in the previous paragraph it has been impossible to analyse whether there is any analogy between the input-functions for maintained roads and unmaintained roads in the four agro-ecological zones or whether there is a relationship with, for example, yield per hectare. The extent to which the results of the case study could be greatly enhanced if such an analogy had been found.

11.4.3 Limits of generalisation for industry and tourism

The input-functions for the effect on industry and tourism are based on the transport needs of individual companies. **The input-functions can not be used for any other road section.**

11.4.4 Limits of generalisation due to method classification

The absence of maintenance history and standardised maintenance programmes has made the classification of roads somewhat hypothetical. This means that the classification criteria used in the case study may not correspond to the expected road quality for maintained and unmaintained roads in case a different maintenance programmes is adopted. Under a different maintenance programme the certain villages may be in a different sample group than which they are in this case study. This can affect the input-functions.

Because the classification is not based on actual maintenance history the classification of roads on maintenance condition has become somewhat hypothetical. The results of the research can therefore not be generalised or applied to other areas or other maintenance schemes.

11.4.5 Conclusions

The results of the case study are very case-specific. They are related to the area in which the case study has taken place and to the maintenace programme designed for tha case study. **The input-functions found in the case study can therefor not be used in other districts, regions or countries and for other maintenance programmes.**

11.5 Prerequisites for extension to other situations

The input-functions found for the case study may not be extended to other areas or maintenance programmes. However, the mechanisms found in the case studies can. The following two boxes show the prerequisites for applying the mechanisms found in the case study.

For the calculation of the effect of road maintenance on rural income per capita in a selected area the following information is required:

- **Input-functions for maintained and unmaintained roads between distance to the trunk road and**
  - **producer prices for each individual product produced in the area**
  - **sales production in hectares per person for each agro-ecological zone**
- **The average composition of sales production in percentage of total sales production.**
- **The average yield per hectare for each individual product.**

For the calculation of the effect of road maintenance on industry and tourism in a selected area the following information is required:

- **The reduction of transport costs per tonkilometre.**
- **The quantity of goods transported by each individual company.**

Chapter 12 Recommendations

The recommendations made in this chapter concerns general recommendations and recommendations for further research. Paragraph 12.1 addresses the general recommendation based on the research findings. Paragraph 12.2 deals with the recommendations for further research.

12.1 General recommendations

The results of the case study show that road maintenance has a very strong positive effect on the income of rural agricultural communities. Other research has shown that smallholder farming is one of Tanzania's comparative advantages and that increments to rural income have very strong multiplier effects. Considering that most of the road network in Tanzania is in very poor condition, especially in rural areas, road maintenance can provide a very strong impulse for economic growth and raising the income per capita. Since the latter is the most important long-term development goal the following recommendation is made:

In order to excellerate economic growth and increasing the income per capita strong emphasis must be placed on maintenance of the road network

Most methods for the appraisal of investments in road infrastructure base the economic benefits on the reduction of transport costs that result from the investment. However, the results of the case study show that the reduction of transport costs resulting from road maintenance underestimate the economic effects by a factor up to 15. Furthermore, the effect on income is shown to vary between the agro-ecological zones in the research area. Reduction of transport costs per tonkilometre may be expected to be roughly the same for all areas. So, apart from underestimating the effect on income, the reduction of transport costs does not present an accurate picture of the economic effects of road maintenance. For these reasons the following recommendation is made:

Appraisal of investments in road infrastructure must be based on the effects on income in order to achieve an appropriate picture of the economic benefits of the investment

12.2 Recommendations for further research

The general recommendations made in the previous paragraph strongly underline the necessity of a model that can prioritise investment in road infrastructure based on the economic effect on income per capita. However, the case study undertaken in this research has been seriously hampered by lack of maintained roads and lack of proper sample data. The research has furthermore encountered problems due to the absence of a maintenance history and standardised maintenance programmes. Because of these hindrances the research has failed in to very important aspects:

1. The research failed to unveil the effects on producer prices and sales production for unmaintained roads that are connected to the trunk road by maintained roads, and
2. failed to produce enough information to discover mechanisms that determine the economic effects of road maintenance on a wider scale. The input-functions can not be generalised.

Therefor it is recommended that further research be carried out in order to produce an appropriate model for determining the economic effects of road maintenance. Further research should focus on the items where this case study has failed

Further research into the effects of road maintenance on the economy should focus on:

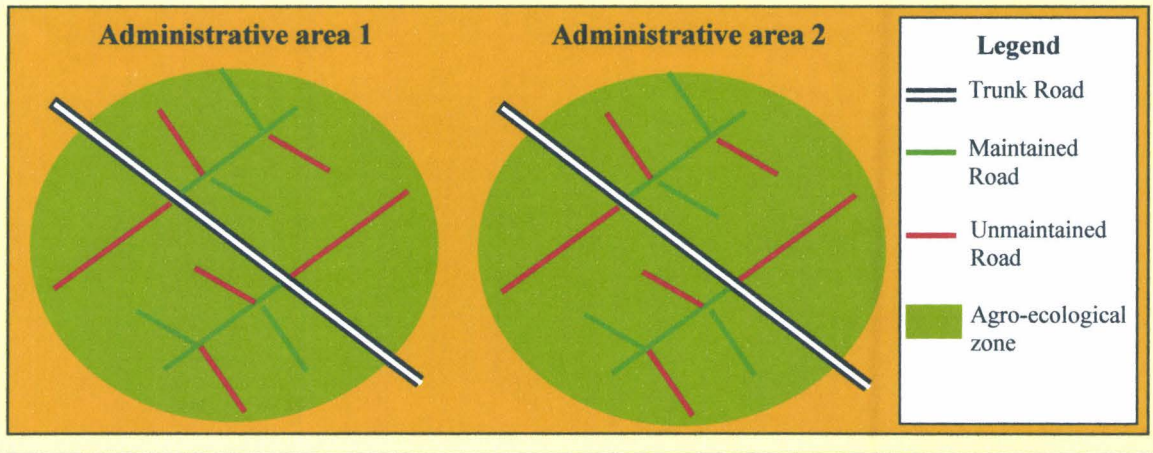
- **Establishing generelisable input-functions describing the effect on income per capita.**
- **The behaviour of the effect on unmaintained roads connected by maintained roads.**

In order to achieve these goals the research must meet the following requirements:

