

Addis Ababa University
School of Graduate Studies
School of Civil and Environmental Engineering

IMPACT OF OVERLOADING
AND
ROLE OF LEGAL AXLE LOAD ENFORCEMENT
(ADAMA-AWASH TRUNK ROAD.)
ETHIOPIA

By

DANIEL LEGESSE ALEMU

October, 2013

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**A THESIS SUBMITTED TO THE SCHOOL OF CIVIL AND
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**Addis Ababa University
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School of Civil Graduate Studies

This is to Certify that the thesis prepared by Daniel Legesse , entitled: IMPACT OF OVERLOADING AND ROLE OF LEGAL AXLE LOAD ENFORCEMENT (ADAMA-AWASH TRUNK ROAD) ETHIOPIA is submitted in partial Fulfillment of the requirement for the Degree of Master Science (Civil and Environmental Engineering) Complies with the regulations of the University and meets the accepted Standard with respect to originality and quality.

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STATEMENT OF AUTHENTICATION

Herewith I stated that this thesis has never been published in other institution except citing from listed references attached.

DANIEL LEGESSE ALEMU

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ABSTRACT

Now a day than it was before road pavement damage associated with vehicle overloading particularly from those heavy vehicles are becoming increasingly threatening in Ethiopia. Most of the road pavements constructed since the last 10-15 years are deteriorating much before their useful design life (period) and are calling for early overlay if not for complete reconstruction. This is mainly associated with the growing economy of the nation and associated increase in transport demand. The ever growing demand in transport in turn calls for an effective transport system. One way of achieving this is currently manifested by introduction of heavy trucks and truck trailers for transporting goods. Although this is a normal trend in growing economies the damage that these vehicles induce on flexible bituminous surfaced roads is intensified by excessive overloading exceeding the permitted axle load limits.

With this in mind and to study the effect of overloading and the role of axle load regulations the research therefore focused on the following two objectives:

- How does vehicles overloading affect the pavement service life
- Role of axle load enforcement or regulation

Accordingly the road segment from Adama to Awash is selected for this study. The Adama - Awash road as part of the main import-export Highway is carrying a considerable amount of truck and truck trailers travelling to and from the port of Djibouti. Furthermore it also serves traffic that are coming and going to the eastern part of the country mainly joining the port traffic at Awash.

Despite a pavement with thick asphaltic layer currently the asphalt concrete is intensively and extensively cracked. It is heavily deformed with extreme undulation and deep rutting to the extent of causing traffic hazard at a number of places particularly along climbing lanes. This is even worst starting from the town of Wolenchiti to that of Metehara and near the Awash bridge crossing where the route corridor is characterized by several ups and downs with high day time temperature (hotter climate). Therefore it is considered to set a very good example for the adverse effect of overloading in line with the core objective of this research.

Finding and Conclusion.

- According to the collected data analysis, the average annual daily traffic (only heavy truck and truck trailer) along Adama-Awash at 2011 is 1697 and the total weighed vehicles in 2011 are 28174. This shows that only 4.5% of heavy vehicles and truck trailers are weighed each day and hence for 4.5% weighing condition, truck owners have the same percentage chance to penalty fines due to overloading and they are allowed to abuse the regulation for 95.5% of their trips.
- The existing weighing equipment established at Awash is equipped with a scale that can measure only one axle at a time, as a result checking of vehicles at weighbridge stations takes longer time. Moreover the weighbridge is not equipped with automatic register that can capture and store the data when vehicles are weighed at the station. Hence, occurrence of error in recording and manipulation is possible.
- The damage from single axle is well compared with that of the tandem and tridem axles through the use of the AASHTO equivalency factors. Accordingly
 - Tandem axles carrying 19 ton have the same amount of damage as that of a single axle carrying 10 ton,
 - Tridem axles carrying 26 ton have the same amount of damage as that of a single axle carrying 10 ton
 - Tandem axles carrying 17 ton have the same amount of damage as that of a single axle carrying 9 ton,
 - Tridem axles carrying 24 ton have the same amount of damage as that of a single axle carrying 9 ton

This leads to preference of tandem and tridem or multiple axles to increase transport efficiency (trip reduction) while minimizing pavement damage.

The Way Forward.

- Selection of vehicle type (Axle Configuration) may require further economic analysis so that restriction could be imposed while importing truck trailers or axles could be modified for those that are on the road.
- An effective, well organized and modernized weight and size control stations covering the national road network will play a vital role in terms of economic gain, pavement lives, environment and safety

1. INTRODUCTION

1.1 General

Vehicle overloading is an untenable problem in developing countries and is particularly challenging in African states like Ethiopia engaged in rapid development. In this connection an efficient freight transport is manifested through overloading of trucks and truck trailers to cope up with an ever increasing demand in transport of goods, agricultural products, construction materials and commodities. As a consequence of this those roads particularly paved ones built at alarming rate since the last 10 years are rapidly deteriorating before proportionally paying back the huge investment spent on them. When the benefit from overloading is compared to the reduction in useful lives of paved roads it is significantly disproportional calling for timely intervention to reduce the setback on the overall economy of the nation.

The aims of this research thesis is therefore primarily intended to asses and study the impact of overloading on main bituminous surfaced roads in Ethiopia and to search for alternative measures to reduce this potential threat.

The damage that a pavement sustains from individual vehicle load is normally expressed in terms of a common damaging unit. Depending on their axle configuration, axle loading and tire pressure, different types of vehicle do normally have different damaging power upon a pavement. Type of the road whether it is asphalt, cement concrete or gravel surfaced, nature of the terrain as flat, rolling or mountainous is also related with distribution of the axle loading and its intensity. When the damaging power of a vehicles' axle is compared to an equivalent 8.16 tons standard axle it is exponential in effect. The most common one that equates the effect of an axle to a standard axle is the Liddle's equation that has been developed from AASHTO road test 1963⁽¹⁾ and is given by,

$$ESA = (\text{Axle load}/8.16)^{4.55}$$

However, there are also road agencies who consider the power as 4.0 instead of 4.55. The mean vehicle equivalency factors are normally derived for each vehicle class after computing the damage from each axle with respect to a standard axle. Every vehicle passing over a road of any

type causes a momentary deformation directly proportional to its mean equivalency factor and inversely proportional to the pavement load carrying capacity (i.e. layers thickness and stiffness). The passages of many of these vehicles have a cumulative effect that gradually lead to permanent deformation and pavement deterioration by cracking, critical among other sorts of damages. In this regard even few overloaded vehicles contribute significantly and disproportionately when their number is compared to the total vehicles per day. And yet this is in account of very small extra loads on top of their payload capacity (not often more than 15% of their payload).

1.2 Problem Overview

One of the problems with assessing ESA factors in Ethiopia has been the incompleteness of the records at the permanent weigh-stations.

It is normal to carry out a special axle load survey during the detailed design of new road projects. These are normally carried out for a period of often 3 days and rarely for 7 days. When the time limitation associated with such surveys are considered it may not be hoped to generate a volume of data that would be compared with what can be collected from permanent weighing stations. Therefore bearing in mind the application of the fourth power law it is unrealistic to design from a survey that would provide the sole basis for estimating ESA factors for any road project. Limited survey results need to be interpreted in the light of other axle load information.

On the other hand utilizing the axle load data from existing weigh bridges is also becoming increasingly suspicious. Furthermore due to poor logistic and station arrangements most of them are working much below their capacities. This in turn puts the representativeness of the date into question. Moreover the measurements from the weigh bridge are not segregate by direction. Consequently;

- Axle load surveys undertaken in the country almost always demonstrate previous assessments to have underestimated the total ESA;
- There is a tendency among traffic analysts to take too little account of the impact of the fourth power law and the impact of extreme values on the total ESA and average per vehicle; as a result

- The risks and cost penalties associated with having underestimated future pavement loading are asymmetrically greater than the corresponding costs associated with overestimating (i.e. premature failure as a result of under investment as against extended life as a result of over-investment);

Beyond substantially reducing pavement life at the cost of the tax payers, problems associated with overloaded heavy vehicles are many folds.

- They are a serious threat to performance and stability of Bridges
- Impose traffic hazard especially with regard to their braking system and the additional braking distance involved. This situation is further aggravated by steep downhill slopes and sharp curves in the road. Traffic accidents caused directly or indirectly by overloaded heavy vehicles are normally not included when the total cost of their damage to the economy, caused by overloading, is estimated.
- Increase in fuel consumption
- Rapid wear of tyres, brakes, engines and the life of the trucks as a whole

Therefore the research is mainly intended to assess the factors that contribute to vehicle overloading. Now a day than it was before road pavement damage associated with vehicle overloading particularly from those heavy vehicles are becoming increasingly threatening. Most of the road pavements constructed since the last 10-15 years are deteriorating much before their useful design life (period) and are calling for early overlay if not for complete reconstruction. This is mainly associated with the growing economy of the nation and associated increasing transport demand. The ever growing demand in transport in turn calls for an effective transport system. One way of achieving this is currently manifested by introduction of heavy trucks and truck trailers for transporting goods. Although this is a normal trend in growing economies the damage that these vehicles induce on paved roads is intensified by excessive overloading on top of their payload capacities. Although a study for axle load management in Ethiopia has been undertaken and penalty was proposed by O'Sullivan and Graham, UK, consultant in 1998⁽¹⁷⁾, the enforcement of axle load regulation is yet poorly exercised and implemented by the ERA. The existing weigh bridge stations were administered by the Ministry of Transport and Communication before they have been transferred to the Ethiopian Roads Authority around 2001.

1.3 Goal Setting and Objective

During the proposal stage the research was aimed to focus on the following two themes with reference to their impact on deterioration of bituminous surfaced roads. It was also proposed to take one of these or both as a core of the paper.

1. The role of legal axle load enforcement
2. The impact of damage from vehicles with different axle configuration but similar loading capacities

Nevertheless to focus on a particular area of research the two themes are combined with a slight modification and the research title is set as Impact of Overloading and Role of Legal Axle Load Enforcement in consultation with my advisor.

To undertake this, the research will therefore focus on the following objectives:

- How does vehicles overloading affect the pavement service life
- Role of axle load reinforcement

To achieve the first objective traffic and axle data is collected from one of the main arterial roads of the country which is serving as the main import-export corridor. In this regard the data is used to analyze the difference in pavement service life between road under standard traffic load and overloading condition. While the role of axle load controlling is mainly based on review of literatures and axle load reinforcements adapted by a number of countries from the sub region and some others. Accordingly the road segment from Awash to Adama is selected for this purpose.

1.4 Road Segment for the Research Study

The Addis –Djibouti trunk road corridor is one of the busiest and heavily congested routes. The road segment, Adama - Awash, is part of this major highway (leading to the port of Djibouti and the eastern regions of the country) covering a length of 120-km. The rehabilitation of Modjo - Adama - Awash by asphalt concrete pavement was completed in provisional acceptance at 2005. However the section of the study area is opened for traffic at 2003. The construction was undertaken by KEANGNAM of South Korea under supervision of CARL BRO of Denmark. It is rehabilitated and built mainly following the previous alignment on the existing formation and subbase by adding the following pavement layers.(Dana consult.)

- 60mm Asphalt Concrete (AC) wearing course
- Two layers of Dense Bituminous Macadam (DBM) of each 70mm
- 250mm of Base obtained from blend of milled asphalt concrete (existing) and new crushed stone

The Adama - Awash road as part of the main import-export Highway is carrying a considerable amount of truck and truck trailers travelling to and from the port of Djibouti. Furthermore it also serves traffic that are coming and going to the eastern part of the country mainly joining the port traffic at Awash. The rehabilitation is designed for a Traffic Class of T8 (17-30 MESA) according to that of ERA manual and/or RN-31.

Despite a pavement with thick asphaltic layer currently the asphalt concrete is intensively and extensively cracked. It is heavily deformed with extreme undulation and deep rutting to the extent of causing traffic hazard at a number of places particularly along climbing lanes. This is even worst starting from the town of Wolenchiti to that of Metehara and near the Awash bridge crossing where the route corridor is characterized by several ups and downs with high day time temperature (hotter climate). **Currently this section is again under further rehabilitation phase though it has only 10 years after opening.** Therefore it is considered to set a very good example for the adverse effect of overloading in line with the core objective of this research. Furthermore the traffic and the axle load data (between now and the completion of the rehabilitation) will reflect the actual situations making the analysis rather realistic by avoiding assumptions and projections.

1.5 Research Scope and Limitations

In this study, the research scope and limitations are the following:

1. The case study taken in this research is Adama to Awash 120-km road segment that is a two-lane single carriage flexible pavement.
2. The calculation of pavement service life is based on AADT of ERA Traffic Count from 1999-2011
3. The computation of the Cumulative ESAL is based on the axle load data from the existing weighing station at Awash
4. The standard method to determine the pavement type is the ERA 2002 Flexible pavement Design manual and that of RN-31.

1.6 Organization of Thesis

In accordance with the Master Program, the proposal is organized into five chapters.

- Chapter 1 Introduction: - This chapter consists of background, purpose, objectives, and location of the case study.
- Chapter 2 Literature Review: - This chapter consists literature reviews pertinent to overloading and axle load limitation and regulations adapted by a number of road agencies from the continent of Africa, the USA and Europe and Asia.
- Chapter 3 Methodology: - This chapter presents the descriptions of the approaches and methodology being taken to achieve objectives of this research paper.
- Chapter 4 Analysis Data:- This chapter contains the data analysis to single out how overloading accelerates the ESA values as compared with set of 3-alternative axle limit regulations and enforcements.
- Chapter 5 Role of Axle Load Enforcement:- This will focus on the importance of axle load regulation and enforcement in extending the useful lives or in other word reduces the design service life of pavements, citing the study road as good example.
- Chapter 6 Summary of finding and The way forward:- This chapter contains the finding of the analysis results and recommendation for further works.

2. LITERATURE REVIEW

2.1 Introduction

Overloaded truck traffic is a serious problem in many countries across the world because it incurs huge costs in terms of maintenance and rehabilitation of damaged roads and bridges. Overloaded truck traffic not only causes economic loss but also impose safety and environmental problems. Many countries have established a system to reinforce axle load limit regulation and some are attempting to address the issue and implement strict controlling mechanisms. The struggle for the war since the last decades particularly after the introduction of heavy trucks and truck trailers received more attention. And yet these are playing major rolls in the bulk cargo transportation satisfying the transport demand generated by the growing economy and ever increasing population both in developed and developing countries.

In this regard one cannot deny the need for truck and truck trailers in the road transport sector despite the adverse effect associated with overloading beyond their payload capacities. The problem of overloading is generally under control in many developed countries while it is still a challenge to many developing and under developed nations.

Ethiopia had registered an accelerated economic growth particularly since the last 10 years. In this endeavor the Ethiopian Roads Authority had also played a vital role where remarkable achievement is made towards improving and expanding the road network of the country. Nevertheless transporting agricultural surplus, industrial goods and commodities towards market and development centers is increasing from time to time. To cope up with this demand construction of roads is becoming one of the nation's priorities despite their huge investment cost. Among this, construction of asphalt concrete pavements is consuming the greatest share of the enormous budget allocated towards road infrastructural development. Yet many of the major roads that have been recently constructed and those upgraded to asphalt concrete pavements are suffering from early damage and calling for major interventions and even reconstruction much before their intended service lives.

Among the major causes overloading is becoming rampant over the entire road network. Now a day it is becoming a pain in the neck for the Ethiopian Roads Authority. Based on the data

collected from the ERA (vehicle size and weight axle load team) office, individual axle loads as high as 22 tons from almost all existing weigh bridges are not uncommon.

A study was done By O'Sullivan and Graham in the early 1998⁽¹⁷⁾ for the ERA regarding axle load limit regulation and enforcement. However there is still a growing tendency in overloading across the nation. Axle load limit control through weighing at the existing permanent weigh bridge stations was the mandate of the Ethiopian Transport Authority until it has been recently transferred to the ERA. Now the weigh stations are administered by vehicle size and weight axle load team under ERA and the axle data are also sorted for various subsequent applications including for pavement design purposes.

The core objective of the literatures review is to have an insight regarding previous works done in connection to the two objectives of the present research;

1. Impact of overloading on pavement service life and
2. Axle load limit regulations.

2.2 Review of Literatures in Connection to Impact of Overloading

Traffic is regarded as the key parameter in road deterioration. It is therefore essential to know its composition in terms of;

- total traffic volume (AADT)
- magnitude of the loads (axle load)
- axle configuration
- contact pressure from the loads (mainly from tyre pressure)
- number of load repetitions

It is well known that pavement design and its performance are influenced by the traffic loading on the pavement. The same applies for bridges, although in a different manner. Light vehicles such as cars and delivery vans make a very small contribution to the structural damage of a pavement in comparison to the heavy vehicles. Heavy vehicle wheel load, tyre pressure, frequency and duration together with environmental factors are all important to the performance of pavements. However, the most significant parameter is the axle load.

The two main functions of a pavement structure is to provide a suitable running surface for movement of traffic and a means of reducing the pressure from the wheels of heavy vehicles to a value that the foundation soil (subgrade) under the pavement can support. The wheels of a truck standing on the road pavement exert a direct pressure on the small area of contact between its tyres and the road surface. When the vehicle is moving there is an additional dynamic stress applied (“hammering effect”) due to the up and down movements caused by the slight unevenness of the surface.

The intensity of the pressure is greatest at the surface of the road and spreads in a pyramidal shape through the thickness of the pavement structure on the underlying soil, usually named subgrade. As the area of influence widens the intensity decreases until at the subgrade level the pressure is low enough for the soil to support the traffic load without deforming and causing damage to the pavement.

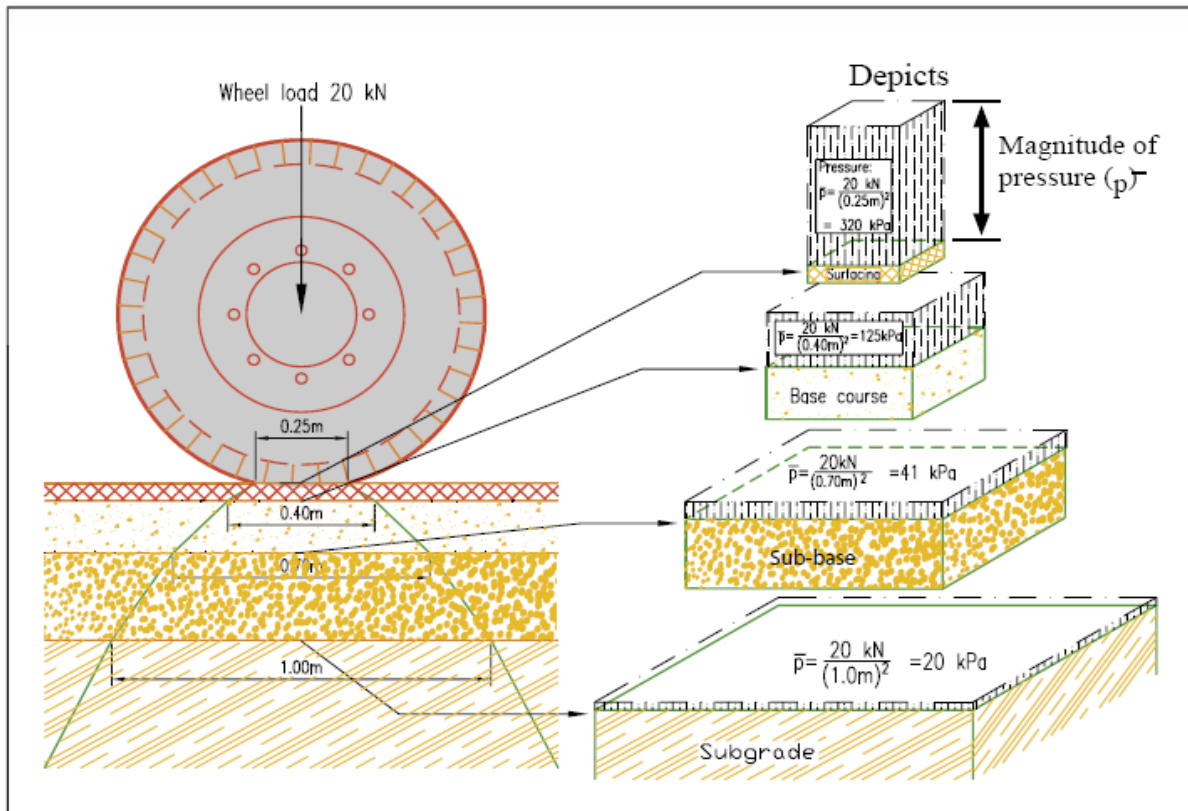


Fig 2.1: Typical load spreading in a road pavement. Axle Load Survey, Published by Ministry of Works, Transport & Communications, Road Department, Gaborone, Botswana December 2000, ISBN 99912-0-358 - 3.⁽¹²⁾

As clearly discussed in the fourth edition of (The Damaging Effects of Overloaded Heavy Vehicles on Roads CSIR 1997⁽⁶⁾), increased tyre pressures result in increased contact stresses at the tyre/road interface. Research done by the **Council for Scientific and Industrial Research (CSIR)** indicates that the measured vertical contact stresses *exceed* the tyre inflation pressures by approximately 30%. On the other hand, *overloaded, under-inflated* tyres may also result in contact stresses *exceeding* the tyre inflation pressures by 2 to 3 times. Generally, this latter condition can be considered the main cause for premature failure of road surfaces and also tyre loss, particularly on rough road surfaces carrying heavy vehicles with sub-standard or worn tyres. The developed stresses, however, are affected, amongst others, by the type and state of the tyre, the load/inflation pressure, the degree of surface roughness of the road and the general operating conditions.

The degree of damage caused to roads by over- or under-inflated tyres can be as much as or even more than the degree of damage caused by overloaded heavy vehicles with correctly inflated tyres. It is thus essential that tyres be inflated according to the manufacturer's specifications for optimum load/inflation pressure, and that the legal axle load limits for roads and bridges, as governed by the axle load regulations, should be complied with.