Requirement for further research

- **The research must compare the income per capita on roads that have recieved scheduled maintenace for a substantial period of time with roads that have not.**
- **The maintenance programme must follow the same standards for every road selected for the research.**
- **The research must focus on a limited number of agro-ecological zones with specific levels of productivity in terms of yield per hectare in order to determine the effect of productivity.**
- **In order to exclude the influence of local habits or government directives the research must take place in at least two different administrative areas for each agro-ecological zone.**
- **For a proper comparison each of the two areas requires:**
  - **Good connection by a trunk road.**
  - **At least two unmaintained roads.**
  - **At least two maintained roads that connect to a number of maintained and unmaintained roads that twine of at different distances from the trunk road.**
- **The proposed layout for a single agro-ecological zone is visualised in figure 12.1.**

Figure 12.1 'Proposed Layout of research area'



Conceptual definitions

Maintained roads are roads that have received routine and/ or recurrent maintenance on structural basis over a longer period of time or roads with a quality profile that is typical for roads that have received routine and/ or recurrent maintenance on structural basis over a longer period of time.

Unmaintained roads are roads that have not received any maintenance except for emergency maintenance.

Scheduled maintenance is a form of planning whereby maintenance activities are planned in repeating cycles with predetermined intervals.

Routine maintenance consists of activities undertaken on a regular basis, often seasonal or perennial. It is generally simple and of small scale. Its main purpose is to reduce roughness or to take preventive measures that slow down the rate of deterioration.

Recurrent maintenance consist of activities that need to be undertaken after a number of years in order to restore a roads surfacing layer to its original thickness. In the case of earth roads recurrent maintenance is necessary to bring the crown and drains of a road back to its original shape.

Emergency maintenance consists of maintaining those sections that are severely damaged in order to keep roads open for motor vehicles. It depends on the type of damage which activities are undertaken. It consists of repairing collapsed bridges and culverts and improving sections of roads that have become impassable with whichever activities necessary to get the road functioning again

Trunk roads constitute the country's principal network. They provide international connections and join regional centres to one another. They also cut through several regions of the county, making them road of national character.

Regional roads provide for transport within the regions and connect districts within the region, while some of them form part of the trunk roads and cross to the next regional centres

District roads ply within a district connecting villages and townships and subsequently to the regional headquarters.

Feeder roads are minor roads, most of which are unclassified. They are collector roads or even tracks into the district roads. They connect one ward or sub-wards into the district or even a trunk road.

Paved Roads
Paved roads are roads that consist of a granular sub-base on compacted soil covered by a layer of tarmac or concrete that distributes traffic load more evenly over the underlying construction.

Gravel Roads
Gravel roads consist of a layer of compacted gravel on compacted soil. The gravel surfacing layer is typically 100 to 300 mm thick and serves as a wearing course as well as a base course of the pavement. It provides sufficient structural strength and cover thickness to distribute traffic loads to the underlying subgrade material.

Earth Roads
Earth roads are basically shaped and graded and compacted sand roads that usually don't require any material except for locally available soil. The definition adapted by the World Bank for its Highway Design and Maintenance Models (HDM-III) is that earth roads have a surface of predominantly fine soil materials with more than 35 percent finer than 0.075 mm. particle size.

List of sources and literature

1. COWI Tanzania Consulting Engineers and Planners Ltd, Socio-economic study on DRDP roads improved during year 1 of DRDP in Rufiji District, Dar Es Salaam, January 2000
2. COWI Tanzania Consulting Engineers and Planners Ltd, DRDP – Iringa Rural District Road Condition Survey, Dar es Salaam, January 2001
3. COWI Tanzania Consulting Engineers and Planners Ltd, DRDP – Mufindi District Road Condition Survey, Dar es Salaam, January 2001
4. Dam, A. v., Landendocument no. 10; Het onderwijs in Tanzania
5. District Planning Officer, Iringa Rural District, 2001 Sensus Preparation Survey, Iringa, 1998
6. Edmonds, G, Wasted Time: The Price of Poor Access, RATP No. 3, ILO, Geneva, 1998
7. Gaviria, J, Rural Transport and agricultural Performance in SSA: 6 County Case Studies, World Bank, May 1991
8. Howe, J.D., Transport for the poor or Poor Transport?, IHE Working Paper T&RE-012, IHE, Delft, October 1996
9. Howe, J.D., Least Cost Planning Methodologies in Rural Transport, IHE Working Paper T&RE-019, IHE, Delft, November 1997
10. Howe, J.D., Impact of Rural Roads on Poverty Alleviationin Developing Countries, IHE Working Paper T&RE-021, IHE, Delft, March 1998
11. Howe, J.D., Poverty Alleviation: transport Policy and Socially Sustainable Development, IHE Working Paper T&RE-025, IHE, Delft, April 1999
12. Iringa Regional Engineers Office, Budget 2001, Iringa, April 2000
13. Kumar, A., Tillotson, H.T., A comprehensive planning methodology for rural roads in India, New Delhi, 1990
14. Kussendrager, N, Landenreeks: Tanzania; mensen, politiek, economie, cultuur, Koninklijk Instituut voor de Tropen, Amsterdam, 1996
15. Mafinga District Engineers Office, Impact assessment study of Maguvani – Udumka road, Mafinga, Dec 1999
16. Ministry of Communications and Transport, Planning, Policy and Research Department, Draft National Transport Policy, Dar Es Salaam, May 1999
17. Ministry of health, National Aids Control Programme, district action plans for implementation of third medium term plan (MTP III) for prevention and control of HIV/AIDS/STI's, Iringa District, Iringa, September 1999
18. Ministry of Regional Administration and Local Government, Performance report for district and feeder roads maintenance programme for FY 1999/2000 and road maintenance program for FY 2000/01, Dodoma, April 2000
19. Ministry of Works Tanzania, Roads in Tanzania, Ministry of Works Tanzania, 1998
20. Ministry of Works Tanzania, Pavement and design materials manual, Dar Es Salaam, 1999
21. Ministry of Works Tanzania, Road Division, Urgent Roads Rehabilitation Programme for FY 2000/01 – 2006/7, Final Report, Dar ea Salaam, june 2000
22. Molenaar, prof.dr.ir.A.A.A., Structural Design of Pavements, Part II: Design of Earth and Gravel Roads, Lecturnotes CTVb4860, Delft, January 1999
23. Mwangosi, G.N.K., Financial Assessment of Rural Highway Road Network Maintenance Strategies in Tanzania, MSc. Thesis paper, IHE Delft, March 1995
24. National Bureau of Statistics, National Population Census Report 1988, Dar Es Salaam, 1988
25. Regional Agricultural Officer, Taarifa ya maendeleo ya kilimo msimu 1999/2000, Iringa, 2001
26. Regional Bureau of Statistics, Iringa Region socio-economic profile, Bureau of Statistics, Ministry of Economic Affairs and Planning, Dar Es Salaam, 1995
27. Regional Bureau of Statistics, Iringa Rural District socio-economic profile, Bureau of Statistics, Ministry of Economic Affairs and Planning, Dar Es Salaam, 1996
28. Regional Bureau of Statistics, Mufindi District socio-economic profile, Bureau of Statistics, Ministry of Economic Affairs and Planning, Dar Es Salaam, 1996
29. Roads Division, Ministry of Works, Urgent Roads Rehabilitation Programme for FY 2000/01 – 2006/07, Final report, Dar Es Salaam, June 2000