The most well known road research project in modern history is the AASHO Road Test conducted in Illinois in 1958 - 60. One of the main objects of this full scale trial was to study the damaging effect of heavy vehicles on different pavements.

Based on an assessment, made by road users, the functional condition of the surface was expressed as Present Serviceability Index (PSI) and a correlation between the observed pavement distress and the road user rating was established taking into account measurable properties such as roughness, rutting, cracking and patching of the road surface.

The most common legal axle limit in the USA at that time of the AASHO Road Test was 18000-kips or 8160-kg for a single axle, with bias tread dual wheels, with a 75 psi. tyre (5.2kg/cm²) pressure. Therefore this axle was used as a reference when comparing the damaging effects from different axle configurations with varying axle loads. One of the most important findings from the AASHO Road test was that the damaging effect of an axle, with a given axle load P, can be related to that of the reference axle, with axle load P_r, with a load equivalence factor (LEF) according to the equation below:

$$\text{Equivalency Factor } F = \left(\frac{\text{Actual axle load (P ton)}}{\text{Standard axle load (8,2 ton)}} \right)^n$$

This formula compares the damaging effect on the road structure of any axle load, P , with that of a standard single-axle load of 8,2 tons (80 kN). An average value of $n = 4.55$ was determined in this AASHO Road Test which is referred as the Liddle's Equation.

However, there are also road agencies who consider the power as 4.0 instead of 4.55. The mean vehicle equivalency factors are normally derived for each vehicle class after computing each axle to the stated damaging power. Every vehicle which passes over a road causes a momentary, very small, but significant deformation of the road pavement structure. The passage of many vehicles has a cumulative effect which gradually leads to permanent deformation and road surface deterioration by cracking.

Research has shown, however, that light vehicles such as cars and light commercial vehicles, make a relatively small contribution to the structural damage of a road pavement compared to that of heavy vehicles. Furthermore, the load carried by each heavy vehicle axle determines its destructive effect. Typical picture illustrating the proportion of pavement damage from different vehicular traffic based on a research conducted in South Africa (the Damaging Effect of Overloaded Heavy Vehicles on Roads, CSIR, 1997⁽⁶⁾) shown below.

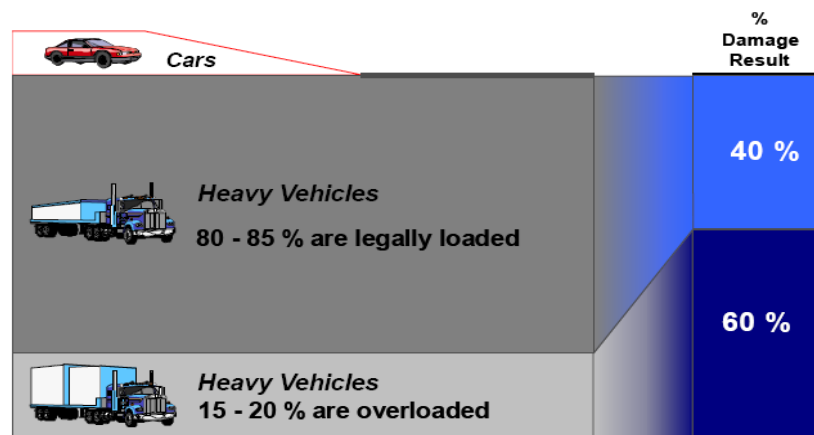


Fig.2.2. Damaging effect of overloaded vehicles

The application of the Equivalency Factor, ESA, makes it convenient to convert all axle loads and vehicle configurations into an equivalent number of standard axles. This relationship indicates, for example when only the forth power is considered, that a single four-wheel axle load which is only 25% over the legal load limit of 9 tons, i.e. 11.25 tons, is equivalent to the loads of 3.6 standard axles and has 2.6 times the damaging effect on the road of a 9 ton legal axle. On the other hand an axle twice over the legal load of 9 ton (18 tons) has 18 times the damaging effect of a legal axle load. In other words, the passage over the road structure of one such overloaded axle is equivalent to the passage of approximately 18 legally loaded axles. Figure overleaf illustrates this effect (the Damaging Effect of Overloaded Heavy Vehicles on Roads, CSIR, 1997⁽⁶⁾).

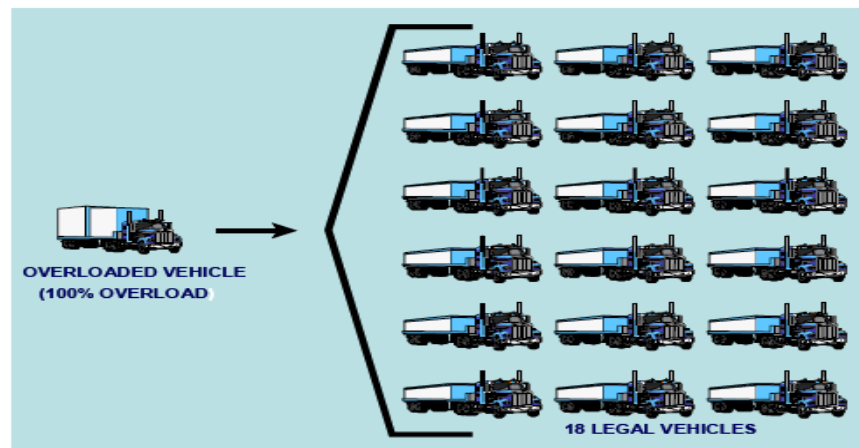


Fig.2.3. Equivalency of overloaded and legal loaded vehicles.

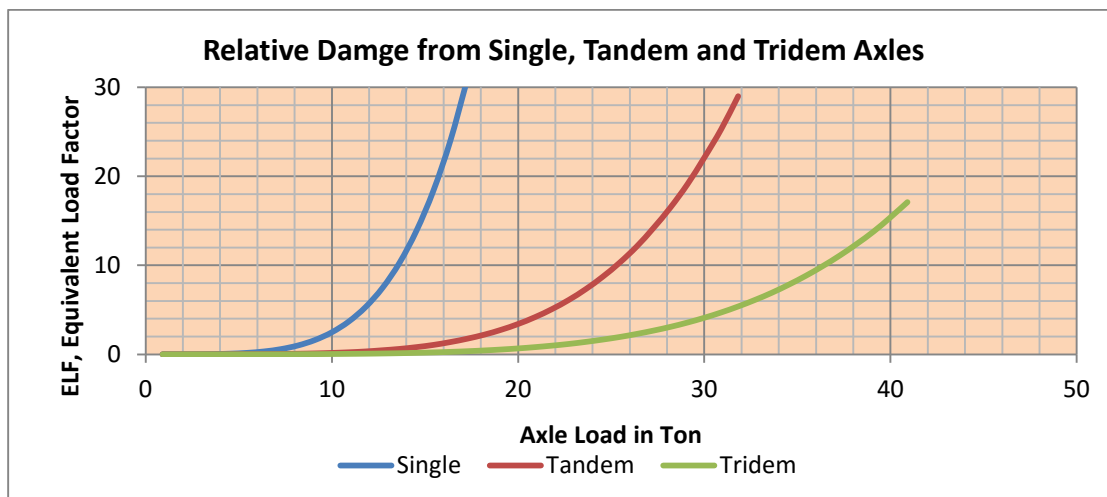
Similarly heavy trucks and truck/trailer combinations (including semi-trailers) normally account for the greater part of the load on road pavements. ESA values in the range 4 to 8 for heavy vehicles and 8 to 16 for truck/trailers can also be considered typical for Ethiopia based on previous analysis (Pavement Design Reports of Gondwana Engineering).

On the other hand the equivalent load factor (ELF) adapted by AASHTO for single, tandem and tridem axles indicates that tandem and tridem axles are lower than that of a single axle as shown in the table below and plot of graph produced from the table. (1Kip=445kg)

Table 2.1. AASHTO ELF for Single, Tandem and Tridem axle. (AASHTO 1993)

Axle load(kip)	Damaging Factor			Axle load(kip)	Damaging Factor		
	Single	Tandem	Tridem		Single	Tandem	Tridem
2	0.004	0.0001	0.0000	48	92.2	5.08	0.979
4	0.003	0.0005	0.0002	50	112.0	6.12	1.17
6	0.011	0.002	0.006	52		7.33	1.40
8	0.032	0.004	0.001	54		8.72	1.66
10	0.078	0.008	0.003	56		10.3	1.95
12	0.168	0.015	0.006	58		12.1	2.29
14	0.328	0.026	0.008	60		14.2	2.67
16	0.591	0.044	0.012	62		16.5	3.09
18	1.00	0.070	0.018	64		19.1	3.57
20	1.61	0.107	0.027	66		22.1	4.11
22	2.48	0.160	0.038	68		25.3	4.71
24	3.69	0.231	0.053	70		29.0	5.38
26	5.33	0.327	0.072	72		33.0	6.12
28	7.49	0.461	0.098	74		37.5	6.93
30	10.3	0.611	0.129	76		42.5	7.84
32	13.9	0.813	0.169	78		48.0	8.83
34	18.4	1.06	0.219	80		54.0	9.92
36	24.0	1.38	0.279	82		60.6	11.1
38	30.9	1.76	0.352	84		67.8	12.4
40	39.3	2.21	0.439	86		75.7	13.8
42	49.3	2.76	0.543	88		84.3	15.4
44	61.3	3.41	0.666	90		93.7	17.1
46	75.5	4.18	0.811				

Fig.2.4: ELF vs. Axle Load (AASHTO)



The following points are drawn from the graph.

- Tandem axles carrying 18.7 ton have the same amount of damage as that of a single axle carrying 10 ton
- Tandem axles carrying 17 ton have the same amount of damage as that of a single axle carrying 9 ton
- Tridem axles carrying 24 ton have the same amount of damage as that of a single axle carrying 9 ton

2.3 Review of Axle Load Regulations

Regulations and literatures in connection to the axle load laws and the limits set by a number of countries have been reviewed. In this case those that are being implemented in the African regions are dealt in depth.

2.3.1 Axle Load Regulation - KENYA

In order to arrest the rapid deterioration of road infrastructure caused by overloading, the Government enforces axle load regulation. The current legal axle load limits are as follows:

Table2.2. Legal Axle load limit(Kenya) ⁽²⁾

Axle Group	Legal Limit (Kg)	Machine Error allowance (Kg)	Allowable Axle group load (Kg)
Single Steering Axle	8000	-	8000
Single rear axle	10000	400	10400
Tandem rear axle	16000	600	16600
Triple rear axle	24000	800	24800

In addition, the maximum total weight (Gross Vehicle Weight, GVW) of any vehicle is shown in the next table.

Table2.3 Gross weight of different vehicle ⁽²⁾

Vehicle Type	Legal Limit
Vehicle with two axles	16,000
Vehicle with three axles	22,000
Vehicles and semi-trailer with total of three axles	26,000
Vehicle and semi-trailer with total of four axles	34,000
Vehicle and semi-trailer with total of five axles	40,000
Vehicle and semi-trailer with total of six axles	46,000
Vehicle and drawbar trailer with total of four axles	34,000
Vehicle and drawbar trailer with total of five axles	40,000
Vehicle and drawbar trailer with total of six axles	46,000

Source:- <http://www.sameerafrica.com>

- The enforcement of axle load limits is currently undertaken by Roads Department of the Ministry of Roads and Public Works.
- There are 5 static (permanent) and 9 mobile Weighbridge stations
- Axle load operations are undertaken on a 24hour basis. All vehicles heavier than 7 tones are required by law to get weighed at all Weighbridge Stations located along the route.
- Compliant vehicles are issued with weighing tickets and allowed to proceed with the journey while overloaded vehicles are detained and charged.
- All overloaded vehicles are prohibited from using public roads until the excess cargo has been offloaded.
- The compliance rate currently stands at between 80% – 90%.

Moreover, minimum fine imposition trend in Kenya is shown in the next table.

Table2.4 Fine Imposition trend in Kenya⁽²⁾

Degree of Each Axle Overloading or Excess Gross Vehicle Weight (KG)	Fine on First Conviction		Fine on Second or Subsequent Conviction	
	(Kenya shilling)	USD	(Kenya shilling)	USD
<1000	5000	59.5	10000	119
1000-2000	10000	119	20000	238
2000-3000	15000	178.5	30000	357
3000-4000	20000	238	40000	476
4000-5000	30000	357	60000	714
5000-6000	50000	595	100000	1190
6000-7000	75000	892.5	150000	1785
7000-8000	100000	1190	200000	2380
8000-9000	150000	1785	300000	3570
9000-10000	175000	2082.5	350000	4165
10000 and above	200000	2380	400000	4760

2.3.2 South Africa, Axle Load Regulations

Besides the load limitations based on the engine power of the vehicle and limitations specified by the vehicle and tyre manufacturers, two additional loading factors are controlled by legislation in South Africa and across border countries:

- The damage or wear caused by an axle load to the road
- And the load concentration applied by a group of axles or axle units to bridge structures.

Although the South Africa's axle load regulations compare favorably with most other countries, there are slight variations to axle load regulations applicable to cross-border countries. The following table gives an indication of the Axle, Gross Combination Mass and Dimensional limits for most of the cross-border partners of South Africa:

Table2.5 Axle load regulation on sample countries

Country	Single kg	Tandem kg	Tridem kg	Max. GCM kg	Max. Length m
Africa					
South Africa	9 000	18 000	24 000	56 000	22
Lesotho	8 200	16 400	21 000	49 000	20
Botswana	8 200	16 400	24 600	50 200	22
Swaziland	8 200	16 400	21 000	49 000	20
Malawi	9 000	18 000	24 600	55 000	18.3
Zimbabwe	7 700	16 400	24 600	48 700	22
Mocambique	10 000	16 000	22 000	38 000	18
North America					
USA	9 000 ¹	18 000 ¹	20 000 ¹	36 000 ¹	25.9 ¹
Canada	9 100 ¹	17 100 ¹	24 000 ¹	53 500 ¹	25.0 ¹
Europe					
Germany	10 000	11 500	21 000	40 000	18
Switzerland	10 000	18 000	-	28 000	18
UK	10 500	20 300	22 500	38 000	18
Australia					
Australia	9 000	16 500	20 000	44 000	17.5

Note: 1. Varies from state to state/province to province

The Damaging Effect of Heavy Overloaded Vehicles on Roads ⁽⁶⁾

An interesting practice regarding the axle load controlling is the Self Regulation Initiative Programme exercised in South Africa to overcome overloading problem. Even though South Africa is exercising other protective measures the self regulation initiative is implemented on the timber industry as pilot project. It is called, Load Accreditation Programme (LAP) In the Timber Industry.

Nordengen and Francois Oberholtzer 2004⁽¹³⁾ identified that an initiative in the timber industry that commenced in 2002 aimed at reducing overloading in order to reduce accelerated road infrastructure deterioration, and to promote good corporate governance. The project in the timber industry resulted in a national pilot project, which was initially funded by the Department of Trade and Industry (DTI) and Forestry South Africa under the DTI's Sector Partnership Fund (SPF).

According to Nordengen and Francois Oberholtzer 2004⁽¹³⁾ the project is essentially driven by the private sector with involvement and support from government.

Because LAP is a self-regulation scheme, and thereby non-mandatory (which is also the Australian approach), it is necessary to identify and adopt incentives or concessions that will encourage operators to participate in the scheme. The first incentive to be accepted by the KwaZulu-Natal and Mpumalanga provincial authorities is the principle of “weigh-less”, i.e. limiting the weighing of accredited operators’ vehicles to spot checks, preferably when the weighbridge is not busy. Accredited operators have already benefited from reduced delays at provincial weighbridges and roadside checks. The regulative authorities also benefit by being able to focus their law enforcement efforts on noncompliant operators.

The second incentive to receive support is the introduction of Performance-Based Standards (PBS) vehicles to increase payload efficiency without compromising vehicle safety and infrastructure protection.

Other possible incentives that are being investigated include discounts on vehicle insurance premiums and discounts on toll fees.

A prerequisite for becoming an accredited operator is that all production vehicles must be coded (which enables the monitoring process) and that 96 percent of *all* vehicle/combinations must fall within the legal load plus the tolerance for a minimum of three consecutive months. This approach has shown significant improvement by an individual operator from 40% of vehicle trips being prosecutable to less than 4%.

Nordengen and Francois Oberholtzer, 2004⁽¹³⁾ finally summarize that the Load Accreditation Programme is a significant initiative in self-regulation in the South African road transport industry and this initiative is to roll out to other industries and to eventually establish a national accreditation system for the whole of the road transport industry.

2.3.3 The economic impact of enforcing axle load regulation in Zambia

Similar to other African countries, Zambia is also suffering from road deterioration through overloaded vehicles. This study (Odd I Larsen, 2007⁽¹⁴⁾) is an economic assessment of regulating and enforcing axle load control of heavy vehicles in Zambia. This enforcement is part of a wider Axle Load Control Programme to prevent premature deterioration of roads and bridges, implemented in 2004 with a time frame of four years. Among the many objectives of the

programme, a new regulation pertaining to maximum permissible axle loads and gross vehicle mass (GVM) was approved in 2007 and included in the Roads Act.

Efficient enforcement of axle load regulations will have two major impacts:

1. Heavy axles (as measured by GVM) inflict an excessive cost in terms of wear and tear on the roads. They may cause additional damage to bridges and impede the safety of traffic. Thus, efficient axle load regulation will lead to a reduction in maintenance cost to the road keeper, i.e., the government.
2. On the other hand, enforcing a strict regulation will imply that excessive payload on overloaded vehicles must be transported by additional vehicles and hence increase vehicle-kilometers driven by heavy vehicles. These added vehicle kilometers will increase the cost of moving any given volume of goods for road haulers. The costs associated with this second impact may to some extent counteract the gains associated with reduced wear and tear on roads.

The enforcement of the axle load regulations will lead to savings in the cost of road maintenance for the road keeper (the Zambian government). The savings will be manifested in longer time intervals between rehabilitation of different road segments. The average annual savings are estimated to be of the order US \$4-4.1 million per year. Thus, in terms of future savings in road maintenance, the programme is profitable.

While the effect on road deterioration is the main motivation for a programme attempting to reduce overloading, the programme may have additional benefits, depending on the specific circumstances. These would include:

- A comprehensive scheme with efficient weighbridges will provide valuable information on the roads exposure to heavy traffic. In the future, this information can be used in the design of maintenance programmes and to set the appropriate design parameters for roads to be built or rehabilitated,
- Training of officers both in administration and operation of the control scheme contributes to a general improvement of skills for the workforce
- The programme can contribute to a more general awareness of the corruption problem and set an example in this respect
- Information about programme and its objectives can improve the general awareness of truckers when it comes to problems caused by overloading,

- The programme will promote fair and efficient competition in the trucking industry by not given a competitive advantage to operators that do not comply with the rules and regulations pertaining to loading of vehicles,
- Depending on the level on non-compliance with the regulations, the fines collected from overloaded vehicles may generate revenues exceeding the cost of operating the programme and thus provide additional funding for road maintenance. However, if the programme is efficient, the rate of compliance will - in the longer run - be high and the revenue consequently low.

These additional benefits have not been possible to measure in monetary terms and will only occur if the programme continues in the future with the intended level of efficiency. If that happens, these benefits alone may well outweigh the negative impacts of the programme which are the extra costs imposed on road haulers due to GVM restriction.

From the *Zambian practice* it is possible to understand that minimizing damaging effect is a parallel issue with increase in number of trips which would result extra cost and hence detail study is required to find out legal axle load limit that optimize the damaging effect with economical trips for goods.

2.3.4 Axle Load Control in Tanzania

Tanzania has a road network of about 85,000km. Recent records from the Tanzanian Roads Authority (2011) ⁽¹⁶⁾ indicates that the overall percentage of overloaded vehicles in Tanzania is between 5 and 24%. Overloading relative to legal load limits is known to be fairly widespread and is responsible for the significant acceleration in pavement deterioration and has resulted into a very serious and costly maintenance problem. The problem may be even more serious in Tanzania as most of the country's first generation roads are reaching the end of their design period.

- Although the history of attempts to control truck overloading in Tanzania started long ago, the undesirable situation still persists. Due to budgetary and other restrictions, law enforcement is operating in a sporadic rather than a systematic manner, and with insufficient power and success
- Axle load control is regulated under the road traffic Act No.30 of 1973, Regulation 2001.

- The Regulation clearly defines responsibilities of the Road Authority (Ministry of Works and TANROADS) in jointly (collaboration) with the Ministry of Home Affairs
- The Regulations sets enforcement procedures to be followed and give guidance as regards to the limits of its applications, procedures for weighing, issuance of abnormal and awkward loads permits, imposition and payment of fees, and administration of appeals.
- The regulation set the maximum allowable single axle load limit of 10 tons and a maximum gross vehicle mass of 56 tons.
- These regulations have been harmonized with the axle load control recommendations of the Southern African Development Community (SADC)
- These limits are of 10 tons for single axle with dual tires, 18 tons for a tandem axle group and 24 tons for triple axle group.
- All vehicles with loading capacity of equal or more than 3.5 tons must be weighed.
- Weighing of a vehicle is by starting with first axle up to the last group of axle, the sum of axle weights is the total Gross Vehicle Mass(weight).
- A tolerance of 5% is provided in the Regulations
- All overloads beyond 5% of legal limit must be offloaded into another vehicle or re-arranged
- To proceed with 5% overload, the transporter shall pay a surcharge fee of 4 times its overload.
- The legislation empowers a weighbridge operator to impose fees on the spot to owners of an overloaded vehicle without necessarily going to criminal court proceedings.

Dimensional Limits

- Maximum height of any vehicle = 4.6 meters.
- Maximum width of any vehicle = 2.6 meters.
- Overall length of rigid vehicles = 12.5 meters.
- Overall length of articulated vehicles = 17 meters.
- Any combination of vehicles = 22 meters.
- Note: Anything above these limits, must get a permit

Weighing Facilities

- Fixed scales (25 nos.) and

- Portable scales (17 nos.)
- All scales are electronically operated and produce printout and store data.