30. Road Fund Manager, Paper on "Status of Road Fund Tanzania", Ministry of Works Tanzania, september 2000.
31. World Bank, World Development Indicators, World Bank, 1999
32. World Bank, The United Republic of Tanzania, Integrated Roads Project, Staff Apraisal Report, Washington D.C., 1990
33. USAID, Impact assessment study of Ilula - Ibumu road, Iringa, May 2001

List of M.Sc. Theses in Technology and Development Studies

M.Sc. Theses in Technology and Development Studies: 1999

99.01 Daan Kers: Industrialisation and electrcity supply: Mbagala, Tanzania as a case.

99.02 Barbara Simaeys: Electrificacion de baja escala en el bosque nublado del Ecuador: La elaboración de dos casos en la provincia del Carchi.

99.03 Ame Kraus: Housing finance in Tanzania, a survey on the demand of the low-income households for a more applicable housing finance system and how it can facilitate the introduction of new bamboo construction technologies.

99.04 Renilde Becque: The sustainability of ferrocement stairs (production) in a social housing project in Nova Friburgo, Brazil, aimed at lower-income groups.

99.05 Bas Lebbing: Energy use in small-scale brick making industries in Northeast Thailand.

99.06 Maike van Rooy: Optimisation of purchasing process for state oil company Suriname in Saramacca.

99.07 Dennis van Hunen: Technologies for municipal solid waste management in Masaya Nicaragua. A study on compost systems.

99.08 Ronald Warmerdam:Opportunities for improving solid waste management in Kanpur, India. The increase of private sector involvement.

99.09 Arjan van Bergeijk: An appropriate school for Tanzania. Evaluation of the involvement of PLAN International Tanzania in school constructions in Dar es Salaam, Coastal region, Morogor region and Mwanza municipality.

99.10 Joris van Iersel: Assessment of an appropriate drying technology for the drying of coffee by small rural producers in the south of Lempira, Honduras.

99.11 Felix Tillie: Terms of Reference for a Training Programme for Roof Tilers in Urban Tanzania.

99.12 Nathalie van Hoeven: Assessment of opportunities to improve the capacity of the Kejetia Public Transport Terminal in Kumasi, Ghana.

M.Sc. Theses in Technology and Development Studies: 2000

00.01 Eric Lakerveld: Information and Performance. The role of Quality Information Systems in a multinational electronics company.

00.02 Martijn Vis: Assessment of the Possibilities to Utilize Large Solar Water Heaters for Industrial and Commercial Sectors in Thailand.

00.03 Amber Beernink: Vehicle/Pedestrian Traffic Conflicts. Appropriate Construction Technology for a Pedestrian Crossing at Kejetia, Kumasi, Ghana.

00.04 Pascal Vlieghe: Lake Pollution and Vulnerability of Fishing Communities. Mwanza Gulf of Lake Victoria, Tanzania.

00.05 Bart Frederiks: Assessment of Sustainable Means of Private Electricity Production. A case study at Katani Ltd., Tanzania.

00.06 Rolf Verlaan: Identification of the Opportunities for Sustainable Production of Energy from Biomass Residues in Swaziland.

00.07 Anne van Hoof: Maintenance and Utilisation of physical capacity at Ghana Textile Printing Co. Ltd.

00.08 Rob van der Werff: The Value of Technical Education. A Cost/Benefit Analysis of Technical education and other Subjects of Education in Tanzania.