Achievements

- With the regulations in place, number of overloaded vehicles has declined from 40% in 1999 to less than 25% in 2011,
- Sensitization and create awareness of transporters and road users on axle load control has also substantially improved
- Reduced number of vehicles by passing weighbridge stations.
- Aged and low capacity of Mechanical weighbridges, were upgraded to electronic fixed weighbridges.
- Number of weighed vehicles increase from 357,413 in 2000/01 to 2,672,304 in 2009/10 over 7 fold in 10 years period of time.

Challenges

- Inadequate budget for the operations, repair and maintenance of the weighbridges
- Inadequate budget to recruit and train more staff for operating weighbridge stations
- Inadequate number of fixed weighbridges at strategic locations, in particular along the central corridor, at ports border posts.
- Inadequate funds for procurement and construction of more weighbridge stations in accordance with the weighbridge master plan.

2.3.5 Economic Effect of Overloading and Weight Enforcement

Strathman, 2001⁽¹⁵⁾ focused on the relationship between the economical effect of overloading and weight enforcement. The study shows that both the intensity of weight enforcement and the level of penalty can discourage overloading activities.

Taylor et.al.2000⁽⁵⁾ was found that the relationship between enforcement level and vehicle overloading rate is relatively inelastic in the initial stage but elastic at the end. That means enforcement has higher efficiency at the initial stage however efficiency decreases rapidly when enforcement levels increase gradually.

Four weight enforcement regimes were proposed by Strathman,2001⁽¹⁵⁾ which includes relative small penalties with extensive enforcement, relatively low level of enforcement with relatively

high penalties, high penalties with extensive enforcement and relatively small penalties with low level enforcement. In summary it is observed that the vehicle overloading enforcement is highly correlated with fines and enforcement. As a result fines must be associated with intensified enforcement and concluded that aggressive enforcement and stiffer fines for weight violators is the best solution.

2.3.6 Enforcement and Overweight violation.

Taylor et.al.2000.⁽⁵⁾ identified that effective weight enforcement which cooperates with a compressive data collection programme and data base for a scientifically based road asset management system has shown significant improvement to minimize the overloading impact. Table below summarize the general functional form between enforcement visibility and overweight violation rate based on several studies performed by seven state enforcement agencies in the US.

Table2.6 Overweight violation rate across state agency (US)

STATE	High enforcement level Violation rate	Low enforcement level Violation rate
Virginia	0.5% to 2%	12% to 27%
Maryland	1%	34%
Arizona	1.5%	30%
Wiscosin	1%	3%
Idaho	11.9%	32%
Florida	1%	29%
Montana	1%	29%

2.3.7 Minnesota Statutes, 2012⁽¹¹⁾

A law enacted by the legislative of the State of MINNESOTA states that No vehicle or combination of vehicles equipped with pneumatic tires shall be operated upon the highways of the state where the total gross weight on any group of two or more consecutive axles of any vehicle or combination of vehicles exceeds that given in the following axle weight limits table summarized from a long list of Gross Weight and Distance between the front-most and rear-most

axle of a vehicle (distance between the centers of the first and last axles of any group of two or more consecutive axles under consideration).

Table 2.7: Minnesota State Statutes 2012 (USA) Axle Weight Limits ⁽¹¹⁾

No. of Axle	Distances between centers of foremost and rearmost axles of a group, M		Maximum Gross Weight in Kg on Group of consecutive axles or any combination of vehicles having a total or more axles		
	From	To	From	To	Remark
2-Axle	1.2	2.4	15300		
	2.4 ⁺	3.4	15300	18000	15300-16200 for Unpaved street and Highways
3-Axle	2.1	2.4	15300		An increase in Wt of 225-Kg per 0.3m increase in front-most and rear-most axle distance
	2.4 ⁺	10.1	18900	27000	
4-Axle	3.0	17.4	22050	32625	
5-Axle	4.3	18.3	25630	37125	
6-Axle	6.1	18.3	29700	40500	
7-Axle	6.1	19.5	32850	43650	
8-Axle	10.7	22.6	38700	48600	

Two consecutive sets of tandem axles may carry a gross load of 15300-Kg each and a combined gross load of 30600-Kg provided the overall distance between the first and last axles of the consecutive sets of tandem axles is 11.09m or more.

To encourage protection of Environment and Fuel Economy the legislation allows an increase in Gross Vehicle Weight of all Axles; credit for idle reduction technology. In order to promote the reduction of fuel use and emissions, the maximum gross vehicle weight limits and the axle weight limits for any motor vehicle equipped with idle reduction technology or emissions-reduction technology must be increased by the amount of weight necessary to compensate for the weight of the idle reduction technology or emissions-reduction technology.

2.3.8 The Need for Truck Weight Monitoring In India

The Indian Government has initiated an enormous road development plan to the year 2020 involving an approximate Rs. 65,000 billion (US \$1,500 billion). Road transport accounts for 65 percent of goods traffic and 80 percent of passenger traffic. Each year, commercial vehicles transport goods valuing billions of rupees across the country and this value is constantly growing. Aman Kishore Nov. 2000⁽³⁾ has described the need of WIM as below.

1. **Preserve the Infrastructure:** Minimize the costly damage and deterioration to infrastructure from overweight trucks by monitoring and controlling truck weights. An increase in loading means an exponential increase in the acceleration of road wear. In other words, if pavement loading is miscalculated by as little as 10%, it can mean an acceleration of road wear by over 40%.
2. **Increase Safety:** With tighter maintenance budgets and increased highway usage, maintaining a high quality road is a challenge. Rutting, cracking, and potholes all decrease the level of safety on the road. Another aspect of safety is the operation and condition of the commercial vehicle. While many accidents involving commercial vehicles are the fault of others, the size and weight of the commercial vehicle often results in crashes of greater severity. It also means that the consequences of safety problems on a commercial vehicle are magnified many times over that of an automobile.
3. **Save taxpayers' money:** A WIM (Weigh-In-Motion) system helps to monitor and keep weights under control so that road wear is minimized. Implementation of WIM helps to protect the infrastructure, maximizes the efficiency of trucking and targets violators. This means savings to the taxpayer through better roads, cheaper goods and more efficient enforcement operations. When less funds are required for liability and to maintain and sustain the highway system, it means more funds for other areas fiscal or fewer taxes.
4. **Prevent Overloading:** Implementing WIM systems on the mainline allows agencies to control the loads on the roads to prevent the acceleration of road wear. Thus, no overweight trucks will be allowed to bypass and create unacceptable amounts of wear to the road.
5. **Minimize delays to trucking industry:** Traditional weigh stations with static scales require approximately 2 minutes per vehicle for weight compliance checks. This time increases with the traffic at the weigh stations. Loss of time results in loss of revenues. With the

implementation of WIM systems, weighing takes place dynamically at normal highway or ramp speeds, without any interruption to truckers. The WIM system sorts all vehicles based on weight and, where applicable, credentials. The WIM system directs only out of compliance vehicles to report for further inspection. All other trucks are allowed to bypass without stopping at the station. With fewer delays at weigh stations, the good carriers are able to deliver goods on time without the disadvantage of competing against carriers who attempt to cheat the system to gain financially by overloading their trucks.

6. Protect the environment: Minimize truck emissions and maximize fuel efficiency by limiting the number of idling trucks at weigh stations.

2.3.9 Axle load Control Practice in Ethiopia

There are nine weighbridge stations established at different areas on trunk roads of the country which are administrated by Ethiopian roads authority also there are two newly established control stations at Sendafa and Humera. The existing axle load control system served more than thirty years with limited efficiency and frequent maintenance. Moreover the system has the following limitations to cope up with the current freight transportation and technological advancement in this area:

- All weighbridges are equipped with single axle scales that can measure only one axle at a time, as a result checking of vehicles at weighbridge stations takes longer time.
- The weighbridges are not equipped with a device that can automatically register the data when vehicles are weighed at the station. Hence, occurrence of error in recording and data manipulation could be high.
- The coverage of axle load control is limited as the existing weighbridges are few in number, compared to the size of the road network.
- Most of the existing weighbridges are located over the central part of the country. Thus there is a possibility of escaping from being weighed and even weighed after travelling over a considerable length of the road network.

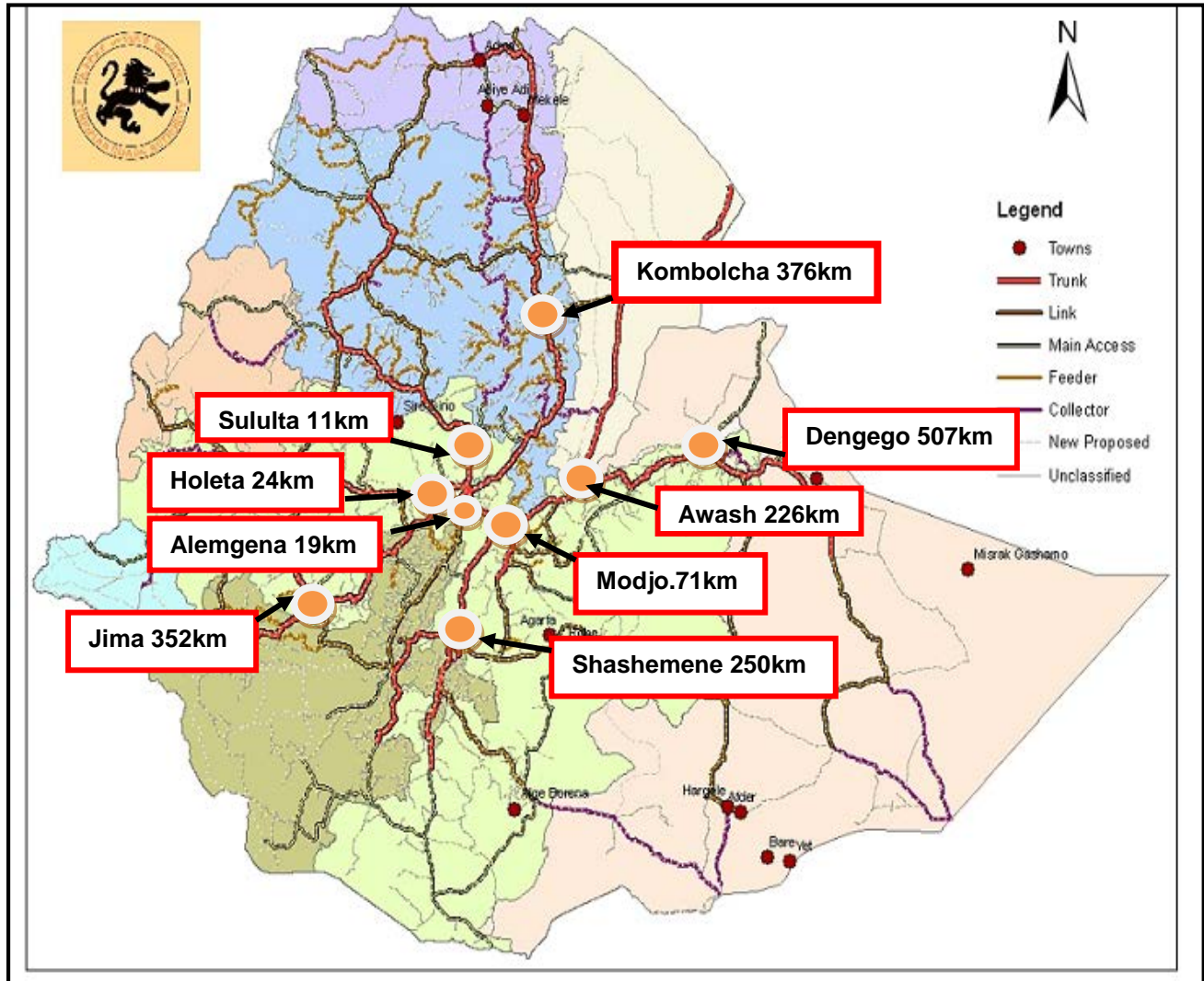
- The stations are not equipped with appropriate facilities to carry out the axle load control work effectively and efficiently.

The location of the existing weighbridge stations are shown in the following table.

Table 2.8: Locations of Existing Weight and Size Control Stations

No	Location of weigh bridge station	Distance of weigh bridge station from Addis Ababa (Km)	Trunk roads served by weigh bridge station
1	Modjo	71	<ul style="list-style-type: none">▪ Addis-Modjo-Awash▪ Modjo-Awash
2	Awash	226	<ul style="list-style-type: none">▪ Awasm-Mille-Gallafi▪ Awash-Harar-Diedawa-Dewelle
3	Dengego	507	<ul style="list-style-type: none">▪ Harar-Jijiga▪ Diedawa-Dewelle
4	Shashemane	250	<ul style="list-style-type: none">▪ Shashemane-Hawassa-Moyale▪ Shashemane-Arbaminch-Jinka▪ Shashemane-Dodola--Goba
5	Holleta	24	<ul style="list-style-type: none">▪ Addis-Nekemt-Assosa
6	Alemgena	19	<ul style="list-style-type: none">▪ Addis-Welkite-Jima
7	Sululta	11	<ul style="list-style-type: none">▪ Addis-D/Markos-Gonder
8	Jima	352	<ul style="list-style-type: none">▪ Jima-Matu-Kombolcha▪ Jima-Bonga-Miza
9	Kombolcha	376	<ul style="list-style-type: none">▪ Addis-Dessei-Mekelle▪ Kombolcha-Mille

FIG 2.5 location of weighing station and distance from Addis Ababa.



Several visits to axle load control and ERA road Asset office has been done .Also a one day visit was made to Awash weigh and size control station and few observations are captured by a digital camera as shown below.

	
<p>No.1 Weighing platform for single axle at a time</p>	<p>No.2 Digital weighing meter without data recording facility. Data is captured manually from screen</p>
	
<p>No.3 Raw of Fuel tanker trucks passing the weight station un-weighed but impose significant damage on the pavement.</p>	<p>No.4 Fully loaded truck and truck trailers slowed along climbing lane imposing pavement overstressing</p>

A number of studied reports have been prepared to control and set legislation regarding axle load. Among these the one conducted by WSP International Ltd incorporating O’Sullivan & Graham Ltd in association with TRL, 1998.⁽¹⁷⁾ for the Ethiopian Roads Authority under a procurement **No. 7ET.089** and by a team of experts from different concerned authorities are extracted as discussed below.

1. WSP International Ltd (O’Sullivan & Graham Ltd) in association with TRL. ⁽¹⁷⁾

Ethiopian roads authority had entered contractual agreement of consultancy service for axle load management study with WSP International Ltd (incorporating O’Sullivan & Graham Ltd) in association with TRL, Old Wokingham road, Crowthorne, Berks, RG45 6AU UK. In1998 ⁽¹⁷⁾

The consultant had collected all relevant data for the study and submitted a comprehensive report in 2000.

As part of review of previous study, some relevant points with the study area are extracted from this final report.

It is stated in the report that Ethiopia has both axle load legislation and mechanisms for its enforcement. The current income derived from vehicle users is inadequate to pay for an appropriate level of road maintenance. Since the road fund and fuel levy are already in place, the provision of funds to pay for maintenance should not be a problem. This assumes that the funds will be spent effectively on maintaining smooth roads and hence the road transport industry will be able to afford to pay the fuel tariff.

Some vehicles carry loads more effectively than others. A more even distribution of load across all axles reduces road damage, substantially. More axles per ton of gross weight lead to less damage to the road but may involve greater cost to the vehicle operator (initial cost of vehicle and increased tire wear.). This leads to the recommendation for vehicle type where axle loads are specified for different axle spacing and suspension systems.

According to the study by O’Sullivan & Graham ltd in 1998 ⁽³⁾ between 27% and 36% of axles from heavy and articulated trucks are overloaded to maximum loads of 27.5 tones or nearly three times the legal limit.

Table2.9 Spectra of overloading (% of all heavy trucks)

Type	% of vehicles overloaded	% of all axles overloaded	% of rear axles overloaded	Max. axle load (tones)
Heavy trucks 1.2	70	36	70	27.4
Heavy trucks 1.22	>47	34	45	21.0
Articulated trucks	>54	27	33	21.6

SOURCE(AXLE LOAD MANAGEMENT FINAL REPORT) BY O’Sullivan & Graham ltd ⁽¹⁷⁾

On the other hand there are a considerable number of lightly loaded or empty trucks running which are about 30% of the three axle heavy and articulated trucks. This indicates a considerable

over capacity in the industry. Furthermore it is mentioned in the report that the existing enforcement system suffers from the following problems:-

- Weighbridges, recorders and printers that are not operational because of age and poor maintenance;
- Suspected bribery and corruption by some weighbridge station staff;
- Shortage of spare parts and repair workshops;
- Low level of penalties for overloading;
- Staff who are ill paid and unmotivated; and
- Staff who are poorly trained.

To alleviate these shortcomings the report had proposed some measures;

- Increase the scales of penalties to more realistic levels
- Improve the efficiency of operation of the existing weighbridge stations.
- Axle load control through type approval
- Containerization
- Public Participation.

The final report indicates that scale of penalty levied set in 1957 is rather too low which ranges from 0 up to 500 birr and possibly up to 1000 for particularly serious offences. Anecdotal evidence suggests that penalties imposed during the study period (1998) were birr40-100 per offence. GTZ reported that the penalties at Alemegena were Birr 100/tonne of overload

The Preferential Trade area Treaty (PTA) signed by Ethiopia but not yet implemented recommends COMESA penalties increasing in accordance with the fourth power, commensurate with the rate of increase of damage to the road pavement as shown below.

Table 2.10. Penalty rate for different extra load.

PTA/COMESA Agreement	
Over-load per axle (MT)	Penalty per axle(BIRR)1995
0 - 1	300
1 - 2	1100
2 - 3	2100
3 - 4	3400
4 - 5	5000
5 - 6	6900
6 - 7	9300
7 - 8	12200

SOURCE(AXLE LOAD MANAGEMENT FINAL REPORT) BY O'Sullivan & Graham Ltd.⁽¹⁷⁾

It is recommended that the penalties be applied per axle (or axle group) as measured on site and as laid down by the existing legislation rather than GVW, which can mask individual heavy axles which cause most damage. The problem of persistent offenders also needs to be addressed. This should be relatively simple to arrange if records are computerized. For drivers the penalty could be the loss of driving license for a month for each offence after the second one. For the owners the truck's operating license be withhold or the vehicle impounded for each offence after the second or the penalty could be doubled for each sub sequential offence.

2. Team of Delegates

A team composed of delegates from the Ethiopian Roads, Road Transport and Maritime and Transit Authorities⁽¹⁰⁾ was assigned in 2003 (2010-2011) to prepare a proposal and recommendation on how to enforce axle load limits. The main points from the Amharic version of the proposal report are taken as indicated below.

The team presented its finding and recommendation as short and long term solutions to control overloading.

The short term recommendation includes;

- To check transporters and operators to abide by the load capacity specified for each type of containers

- The team had discovered the overloading associated with multimodal transport system as a package that is coming from the port of Djibouti. To have control of this the team proposed to check for the vehicles carrying containers at Semera dry port offload any excess load if any and continue their trip to their destination with loads to the legal limit.
- To arrange and obtain a special permit from the ERA to import heavy equipments and machineries for the construction industry.
- Oils and other goods subsidized by the government should be imported through arranged agreements with the consigner.
- Selection of appropriate vehicles (trucks and truck trailers) so that an effective transport of goods be made to minimize the overloading effect.
- To check and verify weight documents carried by transporters engaged in multimodal transport. Then penalize and present to the court of law those who are loaded above the loads stated in their document.

On the other hand Long term solution was proposed;

- To set criteria and encourage to import truck and truck trailers with an effective transportation while operation within the legal lad limits (i.e. tandem and tridem axles) and continue with the ongoing multimodal transport system.
- System should be established to encourage the indoor heavy vehicle owners to modify their vehicles to an efficient axle configuration.

Furthermore it is also stated in the report that the team had proposed fines (not disclosed) and its implementation. Finally the recommendations and proposal prepared by the team had been further scrutinized by the Ethiopian Roads Authority presented to The Ministry of Transport in 2004 (Ethiopian calendar) that might be still in pending.

From both foreign consultant and team of delegates report, it is learnt that the government has given due attention for the overloading problem despite no action is taken on the ground yet.

2.4 Enforcement Technology and Methods

An integral part of highway management activities must include the weighing of vehicles, both to manage existing infrastructure and plan for future investments in infrastructure. Weighing vehicles serves two very important functions:

1. Protecting the infrastructure from premature wear and deterioration
2. Data collection for planning and management purposes

The most widely practices of axle load and Gross Vehicle Weight measurements to reinforce load limit regulations are:-

- Permanent weigh bridges
- Mobile and
- Vehicle In Motion Weighing

Ethiopia and many other African countries are using permanent weigh bridges as part of their axle limit regulation and data collection. And yet these are mainly of technology dependent and vary in their capacity, data handling technology and accuracies.

Mobile weighing scales are often used in road design projects for a short period of days often 3 - 7 days. Moreover they are used to check overloading at some of the arterial roads on seasonal basis.

Despite its initial cost of investment Vehicle in Motion Weighing is becoming so popular and the most effective one.

Legal loads must be allowed to move unencumbered (creative) throughout the system to improve the efficiency and productivity of truck carriers, and illegal loads must be caught and penalized. The challenge is increasing the use of technology and forward-thinking practices and procedures to intelligently target enforcement activities to ensure safety, preserve the Nation's infrastructure investment, and improve truck productivity.

(Jodi Carson and Tom Kearney, 2009⁽¹⁰⁾) mentioned that to improve the efficiency and effectiveness of VSW (Vehicle Size and Weight) enforcement in the United States, the Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials (AASHTO), and National Cooperative Highway Research Program (NCHRP) conducted an international scan tour in 2006 to six European countries that are using innovative practices, procedures, and technologies to enforce VSW.

Among six countries visited, Switzerland and Germany, use technology to support enforcement of commercial motor vehicle size regulations. To permit direct enforcement, the Swiss use an automated vehicle profiler system in low-speed applications of less than 6 miles per hour, mi/h (10 kilometers per hour, km/h).