00.09 John Brenters: Design and financial assessment of small scale sisal decortication technology in Tanzania.

M.Sc. Theses in Technology and Development Studies: 2001

01.01 Piet Hein Breeuwsma: The Demand-led Approach to Vocational Skill Training: The Cosdec Programme Namibia.

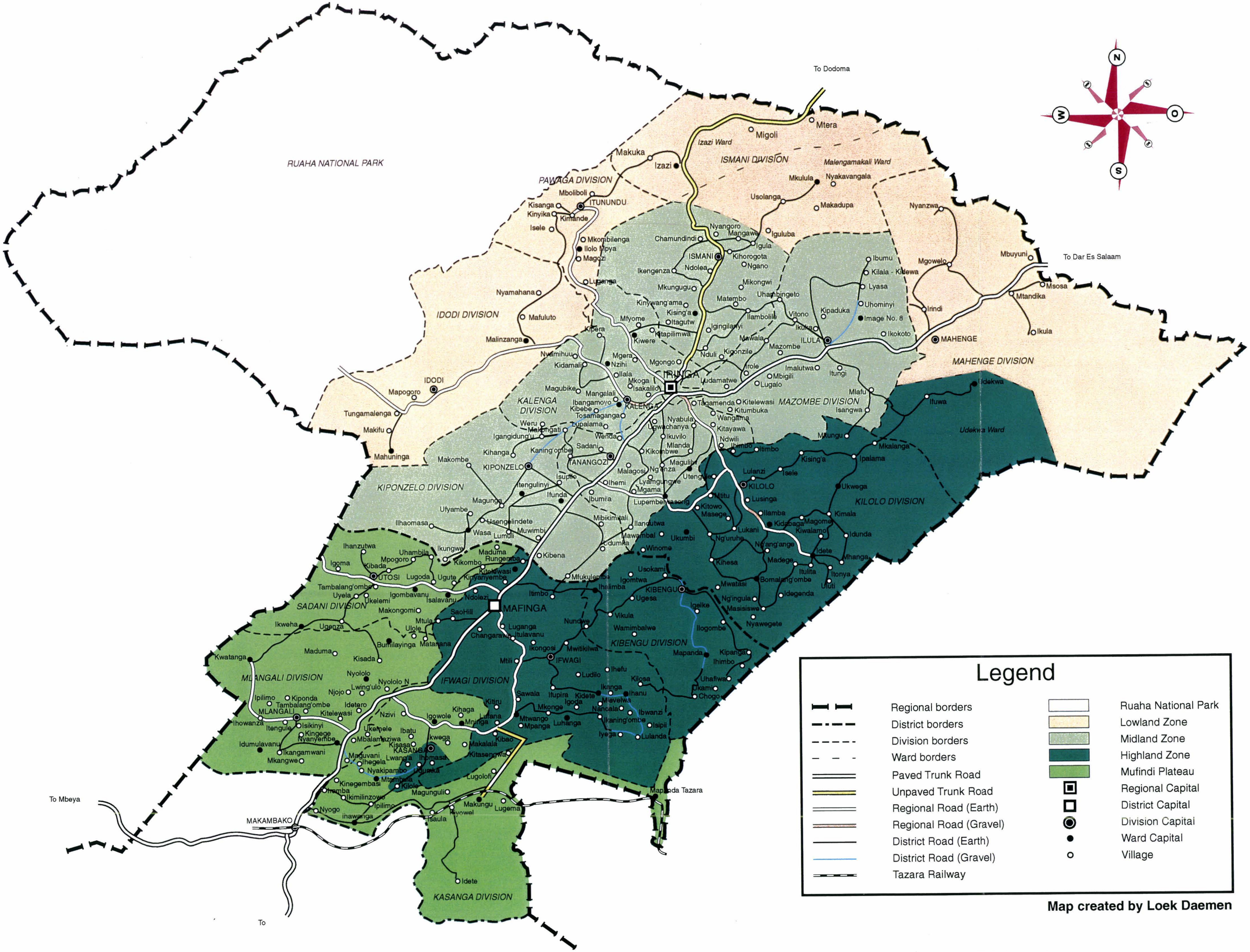
01.02 Eduard J. Boonstra: Establishment of a Calcium-silicate unit Industry in Indonesia.
01.03 Arjan van Dal: Assessment of a more Sustainable Sanitation Technology System for a Harijan Community in India.
01.04 Benoit Chamuleau: Energy Efficient Low Cost Housing in South Africa.
01.05 Arnoud van Bemmelen: Energy Conservation Opportunities in Hotels in Costa Rica.
01.06 Herwich Hobbelen: Assessment of Domestic Liquid Waste Runoff, Dar es Salaam, Tanzania.
01.07 Sander Gelsing: Solar Home Systems in the Caprivi. Evaluation of the Technology Choice and the Implementation of Small-scale Electricity Technologies in rural Namibia.
01.08 Ilse Oosterlaken: Industry Study: Thai Building Material Industry (1960 - 2000) - "Opportunities for SMEs Producing Building Materials: Case of Northeast Thailand.
01.09 Joost Ossevoort: Systematic Assessment of Water Pollution in Ebrié Lagoon, Ivory Coast. Modelling eutrophication, followed by an inquiry into the causes and impacts of this phenomenon.
01.10 Jeroen Steman: Pre-feasibility Study on Centrifugal Pump Manufacturing in Zambia. An identification of feasible production technologies.
01.11 Krista Jansen: Future Supply and Demand for Petroleum Products in Indonesia; Challenges and Options for the Refining Sector.
01.12 Marieke de Ruijter de Wildt: The Searching Enterprise. Information Usage of Small Enterprises and Business Development Services.El Salvador.

M.Sc. Theses in Technology and Development Studies: 2002

02.01 Jeannette Klein: Water Pollution in the Accra-Tema Metropolitan Area. Sources and Impacts. Ghana.
02.02 Shila de Vries: Bamboo Construction Technology for Housing in Bangladesh. Opportunities and constraints of applying Latin American bamboo construction technologies for housing in selected rural villages of the Chittagong Hill Tracts, Bangladesh.
02.03 An Nguyen: The Introduction of Digital Terrestrial Television in Vietnam. An opportunity study.
02.04 Martijn Jonker: Building Technological Capabilities to Improve Performance. A case study of the paper industry in West Java, Indonesia.
02.05 Jeroen Nuijten: Sustaining the Basic Research Program of the International School of Photonics. Cochin, Kerala. India.
02.06 Brecht Mommen: Changes in the Basic Needs Situation due to Hydro-projects in Nepal. A case study of Kali Gandaki project.
02.07 Roy Vink: Assessment of Impacts of Hydro-project Balsa Superior on Economic Activities in the Canton San Ramón de Alajuela, Costa Rica.
02.08 Svend Minderhoud: Technological Performance in Indonesian Paper Industry. A case study.
02.09 Mirjam Pronk: Sustainable Building Systems for Low-cost Housing in Guayaquil, Ecuador.
02.10 Thijs Gilde: "Save Water"- An assessment of the major causes of non-revenue water in the drinking water distribution system of SEMAPA in Cochabamba, Bolivia.
02.11 Mark van Stiphout: What are the costs of wetland pollution? Integrating the environmental effect chain and the total economic value for a coastal wetland in Ghana.
02.12 Rick Boellaard: Op weg naar ontwikkeling.CFAR-Kasangulu, Zaïre.

If you would like to receive a copy of one of the above indicated M.Sc. theses, please contact:
Department of Technology and Development Studies
Eindhoven University of Technology
M.Sc. research co-ordinator
Mrs Dr.Ir. E.L.C. Van Egmond
DG 1.02
PO Box 513
5600 MB Eindhoven
The Netherlands

Map 1: Iringa Rural and Mufindi District Basemap



Map created by Loek Daemen

Map 2: Iringa Rural and Mufindi Districts Road Network

RUAHA NATIONAL PARK

To Dodoma

Mtera

Izazi

ISMANI DIVISION

PAWAGA DIVISION

Mkululu

Nyanzwa

Kisanga

Kimande

Nyangoro

Igula

Kihorogota

Mgowelo

To Dar Es Salaam

Msosa

Mtandika

Ibumu

Lyasa

Irindi

Ikula

MAHENGE

MAHENGE DIVISION

IDODI DIVISION

Mkungugu

Uhambingeto

Kising'a

Ilamboliile

Vitono

ILULA

Malinzanga

Kipera

Kiwere

Nduli

Kidamali

Nzihi

Ilala

IRINGA

Irole

Lugalo

Mlafu

Tungamalenga

KALENGA DIVISION

KALENGA

Tosamaganga

Ugwachanya

Kitayawa

MAZOMBE DIVISION

Mkungu

Mahuninga

Igangidung'u

Makongati

Wenda

Kaning'ombe

Kihanga

Kikombwe

Ilimbo

Itimbo

Ipalama

Makombe

KIPONZELO

TANANGOZI

Ng'anza

Utengule

KILOLO

Ukwega

KIPONZELO DIVISION

Isupilo

Ihemi

Mgama

Lupembelwasenga

Kitowo

KILOLO DIVISION

Kimala

Magunga

Ilunda

Kidabaga

Idunda

Ilhaomasa

Usengelindete

Wasa

Muwimbi

Lukani

Ng'uruhe

Ng'ang'ange

Idete

Mhanga

Ihanzutwa

Ikungwe

Rungemba

Kihesa

Madege

Itulila

Bomalang'ombe

Uluti

UTOSI

Lugoda

Kinyanyembe

Mfukulembe

Ihalimba

KIBENGU

Tambalang'ombe

Isalavanu

SADANI DIVISION

MAFINGA

Masisiwe

Mtula

Changarawe

Ugenza

Matanana

Mtili

IFWAGI

Kwatanga

Kisada

Mapanda

Kipanga

MLANGALI DIVISION

IFWAGI DIVISION

KIBENGU DIVISION

Nyololo N

Uhafiwa

Kideta

MLANGALI

Igowole

Mtwango

Nyanyembe

Mbalamaziwa

Kibao

Lulanda

Maguvani

Udumka

Mtambala

Imamba

To Mbeya

Nyogo

Ipilimo

Makungu

Ihawanga

Nyowel

Idete

KASANGA DIVISION

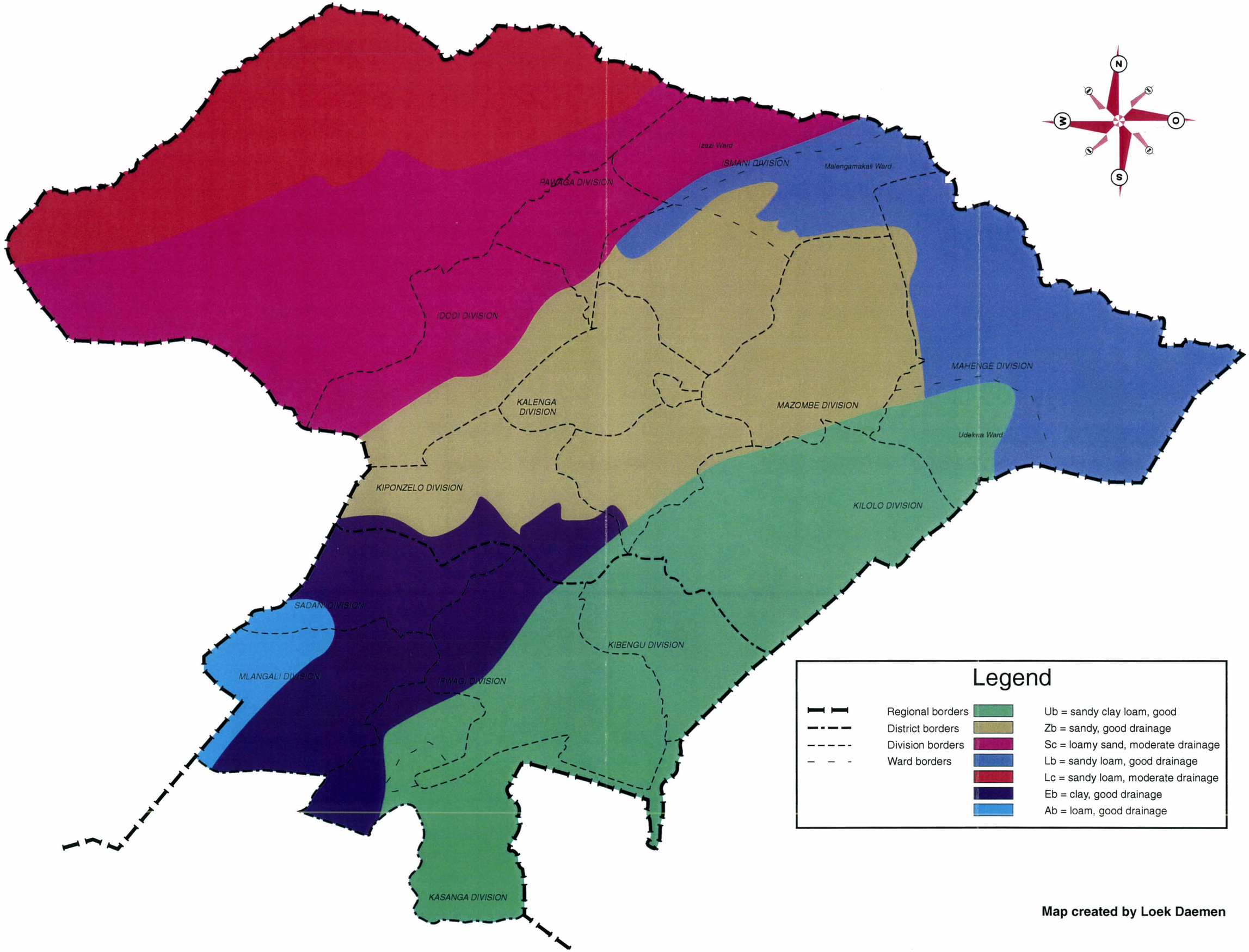
To

Legend

- Regional borders
- District borders
- Division borders
- Ward borders
- Paved Trunk Road
- Unpaved Trunk Road
- Regional Road (Earth)
- Regional Road (Gravel)
- District Road (Earth)
- District Road (Gravel)
- Tazara Railway
- Ruaha National Park
- Lowland Zone
- Midland Zone
- Highland Zone
- Mufindi Plateau
- Regional Capital
- District Capital
- Division Capital
- Ward Capital
- Village
- R628 — Road Number