For high-speed applications, the Germans use the same gantry- mounted vehicle profiler system, installed along 7,456 miles (12,000 kilometers) of German autobahn as part of its larger toll collection system, to preselect potentially oversized vehicles from the traffic stream.

To support enforcement of commercial motor vehicle weight regulations, Slovenia is using a bridge WIM system successfully and extensively for a variety of applications, including pre selection for mobile enforcement; remote field verification of permitted overweight vehicles; alternate route monitoring for possible bypass by noncompliant vehicles; and data support for planning, design, and structural analysis.

Slovenian bridge WIM system has proven most successful on short, stiff structures with integral concrete slabs.

In several of the countries visited, the scan team observed a high level of collaboration in VSW enforcement among similar agencies of different jurisdictional levels (that is, national and regional law enforcement agencies) and among different agencies (such as transportation and law enforcement). In addition, private sector entities work closely with government and research bodies to refine and enhance product performance and accuracy.

The scan team observed mobile enforcement activities in France, the Netherlands, Slovenia, and Switzerland. In each case, high-speed WIM technology provides for mainline prescreening of suspected overweight commercial motor vehicles

Traditional overloading enforcement by a police or by traffic inspectorates is strictly repressive, requires a lot of staff, is inefficient and only controls a fraction of the total trucks fleet. Furthermore the manual selection method is often biased.

Weigh-in-Motion offers the potential to the enforcement agencies to increase the number of checks on trucks significantly. At the same time it enables free flow for non overloaded vehicles. A few EU member states have some expertise in using WIM for pre-selection of overloaded vehicles. However, this application only scratches the surface when considering the full potential of WIM.

3. RESEARCH METODOLOGY

3.1 Background and Overview

Premature failure of road pavements before their useful design lives and related lose in economic values had attracted several researchers to identify the major factors affecting pavement performances. Among these, the effect of overloading had received greater attention and several researches have been undertaken whose results continuously proved that overloading is one of the main causes for premature failure of road pavements. Furthermore when the economic gain from transporting extra loads is compared with the lose in road asset it becomes more and more disproportional with an increase in overloading. It is this lose in economic value that had called to exercise axle load limitation and set strict enforcement regulations by road agencies from time to time especially following the introduction of heavier trucks and truck trailers overtime. Since the last 15 to 20 years the Government of Ethiopian is increasingly focusing towards expanding its road network and is allocating the lion share of its capital budget. Nevertheless most of the roads, particularly paved ones are also increasingly becoming victims of overloading.

3.2 Methodology

The research is conducted following several stages or phases that have been identified right from the onset and refined in due course of the research work. The chart in figure 3.1 illustrates a flow of methods adapted and these are briefly described in the following sections.

3.2.1 Preparation Phase

Up on setting the project objectives review of a number of literatures and legal limit regulations in practice by different countries especially with direct relevance to the Ethiopian conditions have been reviewed. This is then followed by data collection.

3.2.2 Data Collection

Historic traffic count and axle load data relevant to the research road segment have been collected this includes:-

1. Historic traffic count downloaded from ERA web site
2. Vehicle weighing data from Ethiopian roads authority office of vehicle size and weight axle load team.
3. Weighing method and weighing facilities, site observation and interrogation

Fig. 3.1: Flowchart depicting sequence of the research work



4. DATA ANALYSIS

The collected data had been analyzed using the acquired knowledge from engagement in road design, supervision and theories that had been learnt in the course of the literature reviews

4.1 Historic Traffic Count Data

13 Years (1999-2011 inclusive) historic traffic count data of Adama - Awash (120-km), the road segment proposed for the research work had been downloaded from the ERA web site. The rehabilitation of Modjo - Adama - Awash by asphalt concrete pavement was completed in provisional acceptance at 2005. However the section of the study area is opened for traffic at 2003. The traffic data is selected so that the actual data since 2001 to 2011 (11 years) will form part of the analysis and projection would be made to forecast the traffic volume up to the analysis period of 20 years from opening to traffic. The counting period is intentionally selected so that the existing pavement situation could be compared in terms of the design cumulative ESA and the actual total ESA it carries to-date.

ERA is conducting 7-days traffic count during each 3 count seasons, over the roads under its jurisdiction, assumed to represent 3 different business periods mainly related to agricultural activities. These are:

1. Feb 01 to 07
2. July 01 to 07
3. Nov.01 to 07

The counts are normally undertaken for 12 hours for five of the counting days and for 24-hours for the remaining two days. The 24-hours count is taking place at one of the week and weekend. Based on the 24-hours count the remaining counts will then be adjusted for a night factor to obtain the seasonal average daily traffic. The Average Daily Traffic (ADT) from the three seasons is finally taken as the Annual Average Daily Traffic (AADT). The ERA traffic count classifies vehicles in to 8 traffic classes.

Table 4.1: ERA’s Vehicle Classification

Vehicle Class	Vehicle types
1. Cars	Car and Taxis
2. Land rovers (L/R)	Delivery vans, Land rovers, Land crosiers, Jeeps etc.
3. Small bus (S/B)	Up to 24 passenger seats
4. Large bus (L/B)	Above 24 passenger seats
5. Small trucks (S/T)	Up to 3 ton pay load, 2 axle
6. Medium truck (M/T)	3-7 ton pay load, 2 axle
7. Heavy trucks (H/T)	Over 7 ton pay load, 2 and 3 axles
8. Truck trailer (T/T)	Including semi-trailers.

The 13-years historic traffic data for the study road downloaded from the ERA web site⁽⁴⁾ is also given in the following table.

Table 4.2: Historic Traffic Count 1999-2011, Adama – Awash

No.	Year	Car	L/Rover	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	Truck & Trailer	Total, AADT
1	1999	9	98	82	48	90	89	114	419	2949
2	2000	13	122	96	54	164	127	141	539	3258
3	2001	10	135	90	43	118	86	91	448	3025
4	2002	6	174	92	63	111	97	89	557	3195
5	2003	20	203	129	91	186	141	181	644	3603
6	2004	22	231	152	102	194	199	191	579	3680
7	2005	38	284	274	141	181	422	267	905	4524
8	2006	46	214	191	79	142	229	155	835	3905
9	2007	67	229	246	153	225	276	248	1000	4460
10	2008	52	207	233	138	186	319	298	1007	4458
11	2009	63	289	461	209	224	454	387	1584	5691
12	2010	76	233	380	216	256	433	361	1248	5225
13	2011	86	297	366	135	352	445	378	1,319	5402

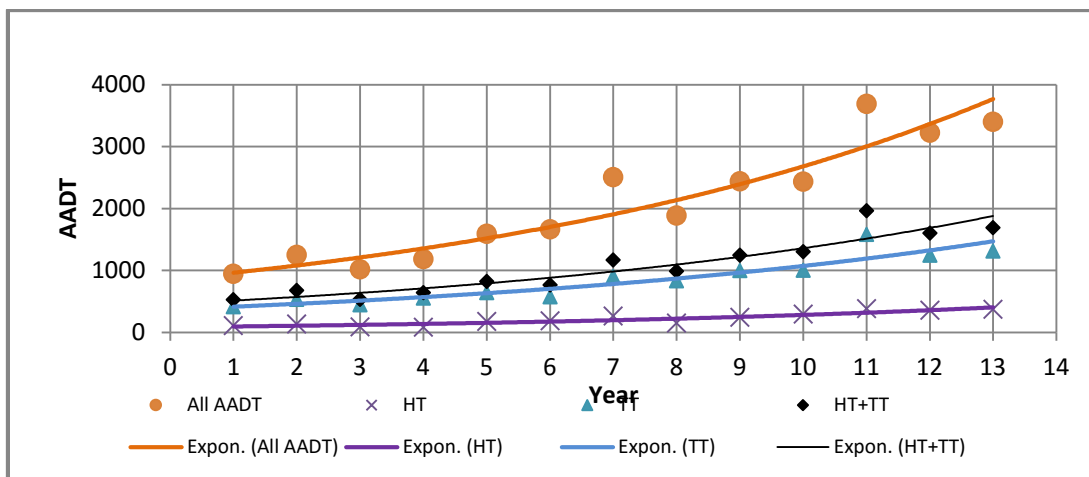
4.2 Growth Rate

Determining traffic growth rate is always best when it is based on historic traffic count data under normal and persistent economic growth. The traffic data for the study road is analyzed to predict the trend in the past traffic growth. This has been done for all Traffic (AADT), Heavy Trucks (2 and 3 axles), Truck Trailers, and the aggregate of Heavy Trucks and Truck Trailers.

The best fit is obtained from exponential regression and is shown in figure below for the 13 years traffic count conducted from the traffic section between Nazareth (Adama) and Awash. Year 1 represents the 1999 count year while year 13 that of the 2011.

Traffic had grown consistently during the count period on Adama - Awash road with all traffic at 12%. Heavy trucks at 12.6%, truck trailers at 11.1% and aggregates of heavy trucks and truck trailers at 11.3% growth rates.

Fig 4.1: Trend in AADT Growth, Adama-Awash.



The growth rates are intended to forecast the traffic beyond the latest traffic count year, 2011, obtained from the web site.

4.3 Axle Load Data

ERA is currently undertaking axle load weighing at the existing 9 permanent size and weight control stations located along the main trunk roads in several parts of the country. This was done by the Road Transport Authority (RTA) before the control stations are handed over to the ERA. For the purpose of this research work the 1-year axle load data (July 1st 2011 to June 30th 2012) from all of the weighing stations are collected from the vehicle size and weight axle load team of the ERA. The data are made available in a summary form for each axle in a range of 1-ton (1000-kg). The axles are designated as F1, F2 for the front axles and R1 to R7 for the rear axles. Then those axles beyond 8-ton for the front axle and those over 10-ton are indicated as ILLEGAL. The axle weights are not desegregated by vehicle type neither by axle configuration and are subject to manipulation by the end user. Typical data sheet obtained from the branch is shown below.

Table 4.3 Axle load report (JULY2011-JUNE 2012)AWASH

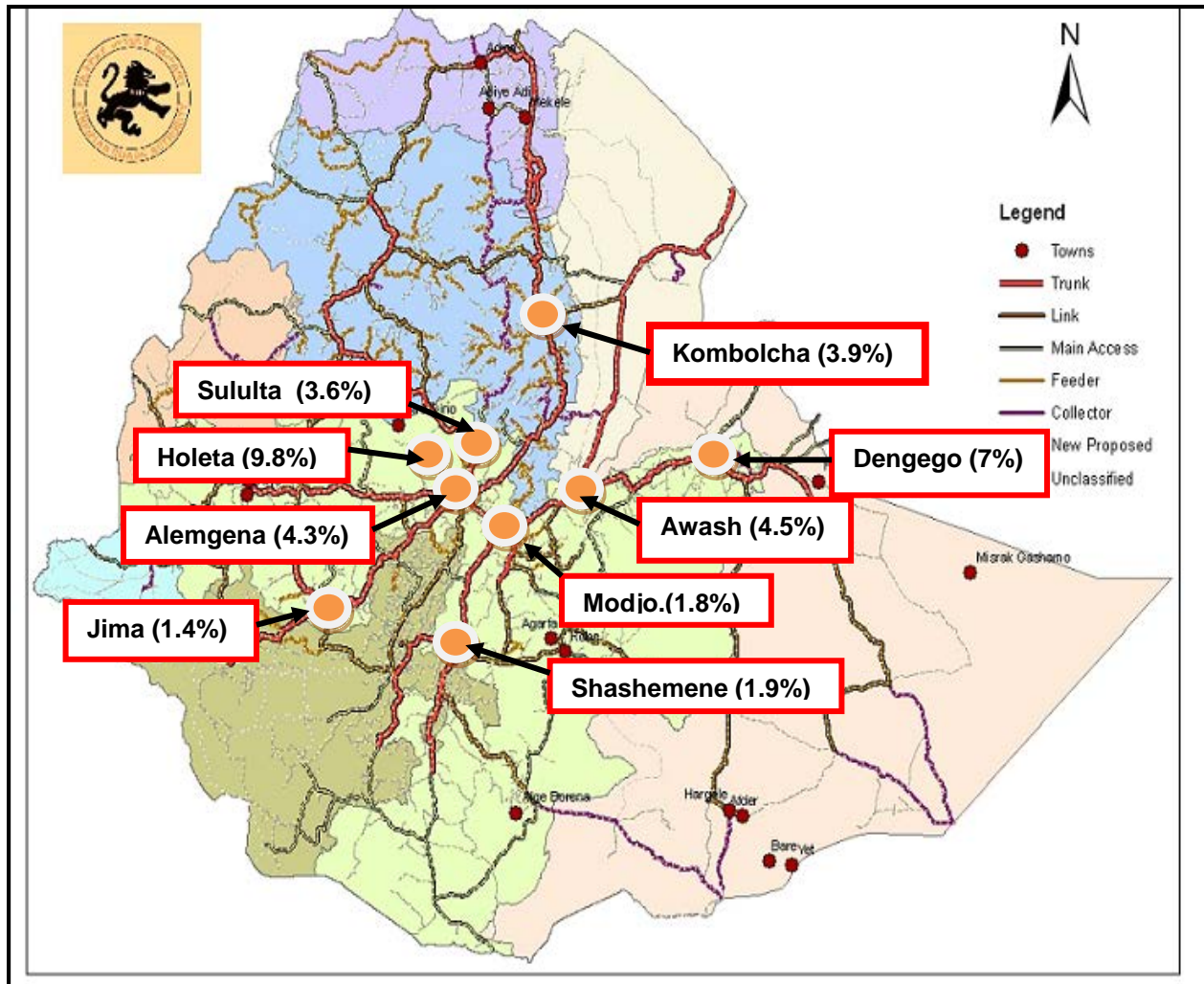
AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES										TOTAL AXLE WEIGHT: NO OF VEHICLES			
											FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL	
1.0-2	0	0	0	0	0	0	3	0		0		3		
2.1-3	8	0	0	2	3	1	6	0		8		12		
3.1-4	160	2	3	6	21	8	6	0		162		44		
4.1-5	927	7	54	136	78	33	52	0		934		353		
5.1-6	4861	4	304	414	290	181	312	0		4865		1501		
6.1-7	10332	0	779	1075	753	1170	1119	0		10332		4896		
7.1-8	11481	0	2268	3405	2398	3902	3360	0		11481		15333		
8.1-9	266	0	7512	9316	8668	8074	7228	0			266	40798		
9.1-10	108	0	13343	10426	11807	10308	9883	1			108	55768		
10.1-11	28	0	1211	721	678	636	699	0			28		3945	
11.1-12	3	0	418	573	588	870	450	1			3		2899	
12.1-13	0	0	437	482	657	665	326	0			0		2567	
13.1-14	0	0	563	497	681	350	282	0					2373	
14.1-15	0	0	616	336	380	137	185	0					1654	
15.1-16	0	0	394	207	168	55	95	0					919	
16.1-17	0	0	169	92	29	23	62	0					375	
17.1-18	0	0	80	32	6	1	9	0					128	
18.1-19	0	0	17	11	0	3	4	0					35	
19.1-20	0	0	1	5	0	2	0	0					8	
20.1-21	0	0	2	4	0	1	0	0					7	
21.1-22	0	0	3										3	
TOTAL	28174	13	28174	27740	27205	26420	24081	2	0	27782	405	118708	14913	

It is only truck and truck-trailers that are obliged to enter into the weigh bridges. In fact these are the ones that are of interest to the study work due to their significant pavement damaging effect, particularly when overloading is taken into account. Nevertheless due to capacity limitation only very few are weighed. To visualize the effect, the number of the average daily trucks and truck-trailers weighed at all the control station in the country is summarized in the following table4.4 Daily traffic volume (H/T+TT) at all weighing station is taken from respective AADT collected at each station from ERA website for the year 2011

Table 4.4: Comparison b/n daily traffic volume vs daily weighed vehicle

Control Station	SULULTA								
Type	Heavy Trucks		Truck-trailers				Total	2011 AADT H/T+TT	% Weighed
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle			
No. of Vehicles	529	3053	111	160	3971		7824		
Average Per Day	1.4	8.4	0.3	0.4	10.9		21	590	3.56
Control Station	MODJO								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	267	27192	1094	1387	16591				
Average Per Day	0.7	74.5	3.0	3.8	45.5		127	7046	1.80
Control Station	DENGEGO								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	141	1233	238	270	7318				
Average Per Day	0.4	3.4	0.7	0.7	20.0		25	356	7.02
Control Station	KOMBOLCHA								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles		Total	AADT H/T+TT	% Weighed
No. of Vehicles	167	208	178	195	3676				
Average Per Day	0.5	0.6	0.5	0.5	10.1		12	311	3.86
Control Station	AWASH								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	434	535	785	2339	24079	2			
Average Per Day	1.2	1.5	2.2	6.4	66.0	0.0	77	1697	4.5%
Control Station	JIMA								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	202	788	81	154	1539				
Average Per Day	0.6	2.2	0.2	0.4	4.2		8	588	1.36
Control Station	SHSHAMENE								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	153	1295	349	305	3944				
Average Per Day	0.4	3.5	1.0	0.8	10.8		17	904	1.9
Control Station	HOLETA								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	4885	4094	2907	2116	6756				
Average Per Day	13.4	11.2	8.0	5.8	18.5		57	582	9.8
Control Station	ALEMGENA								
No. of Axles	2-axles	3-axles	4-axles	5-axles	6-axles	7-axle	Total	AADT H/T+TT	% Weighed
No. of Vehicles	741	1827	396	276	2209				
Average Per Day	2.0	5.0	1.1	0.8	6.1		15	352	4.3

FIG 4.2 : % Overloaded at each weighing station.



The highest number of weighed trucks and truck trailers is at Modjo station (with total one year of 46,531 and average daily of 127) followed by that of Awash (with total one year of 28,174 and average daily of 77). The least is at Jima station with total yearly of 2,764 and average daily of only 8. Furthermore 2006-2011 axle load data at Awash, direct relevant to the study road, is also taken as additional for a better reliability. The additional data at Awash weigh station from July 2006 to June 2011 amounts to a total of 132,366 vehicles with daily average of 72.5 during the 5 years axle load measurements.

On the other hand when the average daily weighed truck and truck trailers are compared with the average daily for the same vehicle types passing along the weight and size control stations they are significantly low (1-8-9.8%). When this is taken for the study road it is only 4.5% of the total daily truck and truck-trailers en route during 2011.

This will certainly put the representativeness of the axle load data into question while applying for pavement design purpose. Above all it also strongly indicates the extent of that axle load control and the freedom to truck owners to overloading.

For 5% weighing condition truck owners have the same percentage chance to penalty fines due to overloading (i.e. they are allowed to abuse the regulation for 95% of their trips).

In this connection could there be a tendency to weigh those vehicles suspected to carry beyond the legal limits or is it random? The worst possibility could also be to deal with the staff of the control station which will underestimates the truck factor during computation of cumulative standard axles.

4.4 Determination of Vehicle Equivalency or Track Factors

Despite the question of representativeness of the weight data the total Cumulative Equivalent Standard Axles (CESA) are normally estimated by applying the truck factor which is the sum of the damage from each axle of a vehicle or truck obtained by the Liddle's equation $(AL/SL)^{4.5}$, where AL is the axle load while SL is a standard axle load of 8.16-ton.

Table below is the summary of the axle load data analyzed from the 9 weight and control stations

Table 4.5: Summary of the axle load data

SULULTA Axle	Vehicle Type Front Axle	Heavy Trucks		Truck-Trailers			
		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	7-Axle
Truck Factor (TF)		3	5.4	7.3	9	10.5	
Weighted Mean TF		4.9		10.4			
% From Total Weighed		6.8%	39.0%	1.4%	2.0%	50.8%	
% Over Legal Limit	0.7%	6.7%	6.7%	3.2%	1.9%	1.1%	
MODJO							
Truck Factor (TF)		2.8	5.1	6.8	8.4	9.9	
Weighted Mean TF		5.1		9.6			
% From Total Weighed		0.6%	58.4%	2.4%	3.0%	35.7%	
% Over Legal Limit	0.2%	6.1%	5.2%	4.5%	3.2%	2.3%	
DENGEGO							
Truck Factor (TF)		2.5	4.4	6.1	7.5	8.9	
Weighted Mean TF		4.2		8.8			
% From Total Weighed		1.5%	13.4%	2.6%	2.9%	79.5%	
% Over Legal Limit	10%	4.8%	4.7%	6.8%	0.9%	0.3%	
KOMBOLCHA							
Truck Factor (TF)		3.5	6.1	7.9	9.7	11.4	
Weighted Mean TF		4.9		11.2			
% From Total Weighed		3.8%	4.7%	4.0%	4.4%	83.1%	
% Over Legal Limit	2.6%	33.0%	33.0%	3.8%	3.4%	2.4%	
AWASH, 2011-2012							
Truck Factor (TF)		3.1	5.3	7.5	9.4	11.3	
Weighted Mean TF		4.3		11.1			
% From Total Weighed		1.5%	1.9%	2.8%	8.3%	85.5%	
% Over Legal Limit		13.9%	10.7%	11.7%	10.4%	8.8%	
AWASH, 2006-2012							
Truck Factor (TF)		4.08	7.06	9.49	11.8	13.99	29.49
Weighted Mean TF		4.35		12.95			
% From Total Weighed		1.7%	0.2%	11.8%	22.8%	63.5%	1.511E-05
% Over Legal Limit	1.4%	55.3%	48.1%	25.1%	24.9%	18.8%	0.5
JIMA							
Truck Factor (TF)		3.4	6.2	8.0	9.4	10.7	
Weighted Mean TF		5.6		10.4			
% From Total Weighed		7.3%	28.5%	2.9%	5.6%	55.7%	
% Over Legal Limit	3.4%	30.1%	28.0%	11.8%	5.2%	3.8%	
SHASHEMENE							
Truck Factor (TF)		2.6	4.6	6.0	6.9	7.9	
Weighted Mean TF		4.4		7.6			
% From Total Weighed		2.5%	21.4%	5.8%	5.0%	65.2%	
% Over Legal Limit	0.4%	10.6%	8.4%	2.7%	1.2%	0.4%	
HOLETA							
Truck Factor (TF)		3.0	5.2	6.9	8.2	9.6	
Weighted Mean TF		4.0		8.7			
% From Total Weighed		23.5%	19.7%	14.0%	10.2%	32.5%	
% Over Legal Limit	1.2%	8.1%	4.0%	2.5%	2.1%	3.4%	
ALEMGENA							
Truck Factor (TF)		2.5	4.5	6.0	7.5	8.8	
Weighted Mean TF		3.9		8.3			
% From Total Weighed		13.6%	33.5%	7.3%	5.1%	40.5%	
% Over Legal Limit	0.9%	3.9%	4.0%	0.9%	0.7%	0.5%	

From the above table it can be seen that the 2 and 3 axle groups are those that are often overloaded from all of the control stations. On the other hands the 5 and 6 axle groups are those with least frequencies of overloading.

5 EVALUATION AND ROLE OF AXLELOAD REGULATION

5.1 General

In line with the objectives of this study paper computations of cumulative ESA's under different legal limit regulations and enforcement standards is exercised in this sections. Axle load limits sets by a number of different countries have been reviewed during literature reviews.

Table5.1 Axle load regulation on sample countries

Country	Single kg	Tandem kg	Tridem kg	Max. GCM kg	Max. Length m
Africa					
South Africa	9 000	18 000	24 000	56 000	22
Lesotho	8 200	16 400	21 000	49 000	20
Botswana	8 200	16 400	24 600	50 200	22
Swaziland	8 200	16 400	21 000	49 000	20
Malawi	9 000	18 000	24 600	55 000	18.3
Zimbabwe	7 700	16 400	24 600	48 700	22
Mocambique	10 000	16 000	22 000	38 000	18
North America					
USA	9 000 ¹	18 000 ¹	20 000 ¹	36 000 ¹	25.9 ¹
Canada	9 100 ¹	17 100 ¹	24 000 ¹	53 500 ¹	25.0 ¹
Europe					
Germany	10 000	11 500	21 000	40 000	18
Switzerland	10 000	18 000	-	28 000	18
UK	10 500	20 300	22 500	38 000	18
Australia					
Australia	9 000	16 500	20 000	44 000	17.5

Note: 1. Varies from state to state/province to province
The Damaging Effect of Heavy Overloaded Vehicles on Roads ⁽⁶⁾

The following points can be drawn from the above table.

- Single axle (be it front or rear) varies from 7.7 (Zimbabwe) to 10.5-ton (UK). It is 8-ton for most African states.

- The limits in Tandem axles vary from 11.5-ton (Germany) to 20.3-ton in UK. It ranges from 16.4 to 18-ton in most African countries and the USA, Canada, Switzerland and Australia.
- Tridem axles are restricted from 20-ton (Australia) limited to 24-ton (most countries)
- The limit in Gross Vehicle Weight (GVW) vary from 28-ton (Switzerland) to 56-ton (South Africa)
- The Limit in maximum length of any vehicle unit is limited from 17.5m (Australia) to 25.9 (USA). It varies from 18 to 22m in the African states in the table.

Emphasis is GVW in most of the countries. It is mainly to limit the use of those vehicles with several axles whose total damaging factor is considerably high. Furthermore long vehicles in particular have significant effect on stability and life of bridges.

On the other hand neither the axle load nor the traffic count data of the ERA would allow computing ESA's for vehicles with different axle configurations. The axle data is captured for each individual axles and it doesn't indicate whether the rear axles are tandem or tridem. Similarly the ERA traffic count form groups vehicles into eight vehicle classes (Table4.1).

5.2 Impact of Overloading on Pavement Life

5.2.1 ESA computation based on axle load data(Awash weighing station 2006-2012)

To assess the impact of the axle limit regulations on life of a pavement 4 different scenarios are considered. Accordingly truck factors derived from Awash weigh bridge data (2006 to 2012) has been adapted to evaluate the reduction or the gain in useful life of the road segment under the study work. Furthermore to compare the condition of the road since it is rehabilitated and opened to traffic in 2003 the cumulative ESAs are also computed for all scenarios. The scenarios are:-

1. Cumulative ESA based on the equivalency or truck factor derived from the axle load data and evaluation of the pavement life
2. Cumulative ESA if axle loading is limited to 8-ton front and 10-ton rear axles. This is to compute what the ESA would be if ERA strictly applies the existing axle reinforcement low (i.e. if trucks and truck trailers are not allowed to carry beyond these legal limits).

3. As above but if the enforcement is based on 8-ton front and 9-ton rear axles. This is intended to simulate the axle load limit that may take the limitations of Tandem axle and Tridem axles (each to 9-ton) which in fact is on the high side for many of the sample countries.
4. Finally taking the increase in the "population" of truck and truck trailers in freight transport from year to year over most trunk road of the country the 8-ton limiting condition is considered to simulate the regulation of most of the countries. This may not apply for single axles which are often front axle that are not normally overloaded and single rear axles that are only common to 2 and 4 rear axle trucks . And yet these are not more than 15-20% (Table 4.4) out of the total truck and truck trailers plying on the Adama to Awash road segment which is part of the main import export highway.

Truck factor computation for all four scenarios is attached as appendix 5.

Table below is the summary of the truck factors for the 4 scenario.

Table 5.2: Truck Factors (vehicle Equivalency Factor), Weighted average

Case	Description	2 and 3-axles, Heavy Trucks	> 3-axles, Truck Trailers
1	Current Overloading	4.35	12.95
2	At ERA LL	2.42	8.04
3	Front axle 8-ton, Rear axle 9-ton	1.71	5.49
4	All axles at 8-ton	1.18	3.45

Based on the truck factors the ESAs are computed for each cases starting from the year 2003 up to 2022. The cumulative ESA in million are also progressively added for service life of year 1 to year 20 corresponding to 2003 and 2022 respectively, table below.

Table 5.3: Twenty Years Cumulative ESA as of Year 2003

		ESA, One directional , Million			
		Case-1	Case-2	Case-3	Case-4
year	Service life	Actual loading condition.	ERA, Legal Limit, Front = 8-ton, and all rear = 10-ton	Front 8 and rear 9-ton	Legal Limit all axles = 8-ton
2003	1	4.3	2.7	1.9	1.3
2004	2	5.9	3.7	2.6	1.7
2005	3	8.4	5.3	3.7	2.5
2006	4	10.6	6.7	4.7	3.1
2007	5	13.2	8.4	5.9	3.9
2008	6	16.0	10.1	7.1	4.7
2009	7	20.2	12.7	9.0	6.0
2010	8	23.6	14.9	10.5	7.0
2011	9	27.1	17.1	12.0	8.0
2012	10	31.0	19.6	13.8	9.2
2013	11	35.4	22.3	15.7	10.5
2014	12	40.3	25.4	17.9	11.9
2015	13	45.8	28.8	20.3	13.5
2016	14	51.8	32.6	23.0	15.3
2017	15	58.6	36.9	25.9	17.3
2018	16	66.1	41.6	29.3	19.5
2019	17	74.4	46.8	33.0	21.9
2020	18	83.7	52.7	37.1	24.6
2021	19	94.0	59.2	41.6	27.7
2022	20	105.6	66.4	46.7	31.1

The following points can be observed from the above table:

1. The Cumulative ESA for any year if the ERA enforcement action was strictly applied would have been only 63% of the ESA calculated from the Axle Load data. This implies damage on the pavement accounts for 37% due to 11.2% overloaded vehicles than the legal limits.
2. Similarly the ESA would have been only 44% and 30% if the regulation limits the rear axles to 9 and 8-tons respectively. In these cases the damage on the pavement accounts for 56% and 70% due to 11.2% overloaded vehicles for 8-ton front and 9-ton rear axle limits for the former and all 8-ton axle limit for the later cases.

Finally the service life for each of the legal limit enforcement condition are compared with that of the prevailing current or existing overloading as obtained from the 6 years axle load data at Awash Control Station. These are as indicated in Figure 5.1 to 5.4.

Fig. 5.1: Case-1 vs. Case 2

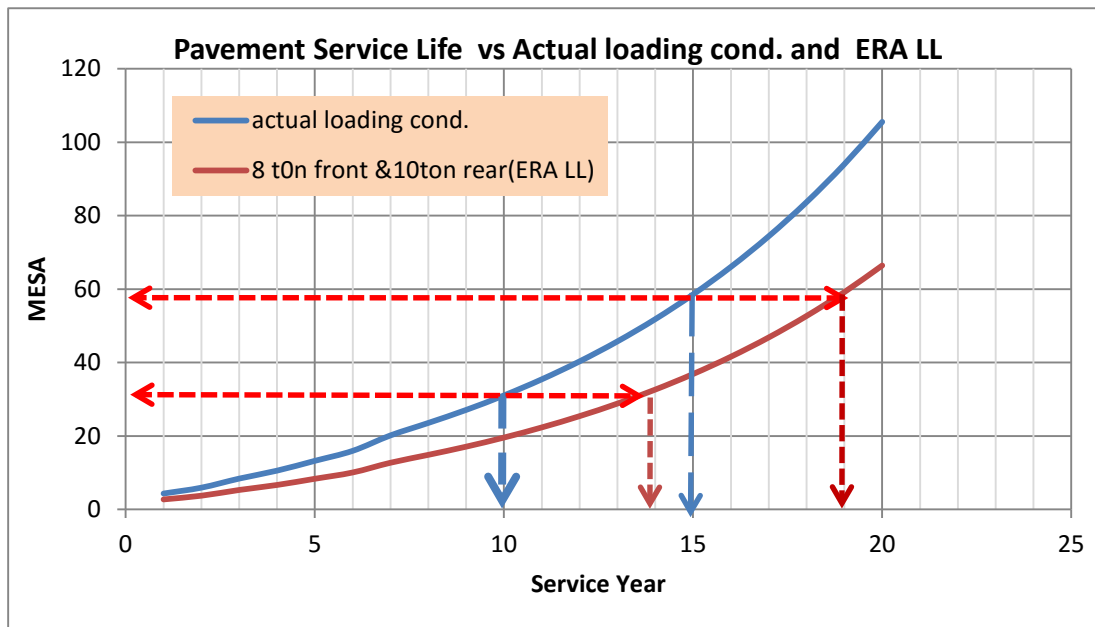


Fig. 5.2: Case 1 vs. Case 3

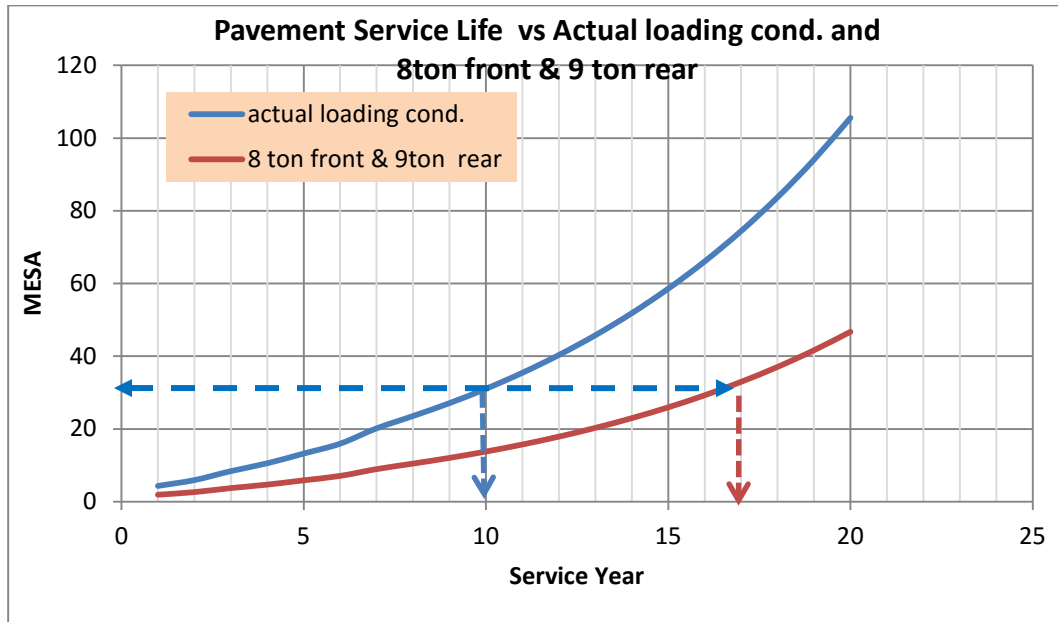


Fig. 5.3: Case 1 vs. Case 4

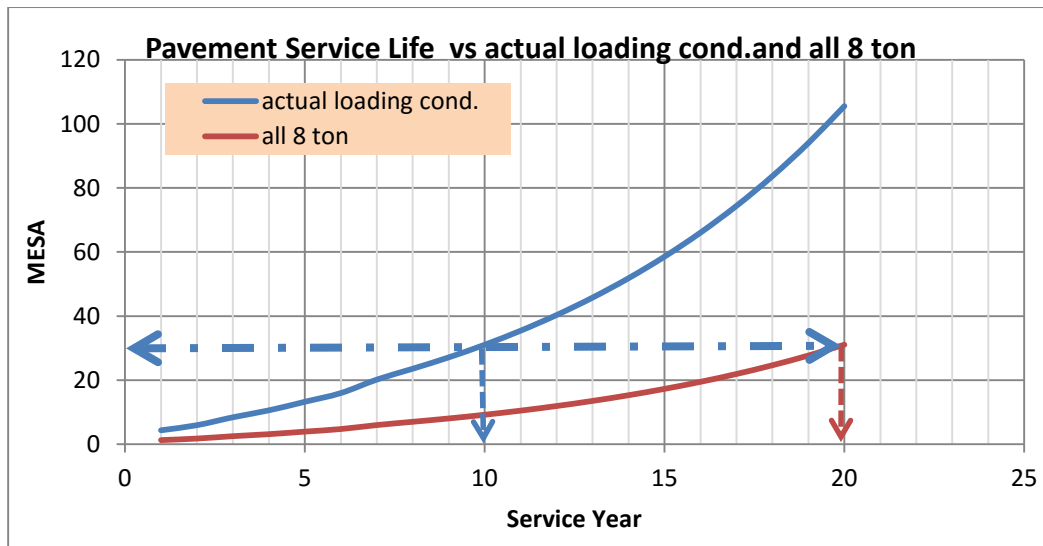


Figure 5.1 clearly indicates that service life of the study road would have been extended from 10 to 14 years if the ERA legal limit would have been strictly adhered. Similarly the service life would increase by 4 years from that of 15 years under the existing condition to that of 19 years

if the regulation was exercised stringently. In other words the pavement life is reduced from that of 14 to 10 years and from 19 to that of 15 years by allowing only 11.2% (Table 4.5) to travel over the road with loads above the legal limits.

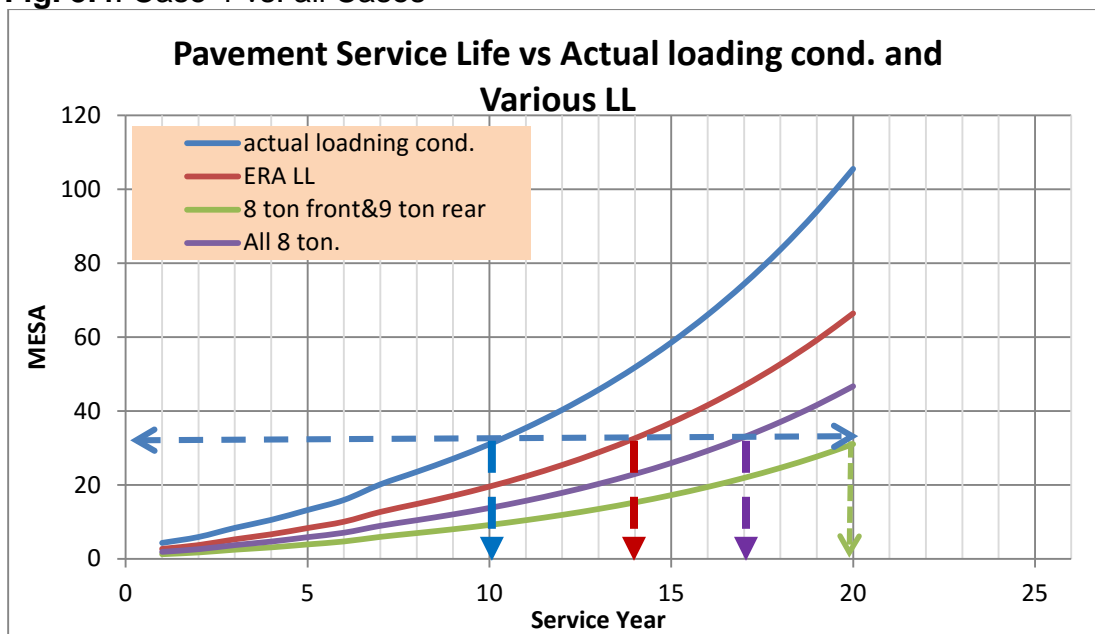
On the other hand Figure 5.2 and 5.3 indicates a further gain of service life if the 8-ton front and 9-ton rear and all 8-ton single axles' limitations were adapted. This corresponds to a gain in pavement life of 7 years for Case-3 against Case-1 (at both 10 and 15 years). Furthermore the pavement life could be extended from 10 to 20 years and from 15 to over 26 years if the axle load is limited to 8-tons for all single axles.

Table and figure below summarizes the condition by putting all the case scenarios together.

Table 5.4: Comparison of service life under different scenarios

MESA at Actual Overloading	Service Life (Period), Years			
	Actual loading condition.	At ERA LL	Front axle 8-ton, Rear 9-ton	All axles at 8-ton
31	10.0	14.0	17.0	20.0
59	15.0	19.0	22.0	26.0

Fig. 5.4: Case-1 vs. all Cases



To compare the effect of truck factor computation from different sources, axle load survey undertaken by CORE CONSULTING ENGINEERS at methera town is collected. The axle load survey has been done from April5/2011-April8/2011 for four days (two days from methara to Addis Ababa side and two days from Addis Ababa to methara side). The survey data contains both empty and loaded vehicles from both directions. The truck factor computation has been carried out for tow options, i.e. considering the whole axle load data both from two directions and the other by considering the vehicle from methara side (mostly loaded). This approach is preferred to show the exact damaging effect of vehicles from each direction. As a result the truck factor computed for truck trailers is found 12.88. This shows that both TF taken from awash weighing station and from that of individual survey are almost similar. Summary of survey data with truck factor computation is attached as annex.

5.3 Impact of Overloading vs. Economic Significance

Despite pavement damage, environmental and safety hazards as a consequence of overloading, overloading also has an advantage in bulk transport by reducing the vehicle kilometer that would be required to transport the same amount of tonnage under legal limit condition. In another words It lowers the number of trips on roads.

In this connection it is also worth to compare the gain in transport of extra loads against the damage on pavement service and life. To have a closer feel of this an attempt was made to collect data regarding the un-laden weight of vehicles particularly truck and truck trailers was made. However due to modification of vehicles body after importation it was difficult to obtain realistic data. Nevertheless up on closer observation made on the axle load data and related information the un-laden (tare weight) and Gross Vehicle Wight (GVW) for those frequent axle configurations has been estimated as shown in the following table.

Table 5.5: Assumed Tare weight and Gross Vehicle Wight (GVW)

Empty VW (ton)	7	10.5	14	17.5	21
Type	2-Axle	3-Axle	4-Axle	5-Axle	6-Axle
Loaded to ERA LL (ton)	11	17.5	24	30.5	37
GVW	18	28	38	48	58

On the base of this the following comparisons have been made.

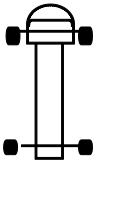
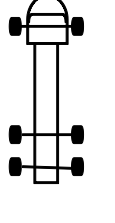
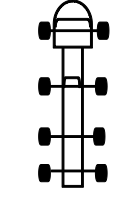
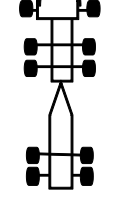
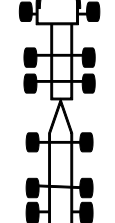
- Legal limits of Case -3 (8-ton front and 9-tone rear) is compared with that of Case -2, ERA and the subsequent percent reduction in load and percent reduction in pavement damage or life
- Legal Limits of Case -4 (8-ton for all single axles) is compared with that of Case -2, ERA and the subsequent percent reduction in load and percent reduction in pavement damage or life
- Allow 1-ton over each of the rear axles above the ERA Legal Limit
- Allow 2-ton over each of the rear axles above the ERA Legal Limit

The outcome of these conditions resulted in an interesting scenarios is summarized below.

1. Adapting the 8-ton front and 9-ton rear axles will reduce vehicles load by 9% for that of 2-axle trucks to that of 14% for 6-axle ones. This implies an increase in trips by the same percentage point. On the other hand this corresponding reduction in pavement damage by 27 to 35%.
2. Adapting an all 8-ton legal limit will reduce truck loads or increase in trips from 18% to 27% with corresponding reduction in pavement damage 46 to 59%.
3. The reverse situation of allowing overloading than the current ERA Legal Limit by one ton on each of the rear axles will result in gain or reduction in trip of 9 to 14% for that of 2-axle trucks to that of 6-axles truck and truck trailers.
4. When allowing overloading to 2 tons increment per rear axles, the reduction in trip will increase to that of 18 to 27% while the pavement damage increases drastically to 93% to 120% for that of 2-axle truck to that of 6-axle ones.

This is all about the exponential effects of overloading on pavement damage.