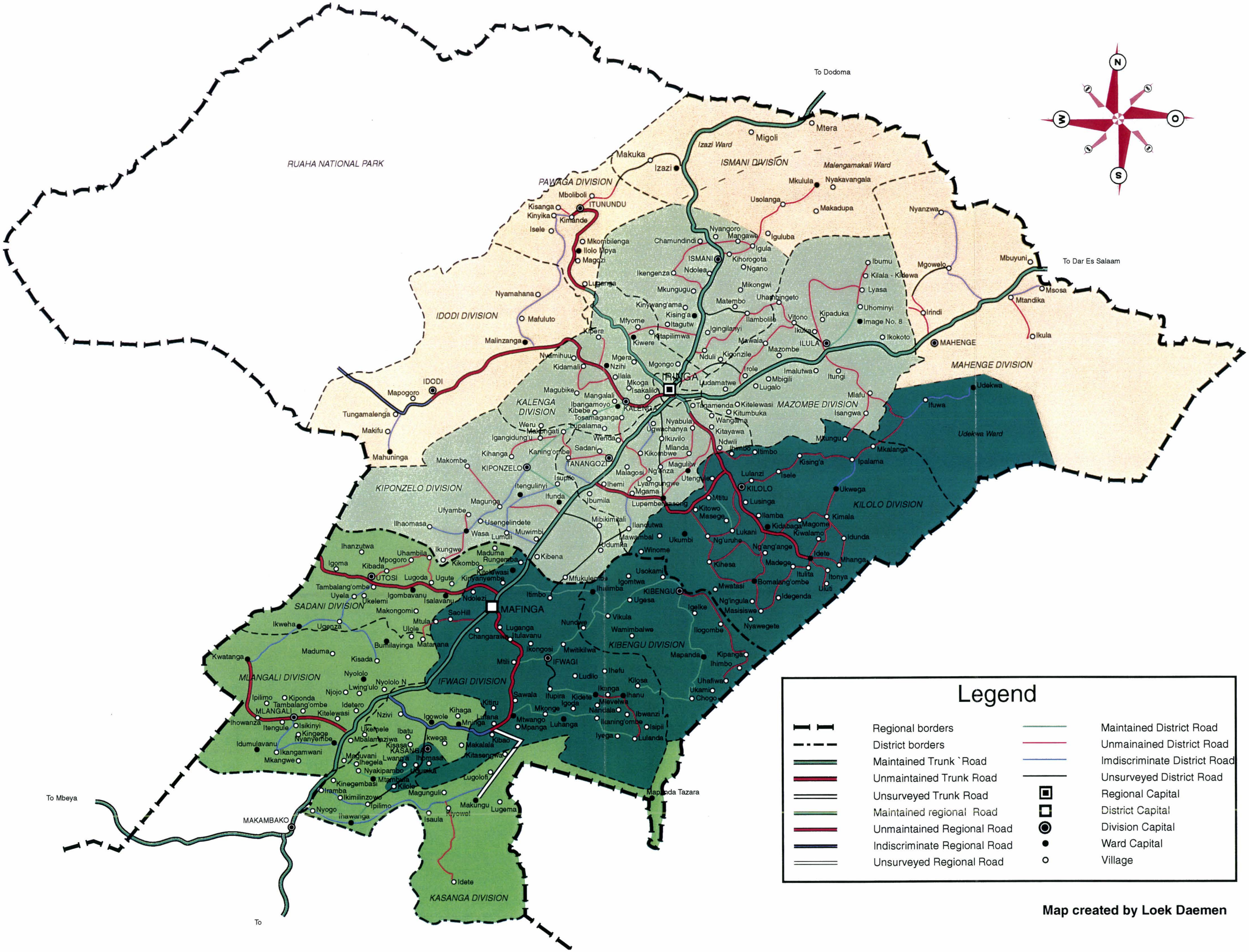
Map created by Loek Daemen

Map3: Soil Types



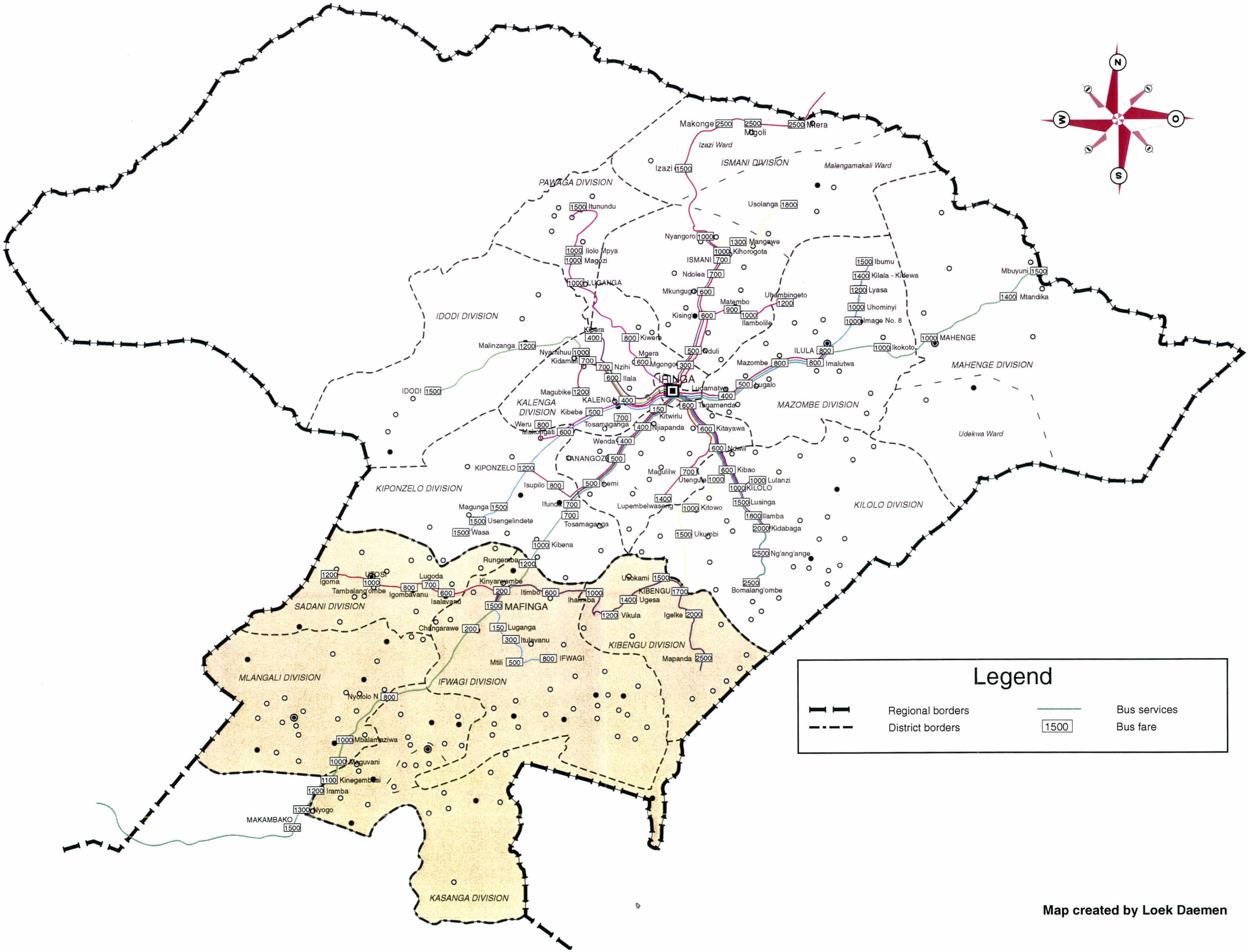
Map created by Loek Daemen

Map 4: Classification of Roads on Maintenance Condition



RUAHA NATIONAL PARK
To Dodoma
To Dar Es Salaam
To Mbeya
To
N
O
S
W
PAWAGA DIVISION
IDODI DIVISION
ISMANI DIVISION
Izazi Ward
Malengamakali Ward
KALENGA DIVISION
KIPONZELO DIVISION
MAZOMBE DIVISION
MAHENGE DIVISION
Udekwa Ward
KILOLO DIVISION
SADANI DIVISION
MLANGALI DIVISION
IFWAGI DIVISION
KIBENGU DIVISION
KASANGA DIVISION
IRINGA
MAFINGA
MAKAMBAKO
ITUNUNDU
IDODI
ISMANI
KALENGA
KIPONZELO
TANANGOZI
ILULA
MAHENGE
KILOLO
UTOSI
MLANGALI
IFWAGI
KIBENGU
KASANGA
Mtera
Migoli
Makuka
Izazi
Mkulula
Nyakavangala
Usolanga
Makadupa
Nyanzwa
Mbuyuni
Mgowelo
Irindi
Msosa
Mtandika
Ikula
Mboliboli
Kisanga
Kinyika
Kimande
Isele
Mkombilenga
Ilolo Mpya
Magozi
Lupenga
Nyamahana
Mafuluto
Malinzanga
Mapogoro
Tungamalenga
Makifu
Mahuninga
Nyangoro
Mangawe
Iguluba
Chamundindi
Igula
Kihorogota
Ngano
Ikengenza
Ndolea
Mkungugu
Mikongwi
Matembo
Uhambingeto
Ibumu
Kilala - Kidewa
Lyasa
Uhominyi
Image No. 8
Ikokoto
Kipaduka
Vitono
Ikuka
Ilambolile
Kinywang'ama
Kising'a
Itagutw
Mfyome
Kiwere
Kitapilimwa
Igingilanyi
Kipera
Mawala
Mazombe
Nduli
Kigonzile
Nyamihuu
Kidamali
Nzihi
Mgera
Mgongo
Ilala
Irole
Imalutwa
Itungi
Mbigili
Lugalo
Mkoga
Isakalilo
Ludamatwe
Mlafu
Magubike
Mangalali
Ibangamoyo
Kibebe
Tosamaganga
Tagamenda
Kitelewasi
Kitumbuka
Isangwa
Weru
Makongati
Lupalama
Nyabula
Ugwachanya
Wangama
Kitayawa
Igangidung'u
Wenda
Ikuvilo
Ndwili
Mkungu
Mkalanga
Ipalama
Kihanga
Kaning'ombe
Sadani
Mlanda
Kikombwe
Ihimbo
Itimbo
Kising'a
Makombe
Malagosi
Ng'enza
Magulilw
Isele
Lulanzi
Isupilo
Itengulinyi
Ihemi
Lyamgungwe
Mgama
Utengule
Ukwega
Ifunda
Ibumila
Lupembelwasong
Mtitu
Lusinga