Table 5.6: Comparison of reduction, in Loading and Road Damage, Case 3 and 4 with Cases 2

Type	2-Axle	3-Axle	4-Axle	5-Axle	6-Axle
Loaded to ERA LL (ton)	11	17.5	24	30.5	37
Loaded to 8-ton front and 9-ton rear LL (ton)	10	15.5	21	26.5	32
% in Load Reducton from ERA, LL (ton)	9%	11%	13%	13%	14%
% reduction in Pavement damage than ERA LL	27%	32%	34%	35%	35%
Loaded to 8-ton front and rear LL (ton)	9	13.5	18	22.5	27
% in Load Reducton from ERA, LL (ton)	18%	23%	25%	26%	27%
% reduction in Pavement damage than ERA LL	46%	53%	56%	58%	59%
Allow overloading than the Existing ERA LL					
Allow over loading by 1 ton per rear axle	12.0	19.5	27.0	34.5	42.0
% gain in extra Load or Reduction in Trip	9%	11%	13%	13%	14%
% Increase in pavement Damage Than ERA LL	39%	45%	48%	49%	50%
Allow over loading by 2 ton per rear axle (TF)	13.0	21.5	30.0	38.5	47.0
% gain in extra Load or Reduction in Trip	18%	23%	25%	26%	27%
% Increase in pavement Damage Than ERA LL	93%	108%	114%	118%	120%
					

5.4 Fine collection trend

According to the information collected at awash weigh station for the extra load found on the vehicle, the driver will be given the penalty charge for the extra load to report to the nearby court office. Even though the weighing activity is performed by Ethiopian roads authority personnel, the fines will be collected by justice office near by the weighing station area.

The amount of fines is not fixed and varies from region to region. Moreover the penalty imposed for overloaded vehicles is not consistent as shown below.

Table 5.7Extra load vs Penalty imposed at Awash weigh station (30/05/13)

Extra load(qtl)	Extra load(tonne)	Penalty (birr)	Extra load(qtl)	Extra load(tonne)	Penalty (birr)
101	10.1	400	98	9.8	490
113	11.3	500	124	12.4	500
119	11.9	1000	113	11.3	500
100	10	500	151	15.1	600
123	12.3	500	125	12.5	500
95	9.5	1425	113	11.3	500
75	7.5	1000	73	7.3	1100
80	8	1100	88	8.8	400
120	12	600	78	7.8	300
170	17	700	82	8.2	400
160	16	700	98	9.8	490

The graph below shows how inconsistent the penalty imposed for different extra loading.

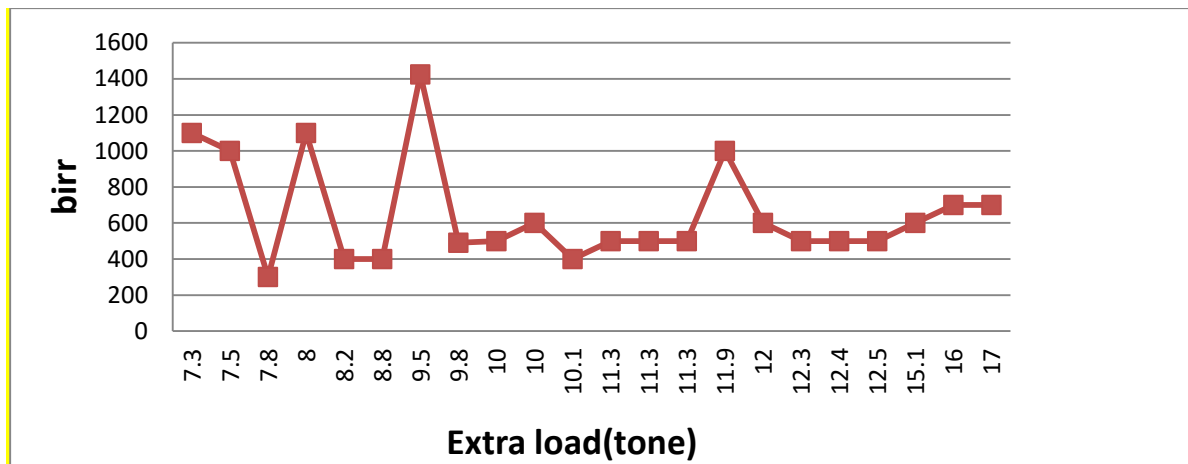


Fig. 5.5: Penalty imposed for different extra load.

It is also tried to compare the practice of penalty on overloaded vehicles. Accordingly the penalty regulation of Kenya is taken for comparison as shown in the next table.

Table 5.8 Fine Comparison (USD)

OVERLOAD (KG)	KENYA (regulation)	ETHIOPIA (actual)	ETHIOPIA(O,SULIVAN)	% ETH. ACTUAL VS KENYA	% ETH(O,SULIVAN) VS KENYA
7300	1190	59.17	656.27	4.97	55.15
7800	1190	16.14	656.27	1.36	55.15
10000	2380	26.9	656.27	1.13	27.57
13000	2380	96.84	656.27	4.07	27.57
17000	2380	37.65	656.27	1.58	27.57

According to Kenya's regulation **1190USD** is imposed for extra loading of **7300kg**. Where as in Ethiopia for the same **7300kg** extra loading an amount of **59.17USD** is imposed which is 4.97% that of Kenya, also surprisingly for extra load of **7800kg** (which is higher than that of 7300kg) **16.14USD** is imposed. As shown in the above table the current penalty trend at awash weigh station is insignificant (below five percent) and it is difficult to say that there is penalty regulation in Ethiopia.

6. Summary of finding and Way forward

6.1 Findings

From the data analysis various causes are cited for the seriousness of overloading problems along the study road.

1. As summarized in the table below the extent of overloading beyond the legal limit under practice (8-ton front and 10-ton rear axles) by ranges of axles weights are analyzed to identify the status of overloading over the road network passing through the nine permanent weigh stations.

Table 6.1: Overloading by range of rear axle weights, existing permanent weigh stations

Range	SUULTA	MODJO	DENGEGO	KOMBOLCHA	AWASH	JIMA	SHASHEMENE	HOLETA	ALEMGENA
10.1-11 ton	0.55%	1.67%	2.38%	13.14%	2.95%	9.63%	3.09%	0.69%	0.20%
11.1-12 ton	0.50%	0.59%	0.25%	0.44%	2.17%	4.15%	0.67%	0.96%	0.31%
12.1-13 ton	0.55%	0.65%	0.65%	0.57%	1.92%	2.00%	0.76%	1.21%	0.61%
13.1-14 ton	1.64%	0.72%	0.30%	1.25%	1.78%	1.63%	0.47%	0.77%	0.60%
14.1-15 ton	1.04%	0.87%	0.03%	0.37%	1.24%	0.52%	0.17%	0.51%	0.45%
15.1-16 ton	0.29%	0.20%	0.02%	0.09%	0.69%	0.27%	0.11%	0.23%	0.16%
16.1-17 ton	0.04%	0.09%	0.00%	0.05%	0.28%	0.13%	0.07%	0.23%	0.17%
>17 ton	0.03%	0.04%	0.00%	0.03%	0.14%	0.10%	0.02%	0.15%	0.07%
All axles	4.6%	4.8%	3.6%	15.9%	11.2%	18.4%	5.4%	4.7%	2.6%

When other countries practice is taken in to account, overloading up to 5% overloading is tolerable and it can be said that the axle load control system in Ethiopia is generally efficient. The data collected and organized by O’Sullivan & Graham ltd in 1998 indicates between 27% and 36% of axles from heavy and articulated trucks are overloaded to maximum loads of 27.5 tones or nearly three times the legal limit. Whereas from the above table the analysis shows that except, weighing stations at Kombolcha, Awash and Jima, all the remaining weighing stations are performing well based on one year axle load data of 2011-2012. Nevertheless there could be several possible reasons for the outcome.

- Tendency to weigh those that are below legal limits
- Capacity limitation to weigh majority of the trucks (the one year axle load data (June 2011-June 2012) indicates that only 2-10% of the trucks and truck trailers plying en routes intercepted by the weigh stations are weighed.
- Exemption of Truck and Truck Trailers carrying fuels from being weighed which could have significant damaging effect.
- Lack of Accuracy of Weigh bridges due to long service life
- Strict reinforcement and overload control
- What Else!!

Beside this the weigh station at Modjo is one of the busiest stations weighing both vehicles from Adama and Shashemene directions. And yet there are quite considerable numbers of mainly 3-axle trucks transporting sand for construction mainly to Addis Ababa that are often overloaded. In this regard the 5% overloading computed from this station may arise a logical suspicion.

2. The existing weighing equipment established at Awash is equipped with a scale that can measure only one axle at a time, as a result checking of vehicles at weighbridge stations takes longer time. Moreover the weighbridge is not equipped with automatic register that can capture and store the data when vehicles are weighed at the station. Hence, occurrence of error in recording and manipulation is possible.
3. The spacing between the existing weight control stations may allow some of the overloaded vehicles serving in between stations left unchecked. This would further increase the un-representativeness of axle load data for pavement design purpose and to study the damage caused from overloading.
4. As observed on the Awash weight station, all vehicles towards mile and Dire Dawa directions are also weighed at this station. Each vehicle requires 1-2 minutes for being weighed. Over a period of 24 hours the station is estimated to weigh up to 720 vehicles per day. Nevertheless according to one year data (july2011-june2012)collected for the purpose of this study, weighed vehicles indicates only 4.5%. This shows for 4.5% weighing condition truck owners have the same percentage chance to penalty fines due

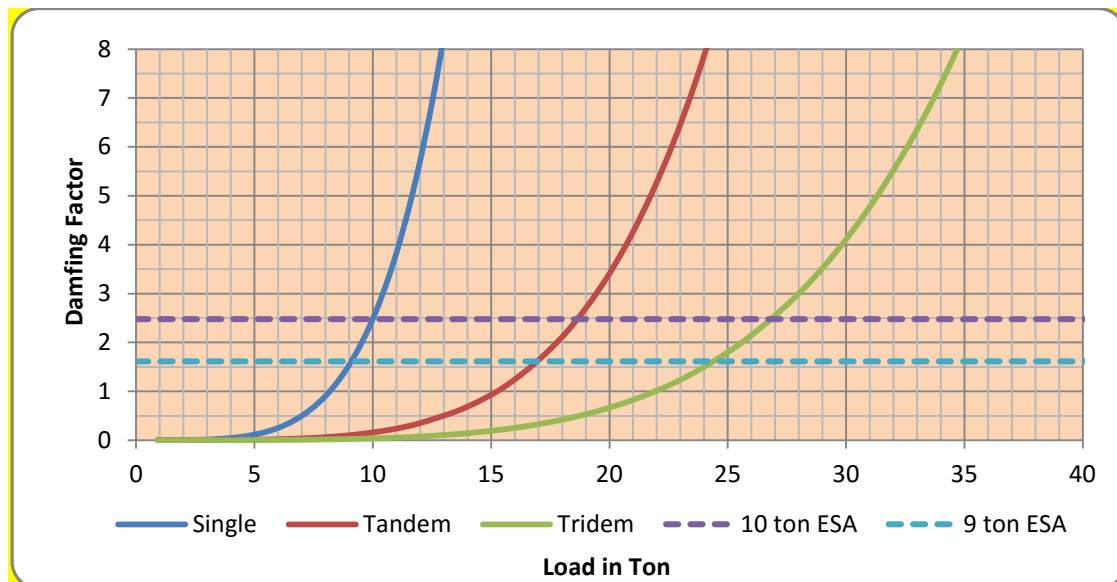
to overloading and 95.5% of truck owners have a chance to abuse the regulation for their trips.

5. The 10 ton rear legal axle load limit permitted by the Ethiopian regulation when compared with a standard axle load of 8.16 ton its equivalent damage per rear axle is 2.5 times. However even, if this was strictly enforced the Cumulative ESA for any year would have been only 63% of the ESA calculated from the Axle Load data of the study area. This implies damage on the pavement accounts for 37% due to only 11.2% overloaded vehicles than the legal limits. This indicates that service life of the study road would have been extended from 10 to 14 years if the ERA legal limit would have been strictly adhered
6. If the regulation limits the rear axles to 9 ton, the ESA would have been only 44% of the one computed since the opening of the road to traffic in 2003. In these cases the damage on the pavement accounts for 56% due to 11.2% overloaded vehicles for 8-ton front and 9-ton rear axle limits. This corresponds to a gain in pavement life of 7 years for the regulation that limits the rear axles to 9 tons for both a design period of 10 and 15 years.
7. If the regulation limits the rear axles to 8-tons the ESA would have been only 30% of the one computed since the opening of the road to traffic in 2003. In these cases the damage on the pavement accounts for 70% due to 11.2% overloaded vehicles for 8-ton front and 8-ton rear axle limits. This corresponds to a gain in pavement life of 10 and 11 years for a design period of 10 and 15 years.
8. According to the information from the Awash Weight Station all fuel transporting vehicles are excepted from axle weighing. In this regard the damage from these trucks and truck trailers is not accounted in axle load data from Awash station for the truck factor computations. In fact these are limited to carry an amount of fuel to the size of their fuel tanks. And yet most of these tanks are locally produced. If these are standardized in terms of fuel tank capacity, axle weights and GVW, their effect could be incorporated provided that the Traffic Count form of ERA is revised to accommodate these vehicles and their axle configurations.
9. Even if weighed vehicles are very small comparing to the traffic volume, fine collection system is not well organized and strictly adhered. Furthermore there is very little

awareness among stakeholders regarding the degree of damage caused by overloaded axles in particular and GVW in general.

10. Overloading by one ton on each of the rear axles than the 10-ton rear axle limit will result in gain or reduction in trip of 9 to 14% while the pavement damage increases from 39% to 50% for that of 2-axle truck to that of 6-axles truck trailers. When this is increased to 2 tons per rear axles the reduction in trip will increase to that of 18 to 27% while the pavement damage increases drastically to 93% - 120% for that of 2-axle truck to that of 6-axle truck trailers. Since now a day most vehicles are truck trailers with multiple axle configurations, it won't be difficult to visualize the severity of pavement damage.
11. Whatever the case may be if efficiency in transporting (reduction in trip) is required it is always advantageous to go for tandem and tridem axles than to allow overloading for single axles. In this regard the damage from single axle is well compared with that of the tandem and tridem axles through the use of the AASHTO equivalency factors in Section 2.2, Figure2.2. The figure is reproduced as shown below so that the load amount on tandem or tridem axles causing the same magnitude of damage as that of a single axle.

Fig.6.1 Relative damage from single, Tandem and Tridem axles



The following can be noted from the above figure.

- Tandem axles carrying 19 ton have the same amount of damage as that of a single axle carrying 10 ton,
- Tridem axles carrying 26 ton have the same amount of damage as that of a single axle carrying 10 ton
- Tandem axles carrying 17 ton have the same amount of damage as that of a single axle carrying 9 ton,
- Tridem axles carrying 24 ton have the same amount of damage as that of a single axle carrying 9 ton

In terms of the above figure and the derivative points, giving an equal level of freedom the damage from a single axle (the minimum number of axle) can be considered as a base line to establish the permitted loads for the other axle configurations. This leads to preference of tandem and tridem or multiple axles to increase transport efficiency (trip reduction) while minimizing pavement damage.

Therefore the choice for trucks and truck trailers is vital and critical during formulating axle limit regulations. The following table illustrates the advantage from different axle configurations when compared to transporting capacities for the following conditions.

- The un-laden mass of each axle equals to 3.5 ton (35 quintals)
- 10-ton rear and 8 ton front axle legal limit, existing ERA practice (Case 2 of the study)
- 9-ton rear and 8 ton front (some African and some other countries (Case 3 of the study)
- 8-ton all axles (some African and some other countries (Case 4 of the study)
- Gross vehicle Weight (mass) = Legal Limit times number of rear axles + 8-ton front axle, and fully loaded condition
- The damage from axle or group of axles is based on AASHTO table of damaging factor

Table 6.2: Axle configuration and its damaging effect.

Photo No.	Axle Configuration	No. of Axle	Capacity, Ton (quintals)	GVM, Ton	Damage Factor (ESA)*	Total ESA per transport 1000 (10,000 quintal)	No of Trips to transport 1000 Ton	Damage, % Highest	
Case 2, 8-ton front and 10-ton rear									
1	1.22-222	6	37 (370)	58	8.52	230	27	65%	
2	1.22+2.22	6	37 (370)	58	10.30	278	27	79%	
3	1.2-222	5	30.5 (305)	48	7.59	249	33	71%	
4	1.2+2.22	5	30.5 (305)	48	9.37	307	33	87%	
5	1.2+2.2	4	24 (240)	38	8.44	352	42	100%	
6	1.22	3	17 (170)	28	4.41	259	59	74%	
7	1.2	2	11 (110)	18	3.48	316	91	90%	
Case 3, 8-ton front and 9 ton rear									
1	1.22-222	6	32 (320)	53	5.88	184	31	66%	
2	1.22+2.22	6	32 (320)	53	7.03	220	31	79%	
3	1.2-222	5	26.5 (265)	44	5.28	199	38	72%	
4	1.2+2.22	5	26.5 (265)	44	6.43	243	38	87%	
5	1.2+2.2	4	21 (210)	35	5.83	278	48	100%	
6	1.22	3	15 (150)	26	3.21	214	67	77%	
7	1.2	2	10 (100)	17	2.61	261	100	94%	
Case 4, all axles 8-ton									
1	1.22-222	6	27 (270)	48	3.78	140	37	63%	
2	1.22+2.22	6	27 (270)	48	4.76	176	37	79%	
3	1.2-222	5	22.5 (225)	40	3.40	151	44	68%	
4	1.2+2.22	5	22.5 (225)	40	4.38	195	44	88%	
5	1.2+2.2	4	180 (180)	32	4.00	222	56	100%	
6	1.22	3	13 (130)	24	2.38	183	77	82%	
7	1.2	2	9 (90)	16	2.00	222	111	100%	
	Most Preferred				Least Preferred				

Table 6.3 Comparison on 1.22-222 Axle configuration

No.	cases	Capacity Ton	GVM, Ton	Damage Factor (ESA)	ESA/1000 ton	No of Trips to transport 1000 Ton
1	All axles 8-ton	27	48	3.78	140	37
2	8-ton front and 9 ton rear	27	53	5.88	184	31
3	8-ton front and 10-ton rear (ERA)	22.5	58	8.52	230	27

- For relatively lesser pavement damage all 8 ton case is preferable
- For less number of trips ERA legal limit is preferable.
- ❖ Further economic analysis is required to get the optimum

6.2 The Way Forward

1. To set up an economical axle load limits, further research shall consider both the reduction in trip while causing an acceptable or tolerable damage to road pavements.
2. Selection of vehicle type (Axle Configuration) may require further economic analysis so that restriction could be imposed while importing truck trailers or axles could be modified for those that are on the road.
3. A thorough review of the axle load regulation set by different road agencies will have a significant impact before setting sound national regulations.
4. An effective, well organized and modernized weight and size control stations covering the national road network will play a vital role in terms of economic gain, pavement lives, environment and safety. Nevertheless to support these endeavors further researches should be encouraged.
5. The effort made by the ERA to increase the capacity of Engineers engaged in the field of road engineering shall continue to enhance the contribution of the road sector development to the overall growth of the nation. Nevertheless it would be to the advantage of the Authority if problem areas requiring specific solutions are identified so that those who are receiving the opportunities for further education would be engaged and focused to a meaning full research works.

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Truck overloading study in developing countries and strategies to minimize its impact

Ethiopian Roads Authority
Size and Weight Control Station
Axle Load Report

SULULTA

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTION OF VEHECLIES									TOTAL AXLE WEIGHT: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0	0	0		0	
2.1-3	3	0	0	0	0	0	0	0	0	3		0	
3.1-4	4	0	0	1	0	1	0	0	0	4		2	
4.1-5	141	1	0	0	1	2	2			142		5	
5.1-6	640	1	0	0	5	8	11			641		24	
6.1-7	2678	0	22	28	26	80	101			2678		257	
7.1-8	4305	1	292	245	260	324	539			4306		1660	
8.1-9	48	0	669	742	780	953	1202				48	4346	
9.1-10	4	0	6316	5789	3033	2686	2071				4	19895	
10.1-11	0	0	28	22	54	27	20				0		151
11.1-12	1	0	31	19	48	26	14				1		138
12.1-13	0		55	60	18	14	5				0		152
13.1-14	0	0	221	211	11	6	1				0		450
14.1-15	0	0	140	135	4	2	4				0		285
15.1-16	0	0	39	39	1	1	0						80
16.1-17	0	0	5	3	1	0	1						10
17.1-18	0	0	5	1	0	1	0						7
18.1-19	0	0	0	0	0	0	0						0
19.1-20	0	0	1	0	0	0	0						1
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	7824	3	7824	7295	4242	4131	3971	0	0	7774	53	26189	1274
	axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5						
	Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles						
	7824		529	3053	111	160	3971						

Modjo

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES									TOTAL AXLE WEIGHT: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	2	0	0	0	0	0	0		2	
2.1-3	0	0	0	11	1	1	2	0	0	0		15	
3.1-4	7	5	0	12	4	3	1	0	0	12		20	
4.1-5	87	3	2	8	8	7	6	0	0	90		31	
5.1-6	5062	3	7	12	33	24	20	0	0	5065		96	
6.1-7	25562	0	11	48	171	235	143	0	0	25562		608	
7.1-8	15697	0	131	240	1670	2753	2671	0	0	15697		7465	
8.1-9	104	1	1406	2034	6162	6813	7047	0	0		105	23462	
9.1-10	8	0	42123	41486	10172	7575	6326	0	0		8	107682	
10.1-11	4	0	841	647	472	239	245	0	0		4		2444
11.1-12	0	0	298	238	179	93	62	0	0		0		870
12.1-13	0	0	365	361	97	96	26	0	0		0		945
13.1-14	0	0	471	427	48	84	18	0	0		0		1048
14.1-15	0	0	609	578	36	34	13	0	0				1270
15.1-16	0	0	140	121	11	15	8	0	0				295
16.1-17	0	0	89	30	4	5	2	0	0				130
17.1-18	0	0	26	8	1	1	1	0	0				37
18.1-19	0	0	7	1	2	0	0	0	0				10
19.1-20	0	0	2	0	1	0	0	0	0				3
20.1-21	0	0	3	0	0	0	0	0	0				3
21.1-22	0	0	0	0	0	0	0	0	0				0
TOTAL	46531	12	46531	46264	19072	17978	16591	0	0	46426	117	139381	7055
	axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5						
	Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles						
	46531		267	27192	1094	1387	16591						

DENGEGO

PERIOD: 2011-12

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES									TOTAL AXLE WEIGHT: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0	0	0	0	0	0
2.1-3	0	0	0	0	0	0	0	0	0	0	0	0	0
3.1-4	0	0	0	4	1	1	1	0	0	0	0	7	0
4.1-5	221	0	1	12	9	19	39	0	0	221	0	80	0
5.1-6	787	0	15	27	51	99	142	0	0	787	0	334	0
6.1-7	2475	1	118	160	251	529	368	0	0	2476	0	1426	0
7.1-8	4795	2	806	914	822	1875	1300	0	0	4797	0	5717	0
8.1-9	921	0	1146	1281	1153	1960	1588	0	0	0	921	7128	0
9.1-10	1	0	6673	6233	5006	3037	3858	0	0	0	1	24807	0
10.1-11	0	0	207	214	502	33	19	0	0	0	0	0	975
11.1-12	0	0	34	33	25	10	2	0	0	0	0	0	104
12.1-13	0	0	133	119	3	12	1	0	0	0	0	0	268
13.1-14	0	0	55	57	2	10	0	0	0	0	0	0	124
14.1-15	0	0	6	4	1	3	0	0	0	0	0	0	14
15.1-16	0	0	6	1	0	0	0	0	0	0	0	0	7
16.1-17	0	0	0	0	0	0	0	0	0	0	0	0	0
17.1-18	0	0	0	0	0	0	0	0	0	0	0	0	0
18.1-19	0	0	0	0	0	0	0	0	0	0	0	0	0
19.1-20	0	0	0	0	0	0	0	0	0	0	0	0	0
20.1-21	0	0	0	0	0	0	0	0	0	0	0	0	0
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	9200	3	9200	9059	7826	7588	7318		0	8281	922	39499	1492

axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5
Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles
9200		141	1233	238	270	7318

KOMBOLCHA

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES										TOTAL AXLE WEIGHT: NO OF VEHICLES			
											FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL	
1.0-2	0	0	0	0	0	0	0	0	0	0	0	0	0	
2.1-3	0	0	0	0	0	0	0	0	0	0	0	0	0	
3.1-4	0	0	0	1	0	0	0	0	0	0	0	1	0	
4.1-5	0	0	0	1	0	0	0	0	0	0	0	1	0	
5.1-6	141	0	0	3	0	0	0	0	0	0	141	3	0	
6.1-7	498	0	0	1	0	0	0	0	0	0	498	1	0	
7.1-8	3672	0	0	8	7	7	16	0	0	0	3672	38	0	
8.1-9	113	0	102	87	1247	1285	1263	0	0	0	113	3984	0	
9.1-10	0	0	2864	2753	2641	2448	2310	0	0	0	0	13016	0	
10.1-11	0	0	1155	1197	122	109	81	0	0	0	0	2664	0	
11.1-12	0	0	47	12	17	11	3	0	0	0	0	90	0	
12.1-13	0	0	55	47	8	4	1	0	0	0	0	115	0	
13.1-14	0	0	128	113	5	6	1	0	0	0	0	253	0	
14.1-15	0	0	45	29	1	1	0	0	0	0	0	76	0	
15.1-16	0	0	13	3	1	0	1	0	0	0	0	18	0	
16.1-17	0	0	8	2	0	0	0	0	0	0	0	10	0	
17.1-18	0	0	4	0	0	0	0	0	0	0	0	4	0	
18.1-19	0	0	2	0	0	0	0	0	0	0	0	2	0	
19.1-20	0	0	0	0	0	0	0	0	0	0	0	0	0	
20.1-21	0	0	1	0	0	0	0	0	0	0	0	1	0	
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL	4424	0	4424	4257	4049	3871	3676	0	0	4311	113	17044	3233	

axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5
Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles
4424		167	208	178	195	3676

AWASH
 PERIOD: 2011- 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES									TOTAL AXLE WEIGHT: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	3	0		0		3	
2.1-3	8	0	0	2	3	1	6	0		8		12	
3.1-4	160	2	3	6	21	8	6	0		162		44	
4.1-5	927	7	54	136	78	33	52	0		934		353	
5.1-6	4861	4	304	414	290	181	312	0		4865		1501	
6.1-7	10332	0	779	1075	753	1170	1119	0		10332		4896	
7.1-8	11481	0	2268	3405	2398	3902	3360	0		11481		15333	
8.1-9	266	0	7512	9316	8668	8074	7228	0			266	40798	
9.1-10	108	0	13343	10426	11807	10308	9883	1			108	55768	
10.1-11	28	0	1211	721	678	636	699	0			28		3945
11.1-12	3	0	418	573	588	870	450	1			3		2899
12.1-13	0	0	437	482	657	665	326	0			0		2567
13.1-14	0	0	563	497	681	350	282	0					2373
14.1-15	0	0	616	336	380	137	185	0					1654
15.1-16	0	0	394	207	168	55	95	0					919
16.1-17	0	0	169	92	29	23	62	0					375
17.1-18	0	0	80	32	6	1	9	0					128
18.1-19	0	0	17	11	0	3	4	0					35
19.1-20	0	0	1	5	0	2	0	0					8
20.1-21	0	0	2	4	0	1	0	0					7
21.1-22	0	0	3										3
TOTAL	28174	13	28174	27740	27205	26420	24081	2	0	27782	405	118708	14913
	axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5	axleR6					
	Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles	7-axles					
	28174		434	535	785	2339	24079	2					

Jimma

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES							TOTAL AXLE WEIGHT: NO OF VEHICLES					
								FRONT		REAR			
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0		0		0	
2.1-3	1	0	0	1	0	0	1			1		2	
3.1-4	6	0	0	2	0	3	2			6		7	
4.1-5	83	0	0	2	4	4	1			83		11	
5.1-6	595	0	3	5	18	37	22			595		85	
6.1-7	1147	0	10	13	37	92	113			1147		265	
7.1-8	837	0	49	68	137	314	354			837		922	
8.1-9	92	0	436	444	469	627	625				92	2601	
9.1-10	2	0	1434	1310	900	528	363				2	4535	
10.1-11	0	0	346	337	182	74	56				0		995
11.1-12	1	0	222	189	15	3	0				1		429
12.1-13	0	0	117	78	4	6	2						207
13.1-14	0	0	83	78	5	2	0						168
14.1-15	0	0	28	20	3	3	0						54
15.1-16	0	0	20	8	0	0	0						28
16.1-17	0	0	9	4	0	0	0						13
17.1-18	0	0	6	3	0	0	0						9
18.1-19	0	0	0	0	0	0	0						0
19.1-20	0	0	1	0	0	0	0						1
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	2764	0	2764	2562	1774	1693	1539		0	2669	95	8428	1904

axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5
Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles
2764		202	788	81	154	1539

SHASHEMENE

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES							TOTAL AXLE WEIGHT: NO OF VEHICLES					
								FRONT		REAR			
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	7	0	0	0			0		7	
2.1-3	0	0	0	5	0	2	0			0		7	
3.1-4	9	0	0	15	0	10	4			9		29	
4.1-5	135	0	2	4	11	26	43			135		86	
5.1-6	755	0	7	16	61	256	235			755		575	
6.1-7	2805	0	135	81	416	1096	695			2805		2423	
7.1-8	2317	0	456	296	750	1134	1032			2317		3668	
8.1-9	20	0	969	1287	1579	1129	1324				20	6288	
9.1-10	4	0	3838	3689	1656	545	595				4	10323	
10.1-11	0	0	418	249	63	20	13						763
11.1-12	0	0	28	88	37	10	2						165
12.1-13	1	0	83	72	21	12	1						189
13.1-14	0	0	52	53	3	8	0						116
14.1-15	0	0	18	21	1	1	0						41
15.1-16	0	0	21	5	0	0	0						26
16.1-17	0	0	13	5	0	0	0						18
17.1-18	0	0	4	0	0	0	0						4
18.1-19	0	0	1	0	0	0	0						1
19.1-20	0	0	1	0	0	0	0						1
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	6046	0	6046	5893	4598	4249	3944		0	6021	24	23406	1324

axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5
Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles
6046		153	1295	349	305	3944

Hollela

PERIOD: From July 1, 2010-June 30, 2011

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES									TOTAL AXLE WEIGHT: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0	0	0		0	
2.1-3	0	0	0	8	1	2	8	0		0		19	
3.1-4	139	0	0	5	2	7	8	0		139		22	
4.1-5	1771	0	1	3	13	37	21	0		1771		75	
5.1-6	5023	0	10	21	69	255	56	0		5023		411	
6.1-7	5253	0	35	144	263	975	323	0		5253		1740	
7.1-8	8317	0	118	1148	689	1513	1124	0		8317		4592	
8.1-9	209	0	792	1524	3786	3655	3103	0			209	12860	
9.1-10	37	0	18124	12381	6656	2240	1886	0			37	41287	
10.1-11	7	0	147	45	82	30	136	0			7		440
11.1-12	1	0	396	63	86	43	29	0			1		617
12.1-13	0	0	501	111	71	57	33	0			0		773
13.1-14	0	0	204	187	40	40	19	0			0		490
14.1-15	1	0	136	152	17	15	7	0			1		327
15.1-16	0	0	94	46	1	3	3	0					147
16.1-17	0	0	115	29	1	0	0	0					145
17.1-18	0	0	65	6	2	0	0	0					73
18.1-19	0	0	18	0	0	0	0	0					18
19.1-20	0	0	2	0	0	0	0	0					2
20.1-21	0	0	0	0	0	0	0	0					0
21.1-22	0	0	0	0	0	0	0	0					0
TOTAL	20758	0	20758	15873	11779	8872	6756		0	20503	255	61006	3032

axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5
Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles
20758		4885	4094	2907	2116	6756

Alemgena

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES							TOTAL AXLE WEIGHT: NO OF VEHICLES					
								FRONT		REAR			
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0		0		0	
2.1-3	0	0	0	0	0	0	0	0		0		0	
3.1-4	41	0	5	4	7	6	3			41		25	
4.1-5	218	0	16	20	16	19	24			218		95	
5.1-6	1060	0	42	29	39	28	56			1060		194	
6.1-7	2117	0	88	126	110	90	238			2117		652	
7.1-8	1965	0	328	298	359	341	421			1965		1747	
8.1-9	43	0	1130	1040	857	791	559				43	4377	
9.1-10	4	0	3627	3003	1468	1192	896				4	10186	
10.1-11	0	0	8	14	6	4	4				0		36
11.1-12	1	0	20	21	6	5	3				1		55
12.1-13	0	0	56	40	6	5	1				0		108
13.1-14	0	0	48	48	6	2	2				0		106
14.1-15	0	0	43	35	0	1	1						80
15.1-16	0	0	15	11	1	1	1						29
16.1-17	0	0	13	17	0	0	0						30
17.1-18	0	0	8	2	0	0	0						10
18.1-19	0	0	2	0	0	0	0						2
19.1-20	0	0	0	0	0	0	0						0
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	5449	0	5449	4708	2881	2485	2209		0	5401	48	17276	456
	axleF1	axleF2	axleR1	axleR2	axleR3	axleR4	axleR5						
	Total No. of Trucks		2-axles	3-axles	4-axles	5-axles	6-axles						
	5449		741	1827	396	276	2209						

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
1	1	ADDIS ABABA DEBRE BERHAN	130	77	366	252	107	193	296	188	68	1,547
	2	DEBRE BERHAN KARAKORE	153	34	170	249	144	181	250	187	117	1,332
	3	KARKORE COMBOLCHA	93	12	132	221	71	69	116	90	61	772
	4	COMBOLCHA DESSIE	25	25	324	530	120	48	236	131	143	1,557
	5	DESSIE WELDIYA	121	7	175	358	75	64	153	74	82	988
	6	WELDIYA MAICHEW	141	48	75	94	43	91	90	84	113	638
	7	MAICHEW QUIHA	111	2	120	199	44	145	103	103	107	823
	8	MAIMEKDEN ADIGRAT	97	3	167	296	48	165	195	127	103	1,104
	9	ADIGRAT ZALAMBESA	35	0	85	117	0	75	57	28	11	373
			906									
2	1	COMBOLCHA BATTI	41	3	86	186	27	85	63	59	101	610
	2	BATTI MILLE	97	0	63	26	20	61	44	90	146	450
	3	MILLE ASSEB	368	4	68	50	10	62	63	215	693	1,165
			506									

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
3	1	ADDIS ABABA COMANDO	113	130	287	505	237	318	380	334	256	2,447
	2	COMANDO DEJEN	116	49	187	280	144	221	297	268	230	1,676
	3	DEJEN D/MARKOS	70	32	195	324	154	176	241	165	172	1,459
	4	D/MARKOS BURIE	112	76	167	401	85	64	140	180	124	1,237
	5	BURIE DANGILA	74	17	168	419	105	153	200	190	163	1,415
	6	DANGILA BAHIRDAR	78	42	166	807	122	278	204	228	153	2,000
	7	BAHIRDAR WERETA	57	23	191	599	92	212	250	278	233	1,878
	8	WERETA A/ZEMEN	25	10	146	460	100	94	193	147	182	1,332
	9	A/ZEMEN AZEZO AIR PORT	78	21	102	561	111	134	206	227	172	1,534
	10	AZEZO AIRPORT GONDER	15	66	86	76	104	74	73	104	8	591
	11	GONDAR DABATE	76	0	75	166	66	42	98	40	26	513
	12	DABATE DEBARK	27	0	63	62	51	88	84	87	28	463
	13	DEBARK ADI ARKAI	76	0	37	35	25	54	65	61	34	311
	14	ADI ARKAI SHIRE	117	0	107	123	55	66	61	59	39	510
	15	SHIRE ADIABUN	85	0	90	171	59	93	105	96	64	678
	16	ADIABUN RAMA	42	0	55	71	0	73	52	62	19	332
1,161												

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
4	1	ADDIS ABABA AKAKI	24	3,106	3,917	3,898	2,908	3,556	3,959	3,946	4,141	29,431
	2	AKAKI D/ZEIT	32	2,994	3,834	3,956	2,749	3,505	3,906	3,814	4,042	28,800
	3	D/ZEIT NAZRETH	51	1,955	2,529	3,123	1,930	2,302	2,850	2,697	3,365	20,751
	4	NAZRETH AWASH	125	86	297	366	135	352	445	378	1,319	3,378
	5	AWASH ST. MIESO	74	22	131	195	87	105	128	169	112	949
	6	MIESO ASEBETEFERI	24	21	125	183	99	77	101	99	89	794
	7	ASEBETEFERI KOBO	111	17	115	173	76	117	116	88	94	796
	8	KOBO KULUBI	27	12	114	244	64	71	146	75	83	809
	9	KULUBI DENGEGO	31	65	175	844	63	262	240	87	91	1,827
	10	DENGEGO DIREDEWA	20	58	200	801	61	270	228	98	93	1,809
	11	DENGEGO HARAR	31	75	230	794	25	373	184	82	83	1,846
	12	HARAR JIJIGA	103	17	246	452	53	255	321	232	114	1,690
			653									

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
5	1	ADDIS ABABA AMBO	126	82	261	503	78	46	243	220	167	1,600
	2	AMBO BACKO	125	13	112	128	77	66	132	116	111	755
	3	BACKO NEKEMPTE	81	12	59	120	38	81	132	129	140	711
	4	NEKEMPTE GIMBI	113	6	53	167	54	31	75	85	33	504
	5	GIMBII MEKENAJO	14	0	87	111	18	56	96	89	60	517
	6	MEKENAJO ASOSSA	220	0	39	62	9	35	39	34	19	237
	7	ASSOSA KURMUK	96	0	46	14	19	27	36	16	8	166
	8	BAMBASI BEGI	60	0	15	41	2	17	30	14	2	121
	9	SHERKOLE GUBA	137	0	32	15	16	20	14	9	3	109
	10	ASSOSA DABUS	46	0	3	5	18	13	7	17	7	70
	11	KINGI DONGORO	18	0	25	15	9	34	26	18	15	142
	12	KINGI BILLA	28	0	23	13	9	34	24	20	14	137
1,064												
6	1	MODJO SHASHEMENE	180	221	521	733	175	383	465	342	340	3,180
	2	SHASHEMENE AWASA	20	174	383	534	254	327	367	269	128	2,436
	3	AWASA APOSTO	42	106	897	738	196	531	587	523	235	3,813
	4	APOSTO DILLA	44	75	173	247	84	192	222	141	80	1,214
	5	DILLA YABELLO	204	35	202	324	76	311	220	161	74	1,403
	6	YABELLO MOYALLE	208	5	79	59	14	22	60	35	10	284
	7	WANDO DILLA	38	0	42	31	40	54	119	29	7	322
	8	MORACHO DIMTU	94	29	317	269	3	367	167	165	4	1,321
	9	MORACHO LEKU	4	27	396	283	2	396	175	177	2	1,458
834												

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
7	1	ADDIS ABABA GHION	116	199	634	1,248	213	284	749	514	118	3,959
	2	GHION WELKITE	42	52	258	709	169	406	391	202	104	2,291
	3	WELKITE JIMMA	188	16	126	239	89	80	191	159	106	1,006
	4	JIMMA BONGA	103	0	60	93	63	55	126	110	37	544
	5	BONGA SHISHINDA	47	0	43	76	32	42	71	68	21	353
	6	SHISHINDA MIZAN	58	2	65	51	38	44	97	62	22	381
	8	SHISHINDA TEPPI	74	0	8	21	7	5	14	16	4	75
628												
8	1	NAZRETH MELKASA	18	370	488	667	468	303	601	361	429	3,687
	2	MELKASA ASSELA	59	203	295	461	295	223	411	252	265	2,405
	3	ASSELA DODOLA	120	3	68	77	41	65	69	48	31	402
197												
9	1	ALEMGENA BUTAJIRA	133	101	275	657	196	216	336	291	61	2,133
	2	BUTAJIRA HOSANA	99	25	157	304	138	126	146	117	42	1,055
	3	HOSANA SODO	98	23	157	270	230	125	124	68	33	1,030
	4	SODO A/MINCH	122	1	70	89	57	46	100	98	22	483
452												

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
13	1	WELKITE HOSANA	127	9	105	209	105	115	225	155	50	973
	2	TARMABER MOLALE	86	10	124	126	75	126	139	118	46	764
	3	ADIGRAT ADIABUN	104	1	135	140	34	86	76	61	59	592
	4	DEBRE BERHAN ANKOBER	41	0	21	40	13	23	33	23	6	159
	5	AWASH ST. MILLE	308	7	86	97	19	47	62	177	841	1,336
	6	QUIHA MEKELE	10	5	145	256	54	143	121	153	163	1,040
	7	MIESO ERER	104	0	33	35	0	41	37	28	8	182
	8	ERER DIREDEWA	56	0	48	127	14	35	33	25	8	290
	9	AZEZO METEMA	207	26	63	332	52	100	155	150	189	1,067
	10	WERETA WELDIYA	300	3	101	169	39	57	95	85	111	660
	11	DEJEN BICHENA	36	6	26	62	43	32	128	42	45	384
	12	BICHENA MOTTA	103	0	29	58	16	31	50	25	10	219
	13	MOTTA BAHIRDAR	120	0	33	80	79	30	105	45	14	386
	14	AZEZO AIR PORT GORGORA	50	7	42	46	84	56	72	87	9	403
	15	DEBRE BERHAN JIHUR	86	4	55	100	15	52	96	33	18	373
	16	JJIGA DEGEHABUR	171	9	208	169	22	119	127	112	53	819
	17	JJIGA TEFFERI BER	80	2	61	59	13	56	36	12	2	241
	18	INJIBARA CHAGNE	57	2	72	172	41	68	97	110	85	647
	19	CHAGINE GUBA	182	1	29	37	58	35	35	55	33	283
	20	GONDER TEKLE DENGAY	26	0	50	189	55	33	87	31	29	474
			2,254									

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL	
35	1	ARBBEREKETE	GELEMSO	60	1	50	72	52	74	57	42	33	381
	2	GELEMSO	MECHERA	38	1	46	62	42	77	99	32	20	379
98													
36	1	JIMMA	SUNTU	60	0	27	64	11	1	33	9	1	146
	2	LOGIA	ASSAITA	49	4	39	53	4	37	46	56	9	248
	3	NEKEMPTE	ARJO	37	3	21	37	39	17	31	28	17	193
	4	ARJO	BEDELLE	56	0	90	75	12	40	108	81	26	432
	5	SHASHEMENE	DODOLA	78	9	86	135	57	95	81	56	34	553
	6	DODOLA	GOBA	128	4	109	114	60	73	159	194	75	788
	7	SHASHEMENE	SODO	130	5	109	193	76	93	194	89	62	821
	8	AGARO	CHIRA	48	2	6	81	16	28	38	12	2	185
	9	SAJA FOFA		26	0	8	32	0	19	9	4	3	75
612													
43	1	JIMMA	AGARO	44	13	130	424	42	42	161	103	37	952
	2	AGARO	BEDELLE	93	2	62	172	20	71	117	83	38	565
	3	BEDELLE	METTU	117	0	65	99	12	60	81	63	25	405
	4	GORE	GAMBELLA	156	0	52	43	17	53	46	49	30	290
	5	GAMBELLA	JIKAWA	120	0	30	13	6	25	29	18	3	124
	6	GAMBELLA	ABOBO	45	0	73	19	8	74	43	43	26	286
	8	GAMBELLA	EALIA DURA	69	0	36	17	6	44	37	61	26	227
644													