Magunga
Ufyambe
Kitowo
Masege
Ilamba
Kidabaga
Magome
Kimala
Ilhaomasa
Usengelindete
Mibikimitali
Ilandutwa
Wasa
Lumuli
Muwimbi
Mawambal
Ukumbi
Lukani
Kiwalamo
Idunda
Ng'uruhe
Ng'ang'ange
Udumka
Ihanzutwa
Uhambila
Ikungwe
Maduma
Rungemba
Kibena
Winome
Idete
Mhanga
Igoma
Mpogoro
Kibada
Kikombo
Kitelewasi
Kihesa
Madege
Itulita
Itonya
Lugoda
Ugute
Kinyanyembe
Mfukulembe
Usokami
Igomtwa
Bomalang'ombe
Uluti
Tambalang'ombe
Uyela
Ukelemi
Igombavanu
Isalavanu
Ndolezi
Itimbo
Ihalimba
Mwatasi
Ugesa
Ng'ingula
Idegenda
Sadani Division
Makongomi
SaoHill
Igeike
Masisiswe
Ikweha
Ugenza
Mtula
Ulole
Nundwe
Vikula
Nyawegete
Bumilayinga
Matanana
Luganga
Changarawe
Itulavanu
Wamimbalwe
Ilogombe
Kwatanga
Maduma
Kisada
Ikongosi
Mwitikilwa
Mapanda
Kipanga
Ihimbo
Mtili
Nyololo
Nyololo N
Ludilo
Ihefu
Njojo
Lwing'ulo
Uhafiwa
Kilosa
Ukami
Chogo
Ipilimo
Kiponda
Idetero
Kitiru
Sawala
Ifupira
Kidete
Ikanga
Ihanu
Igoda
Mlevelwa
Ihowanza
Itengule
Isikinyi
Kitelewasi
Nzivi
Igowole
Kihaga
Lufana
Mninga
Mkonge
Mtwango
Mpanga
Luhanga
Nandala
Ibwanzi
Ikaning'ombe
Isipi
Kingege
Nyanyembe
Ukemele
Ibatu
Iyega
Lulanda
Idumulavanu
Ikangamwani
Mbalamaziwa
Kisasa
Ikwega
Makalala
Kibao
Mkangwe
Maguvani
Ihegela
Lwang'a
Ihomasa
Kitasengwa
Nyakipambo
Udumka
Lugolofi
Kinegembasi
Mtambula
Kilolo
Iramba
Ikimilinzowo
Magunguli
Mapanda Tazara
Ipilimo
Makungu
Lugema
Nyogo
Ihawanga
Isaula
Kiyowe
Idete
Legend
Regional borders
District borders
Maintained Trunk `Road
Unmaintained Trunk Road
Unsurveyed Trunk Road
Maintained regional Road
Unmaintained Regional Road
Indiscriminate Regional Road
Unsurveyed Regional Road
Maintained District Road
Unmainained District Road
Imdiscriminate District Road
Unsurveyed District Road
Regional Capital
District Capital
Division Capital
Ward Capital
Village
Map created by Loek Daemen

Map 5: Iringa Rural and Mufindi District Transport Services

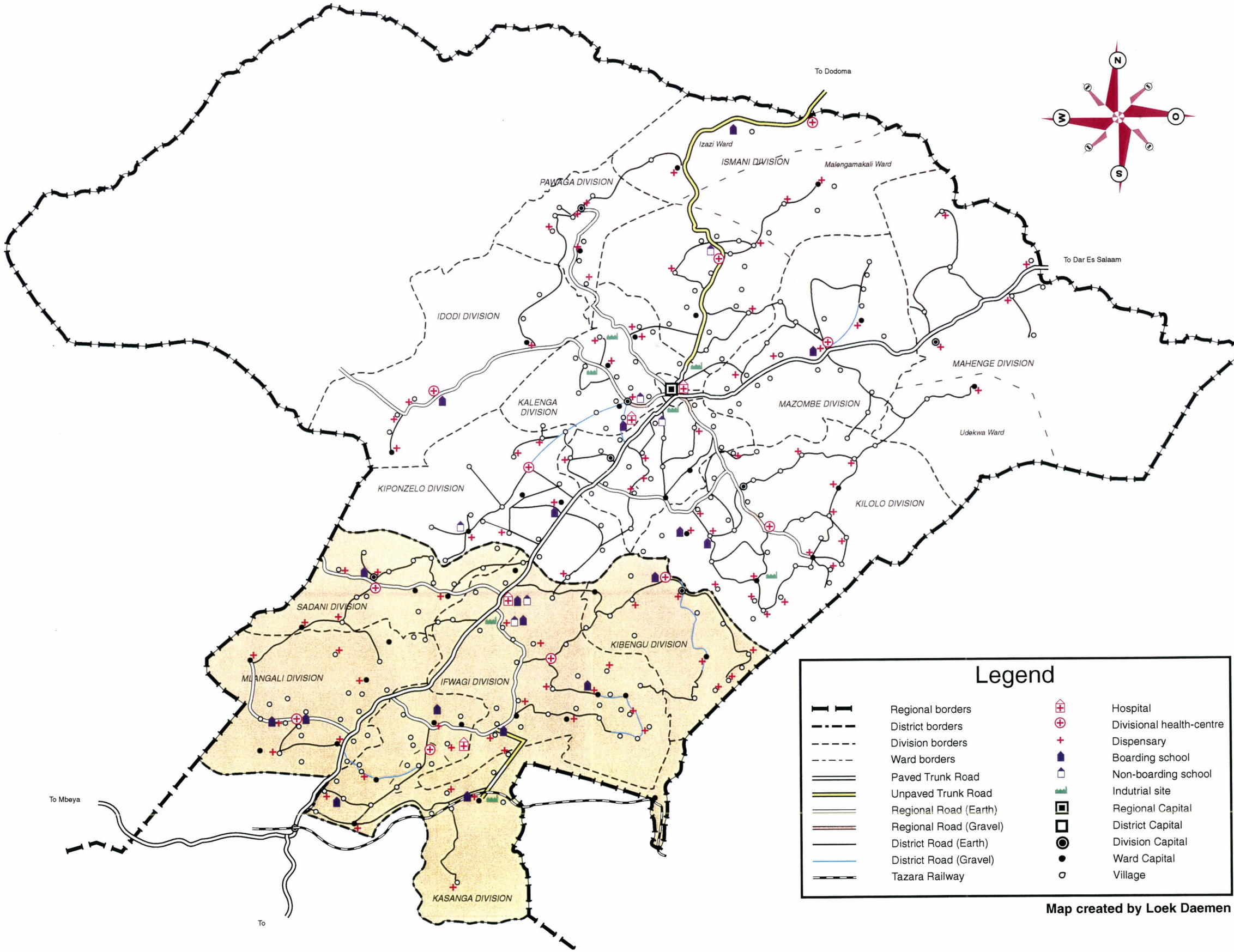


Legend

	Regional borders		Bus services
	District borders	1500	Bus fare

Map created by Loek Daemen

Map 6 Iringa Rural and Mufindi District Social Services


N
W
O
S
To Dodoma
To Dar Es Salaam
To Mbeya
To
Izazi Ward
Malengamakali Ward
Udekwa Ward
ISMANI DIVISION
PAWAGA DIVISION
IDODI DIVISION
KALENGA DIVISION
MAZOMBE DIVISION
MAHENGE DIVISION
KILOLO DIVISION
KIPONZELO DIVISION
KIBENGU DIVISION
SADANI DIVISION
MLANGALI DIVISION
IFWAGI DIVISION
KASANGA DIVISION
Legend
Regional borders
District borders
Division borders
Ward borders
Paved Trunk Road
Unpaved Trunk Road
Regional Road (Earth)
Regional Road (Gravel)
District Road (Earth)
District Road (Gravel)
Tazara Railway
Hospital
Divisional health-centre
Dispensary
Boarding school
Non-boarding school
Indutrial site
Regional Capital
District Capital
Division Capital
Ward Capital
Village
Map created by Loek Daemen