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
44	1	APOSTO WONDO	16	0	78	55	58	72	174	55	32	524
	2	WONDO NEGELE	269	0	57	28	30	66	81	57	37	356
	3	BAHIRDAR TISISAT	29	1	36	39	35	21	35	16	2	185
	4	KOBO DEDER	12	1	16	64	18	26	51	13	3	192
	5	CHANCHO MUGER	23	48	129	188	81	174	172	169	144	1,105
	6	ZEWAY BUTAJIRA	48	8	55	191	73	70	81	40	25	543
	7	MELKASA SODERE	7	265	253	296	229	199	299	222	231	1,994
404												
45	1	GHIMBI DEMBI DOLLO	211	0	45	56	10	32	54	48	26	271
211												
47	1	METU GORE	25	0	51	89	4	63	47	33	20	307
	2	MIZAN TEPPI	50	0	99	105	19	28	122	28	7	408
	3	METU ALGE	50	0	19	49	0	20	43	22	1	154
	4	TEPPI GORE	143	0	54	50	9	57	73	41	6	290
	5	MIZAN AMAN	7	0	210	210	20	22	195	43	11	711
275												

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
88	1	HOLETA MUGER	73	13	41	90	20	11	51	54	141	421
	2	TAREMA BER SELA DENGAI	21	5	78	85	46	91	102	70	27	504
	3	MAYMEKADEN MEKELE	18	4	136	299	21	172	206	135	85	1,058
	4	JIMMA CHIDA	84	0	17	17	36	11	52	34	2	169
	5	GEDO FINCHA	88	6	49	26	37	24	45	71	95	353
	6	NEKEMT BURE	248	1	30	23	38	38	62	67	38	297
	7	SHASHEMENE W/GENET	17	61	130	140	61	119	148	116	16	791
	8	SODO SAWLA	131	0	42	35	14	17	63	7	3	181
	10	MOJO EJERE	30	31	135	255	150	215	310	207	95	1,398
	11	EJERE BALCHI	30	54	101	185	169	123	238	155	50	1,075
	12	EJERE ARERTI	16	30	61	105	97	76	143	105	33	650
	13	MUKATURE ALEM KETEMA	105	0	44	29	25	58	75	71	19	321
	29	ARBA MINCH KONSO	90	0	126	155	10	50	118	75	22	556
	30	GOBA MESLO	110	0	76	30	12	23	52	56	18	267
	31	ROBE GORO GINIR	141	0	57	68	62	78	108	82	50	505
	32	ROBE - ALI - GASSERA	50	0	52	61	46	65	60	57	29	370
	35	ROBIT (GEWANE) AWASH	40	6	62	78	14	77	93	47	9	386
	36	GINIR IMI	180	0	26	28	31	72	96	76	68	397
	37	ALI AGARFA	14	0	41	42	24	43	39	27	4	220
	38	ETEYA ROBE	73	29	132	90	283	144	287	116	60	1,141
	39	MEKELE ABI ADI	80	0	57	76	3	71	63	84	78	432
	40	ADWA ABI ADI	110	0	98	101	9	76	63	59	16	422
	41	CHAGNI DIBATE	40	0	12	21	26	17	17	20	6	119

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
88	42	DERI DAWA DEWELE	224	2	59	38	13	51	48	52	132	395
	43	CHIDA SODO	166	0	18	7	21	24	36	8	2	116
	44	KONSO WOITO	46	0	87	30	6	14	49	32	13	231
	45	WOITI JINKA	82	0	58	9	3	8	32	23	12	145
	46	WOITO TURMI	130	0	44	0	0	7	16	9	3	79
	47	TURMI OMORATE (KELE M)	74	0	98	1	0	29	28	10	1	167
	48	MANKUSA BIR SHELEKO	40	0	23	59	8	13	25	45	24	197
	49	GINDE WOIN MERTO LEMARYM	35	0	18	24	10	18	21	16	4	111
	50	NEGELE FILTU	110	0	23	22	4	26	29	44	35	183
	54	SODERE NEWRA ERA	60	46	159	124	202	164	336	274	370	1,675
	56	ALAMATA HIWANE	135	0	15	23	5	25	29	44	198	339
	58	AGEBE SEKOTA	139	0	8	12	0	13	9	6	1	49
	59	KOREM SEKOTA	100	0	23	17	0	23	19	11	3	96
	60	HARAR COMBOLCHA	37	20	99	380	4	85	108	49	17	762
	61	BABILE FIK	125	53	37	25	18	63	14	6	5	221
	62	BOMBAS GURSUM	18	0	29	76	7	45	34	11	2	204
	63	JIJIGA TOGO WUCHALE	154	6	123	124	5	114	88	44	16	520
	64	JIMMA SHEKI	44	0	4	14	36	4	21	9	1	89
	65	GASHENA LALIBELA	65	0	66	31	9	38	46	29	12	231
	66	DORO GIBER CHIFERA	62	26	74	74	48	88	91	89	134	624
	67	MILE CHIFERA	99	1	82	43	0	67	44	57	157	451
	68	SERDO AFDERA	188	3	28	28	0	30	24	41	145	299
	69	SHIRE SHIRARO	155	0	84	130	49	73	58	50	39	483

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
88	70	GASHNA DAWENT	55	0	38	36	6	33	37	19	7	176
	71	GUBRIA JUNCTION BOJO BER	54	6	70	145	53	85	166	136	37	698
	72	WOLKITE TOLAYE	64	0	59	321	37	51	384	71	1	924
	73	ARERTI SENBO	110	1	20	26	16	30	25	13	3	134
	74	TULUBOLO GINCHI	36	0	42	104	0	6	127	50	7	336
	75	TULUBOLO KELLA	84	2	14	9	1	2	15	6	0	49
	76	ROBE SERO	74	1	111	32	242	139	243	89	38	895
	77	A/ZEMENE EBENAT	59	0	92	79	29	111	112	86	29	538
	78	HAMUST ESTAY	78	0	49	27	72	66	60	41	19	334
	79	SERABA DELGE	100	0	11	16	9	14	17	13	2	82
	80	BIZET K/BER	52	0	37	28	7	12	10	9	1	104
	81	DURBETE KUNZILA	107	0	29	77	3	40	52	35	35	271
	82	DIRE DAWA SHINILE	10	17	206	74	12	37	21	27	24	418
	83	ADDELE GURAW	50	17	165	105	18	131	206	42	9	693
	84	KONSO YABELLO	103	0	46	33	7	29	39	28	4	186
	85	SHONE MAZORIYA DURAME	15	1	28	77	64	20	84	10	3	287
	86	ADI ARIKAI GANAMORA	35	0	73	11	7	59	42	25	1	218
	89	MENDI DALATY	38	0	19	14	9	25	19	16	21	123
	90	ROBE GEBEYA BUI	36	1	4	4	0	1	7	4	0	21
	91	BAKO SHAMBU	68	2	24	24	32	29	40	36	22	209
	92	SHAMBU FINCHA	68	2	19	18	31	31	31	38	18	188
	93	SHAMBU AGIMSA	96	3	15	22	28	31	30	37	22	188
	94	NEJO BEGI	148	0	31	36	6	29	26	15	3	146

ANNUAL AVERAGE DAILY TRAFFIC BY ROAD SECTION

Traffic Year 2011

ROAD NO	ROUTE NO	ROUTE NAME	Length	Cars	Land Rover	Small Buses	Large Bus	Small Trk	Medium Truck	Heavy Truck	Truck & Trailer	TOTAL
			5,617									
89	1	KALITY (AKAKI JUNC.)	0	8	64	53	17	77	87	49	8	363
	4	CHILDREN AMBA JUNC. CHILDREN AMBA	0	0	14	15	6	18	13	7	2	75
	5	GENDO AYANA	0	0	24	14	9	28	32	23	7	137
			0									

16,516.00

AXLE LOAD IN TON		AXLE DISTRIBUTION OF VEHECLIES										TOTAL AXLE WEIGHT: NO OF VEHICLES			
												FRONT		REAR	
		F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL	
1	2	82	0	0	5	0	14	13	0	0	82	0	32	0	
2.1	3	275	0	545	135	33	54	43	0	0	275	0	810	0	
3.1	4	1005	3	525	253	199	107	75	1	0	1008	0	1160	0	
4.1	5	4456	17	360	1340	775	327	244	0	0	4473	0	3046	0	
5.1	6	21403	10	658	1796	2469	731	493	0	0	21413	0	6147	0	
6.1	7	49130	0	1615	3841	5235	6163	2264	0	0	49130	0	19118	0	
7.1	8	54034	1	4980	7501	11504	10968	12004	0	0	54035	0	46957	0	
8.1	9	1378	0	13000	13779	23493	20279	16337	0	0	0	1378	86888	0	
9.1	10	441	0	37535	38865	53592	47135	36750	0	0	0	441	213877	0	
10.1	11	108	0	41932	43099	21115	18359	10977	0	0	0	108	0	135482	
11.1	12	38	0	16953	10244	5677	4659	2276	0	0	0	38	0	39809	
12.1	13	13	0	6069	3508	1982	2459	893	0	0	0	13	0	14911	
13.1	14	3	0	2672	2271	1361	1405	598	0	0	0	3	0	8307	
14.1	15	0	0	2446	1892	1048	705	434	0	0	0	0	0	6525	
15.1	16	0	0	1657	975	666	394	287	0	0	0	0	0	3979	
16.1	17	0	0	831	469	385	263	171	0	0	0	0	0	2119	
17.1	18	0	0	365	164	218	114	80	1	0	0	0	0	942	
18.1	19	0	0	130	26	92	77	52	0	0	0	0	0	377	
19.1	20	0	0	77	4	47	29	20	0	0	0	0	0	177	
20.1	21	0	0	41	2	31	17	14	0	0	0	0	0	105	
21.1	22	0	0	25	1	22	11	9	0	0	0	0	0	68	
TOTAL		132,366.00	31.00	132,416.00	130,170.00	129,944.00	114,270.00	84,034.00	2.00	-	130,416.00	1,981.00	378,035.00	212,801.00	

PREPARED BY _____
Title _____
Signature _____

Approved by _____
Title _____
Signature _____

**Ethiopian Roads Authority
Size and Weight Control Station
Axle Load Report**

SULULTA

PERIOD: From July 1, 2011-June 30, 2012

		AXLE DISTRIBUTIOIN OF VEHECLIES																
AXLE LOAD IN Ton		F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5	Axle load ton(mean)	EF	
		1	2	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.5
2.1	3	3	0	0	0	0	0	0	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.5	0.00	
3.1	4	4	0	0	1	0	1	0	0.09	0.00	0.00	0.02	0.00	0.02	0.00	3.5	0.02	
4.1	5	141	1	0	0	1	2	2	9.47	0.07	0.00	0.00	0.07	0.13	0.13	4.5	0.07	
5.1	6	640	1	0	0	5	8	11	106.08	0.17	0.00	0.00	0.83	1.33	1.82	5.5	0.17	
6.1	7	2678	0	22	28	26	80	101	941.37	0.00	7.73	9.84	9.14	28.12	35.50	6.5	0.35	
7.1	8	4305	1	292	245	260	324	539	2881.29	0.67	195.43	163.98	174.02	216.85	360.75	7.5	0.67	
8.1	9	48	0	669	742	780	953	1202	56.42	0.00	786.41	872.22	916.89	1120.25	1412.95	8.5	1.18	
9.1	10	4	0	6316	5789	3033	2686	2071	7.76	0.00	12247.18	11225.29	5881.20	5208.35	4015.82	9.5	1.94	
10.1	11	0	0	28	22	54	27	20	0.00	0.00	85.18	66.93	164.28	82.14	60.84	10.5	3.04	
11.1	12	1	0	31	19	48	26	14	4.58	0.00	142.02	87.04	219.90	119.11	64.14	11.5	4.58	
12.1	13	0		55	60	18	14	5	0.00	0.00	366.69	400.02	120.01	93.34	33.34	12.5	6.67	
13.1	14	0	0	221	211	11	6	1	0.00	0.00	2083.20	1988.94	103.69	56.56	9.43	13.5	9.43	
14.1	15	0	0	140	135	4	2	4	0.00	0.00	1820.21	1755.20	52.01	26.00	52.01	14.5	13.00	
15.1	16	0	0	39	39	1	1	0	0.00	0.00	684.53	684.53	17.55	17.55	0.00	15.5	17.55	
16.1	17	0	0	5	3	1	0	1	0.00	0.00	116.27	69.76	23.25	0.00	23.25	16.5	23.25	
17.1	18	0	0	5	1	0	1	0	0.00	0.00	151.52	30.30	0.00	30.30	0.00	17.5	30.30	
18.1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18.5	38.91	
19.1	20	0	0	1	0	0	0	0	0	0	49.32	0	0	0	0	19.5	49.32	
20.1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.5	61.76	
21.1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53	
Total		7824	3	7824	7295	4242	4131	3971	4007	1	18736	17354	7683	7000	6070			
		7824		529	3053	111	160	3971	0.51		2.39	2.38	1.81	1.69	1.53			
				2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		2.9	5.3	7.1	8.8	10.3			
%fm total weighed				6.8%	39.0%	1.4%	2.0%	50.8%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL		0.7%		6.7%	6.7%	3.2%	1.9%	1.1%	Weighted Mean		4.9		10.2					

- 10.1-11 ton 0.55%
- 11.1-12 ton 0.50%
- 12.1-13 ton 0.55%
- 13.1-14 ton 1.64%
- 14.1-15 ton 1.04%
- 15.1-16 ton 0.29%
- 16.1-17 ton 0.04%
- >17 ton 0.03%
- All axles 4.64%

Modjo

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
1.0-2	0	0	0	2	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.5	0.00
2.1-3	0	0	0	11	1	1	2	0.00	0.00	0.00	0.05	0.00	0.00	0.01	2.5	0.00	
3.1-4	7	5	0	12	4	3	1	0.15	0.11	0.00	0.26	0.09	0.07	0.02	3.5	0.02	
4.1-5	87	3	2	8	8	7	6	5.85	0.20	0.13	0.54	0.54	0.47	0.40	4.5	0.07	
5.1-6	5062	3	7	12	33	24	20	839.06	0.50	1.16	1.99	5.47	3.98	3.32	5.5	0.17	
6.1-7	25562	0	11	48	171	235	143	8985.51	0.00	3.87	16.87	60.11	82.61	50.27	6.5	0.35	
7.1-8	15697	0	131	240	1670	2753	2671	10505.82	0.00	87.68	160.63	1117.71	1842.55	1787.67	7.5	0.67	
8.1-9	104	1	1406	2034	6162	6813	7047	122.25	1.18	1652.75	2390.97	7243.43	8008.69	8283.75	8.5	1.18	
9.1-10	8	0	42123	41486	10172	7575	6326	15.51	0.00	81679.52	80444.33	19724.24	14688.47	12266.57	9.5	1.94	
10.1-11	4	0	841	647	472	239	245	12.17	0.00	2558.50	1968.31	1435.92	727.09	745.34	10.5	3.04	
11.1-12	0	0	298	238	179	93	62	0.00	0.00	1365.19	1090.32	820.03	426.05	284.03	11.5	4.58	
12.1-13	0	0	365	361	97	96	26	0.00	0.00	2433.47	2406.80	646.70	640.04	173.34	12.5	6.67	
13.1-14	0	0	471	427	48	84	18	0.00	0.00	4439.77	4025.01	452.46	791.81	169.67	13.5	9.43	
14.1-15	0	0	609	578	36	34	13	0.00	0.00	7917.92	7514.87	468.05	442.05	169.02	14.5	13.00	
15.1-16	0	0	140	121	11	15	8	0.00	0.00	2457.30	2123.81	193.07	263.28	140.42	15.5	17.55	
16.1-17	0	0	89	30	4	5	2	0.00	0.00	2069.69	697.65	93.02	116.27	46.51	16.5	23.25	
17.1-18	0	0	26	8	1	1	1	0.00	0.00	787.92	242.44	30.30	30.30	30.30	17.5	30.30	
18.1-19	0	0	7	1	2	0	0	0	0	272.400865	38.91440927	77.82881853	0	0	18.5	38.91	
19.1-20	0	0	2	0	1	0	0	0	0	98.63	0	49.31663267	0	0	19.5	49.32	
20.1-21	0	0	3	0	0	0	0	0	0	185.289707	0	0	0	0	20.5	61.76	
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53	
Total	46531	12	46531	46264	19072	17978	16591	20486	2	108011	103124	32418	28064	24151			
	46531		267	27192	1094	1387	16591	0.44		2.32	2.23	1.70	1.56	1.46			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		2.8	5.0	6.7	8.3	9.7			
%fm total weighed			0.6%	58.4%	2.4%	3.0%	35.7%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	0.2%		6.1%	5.2%	4.5%	3.2%	2.3%	Weighted Mean		5.0		9.4					

10.1-11 ton	1.67%
11.1-12 ton	0.59%
12.1-13 ton	0.65%
13.1-14 ton	0.72%
14.1-15 ton	0.87%
15.1-16 ton	0.20%
16.1-17 ton	0.09%
>17 ton	0.04%
All axles	4.82%

DENGEGO
 PERIOD: 2011-12

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
	1.0-2	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
2.1-3	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.5	0.00
3.1-4	0	0	0	4	1	1	1	0.00	0.00	0.00	0.09	0.02	0.02	0.02	0.02	3.5	0.02
4.1-5	221	0	1	12	9	19	39	14.85	0.00	0.07	0.81	0.60	1.28	2.62	4.5	0.07	
5.1-6	787	0	15	27	51	99	142	130.45	0.00	2.49	4.48	8.45	16.41	23.54	5.5	0.17	
6.1-7	2475	1	118	160	251	529	368	870.01	0.35	41.48	56.24	88.23	185.95	129.36	6.5	0.35	
7.1-8	4795	2	806	914	822	1875	1300	3209.24	1.34	539.45	611.73	550.16	1254.92	870.08	7.5	0.67	
8.1-9	921	0	1146	1281	1153	1960	1588	1082.64	0.00	1347.12	1505.82	1355.35	2303.98	1866.69	8.5	1.18	
9.1-10	1	0	6673	6233	5006	3037	3858	1.94	0.00	12939.43	12086.23	9706.99	5888.96	7480.94	9.5	1.94	
10.1-11	0	0	207	214	502	33	19	0.00	0.00	629.74	651.03	1527.19	100.39	57.80	10.5	3.04	
11.1-12	0	0	34	33	25	10	2	0.00	0.00	155.76	151.18	114.53	45.81	9.16	11.5	4.58	
12.1-13	0	0	133	119	3	12	1	0.00	0.00	886.72	793.38	20.00	80.00	6.67	12.5	6.67	
13.1-14	0	0	55	57	2	10	0	0.00	0.00	518.44	537.30	18.85	94.26	0.00	13.5	9.43	
14.1-15	0	0	6	4	1	3	0	0.00	0.00	78.01	52.01	13.00	39.00	0.00	14.5	13.00	
15.1-16	0	0	6	1	0	0	0	0.00	0.00	105.31	17.55	0.00	0.00	0.00	15.5	17.55	
16.1-17	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.5	23.25	
17.1-18	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.5	30.30	
18.1-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18.5	38.91	
19.1-20	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0	19.5	49.32	
20.1-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.5	61.76	
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53	
Total	9200	3	9200	9059	7826	7588	7318	5309	2	17244	16468	13403	10011	10447			
	9200		141	1233	238	270	7318	0.58		1.87	1.82	1.71	1.32	1.43			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		2.5	4.3	6.0	7.3	8.7			
%fm total weighed			1.5%	13.4%	2.6%	2.9%	79.5%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	10.0%		4.8%	4.7%	6.8%	0.9%	0.3%	Weighted Mean		4.1		8.6					

10.1-11 ton 2.38%
 11.1-12 ton 0.25%
 12.1-13 ton 0.65%
 13.1-14 ton 0.30%
 14.1-15 ton 0.03%
 15.1-16 ton 0.02%
 16.1-17 ton 0.00%
 >17 ton 0.00%
 All axles 3.64%

KOMBOLCHA

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
	1.0-2	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
2.1-3	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.5	0.00
3.1-4	0	0	0	1	0	0	0	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	3.5	0.02
4.1-5	0	0	0	1	0	0	0	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	4.5	0.07
5.1-6	141	0	0	3	0	0	0	23.37	0.00	0.00	0.50	0.00	0.00	0.00	0.00	5.5	0.17
6.1-7	498	0	0	1	0	0	0	175.06	0.00	0.00	0.35	0.00	0.00	0.00	0.00	6.5	0.35
7.1-8	3672	0	0	8	7	7	16	2457.63	0.00	0.00	5.35	4.69	4.69	10.71	7.5	0.67	
8.1-9	113	0	102	87	1247	1285	1263	132.83	0.00	119.90	102.27	1465.85	1510.52	1484.66	8.5	1.18	
9.1-10	0	0	2864	2753	2641	2448	2310	0.00	0.00	5553.50	5338.26	5121.09	4746.85	4479.26	9.5	1.94	
10.1-11	0	0	1155	1197	122	109	81	0.00	0.00	3513.76	3641.53	371.15	331.60	246.42	10.5	3.04	
11.1-12	0	0	47	12	17	11	3	0.00	0.00	215.32	54.97	77.88	50.39	13.74	11.5	4.58	
12.1-13	0	0	55	47	8	4	1	0.00	0.00	366.69	313.35	53.34	26.67	6.67	12.5	6.67	
13.1-14	0	0	128	113	5	6	1	0.00	0.00	1206.56	1065.17	47.13	56.56	9.43	13.5	9.43	
14.1-15	0	0	45	29	1	1	0	0.00	0.00	585.07	377.04	13.00	13.00	0.00	14.5	13.00	
15.1-16	0	0	13	3	1	0	1	0.00	0.00	228.18	52.66	17.55	0.00	17.55	15.5	17.55	
16.1-17	0	0	8	2	0	0	0	0.00	0.00	186.04	46.51	0.00	0.00	0.00	16.5	23.25	
17.1-18	0	0	4	0	0	0	0	0.00	0.00	121.22	0.00	0.00	0.00	0.00	17.5	30.30	
18.1-19	0	0	2	0	0	0	0	0	0	77.8288185	0	0	0	0	18.5	38.91	
19.1-20	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0	19.5	49.32	
20.1-21	0	0	1	0	0	0	0	0	0	61.7632356	0	0	0	0	20.5	61.76	
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53	
Total	4424	0	4424	4257	4049	3871	3676	2789	0	12236	10998	7172	6740	6268			
	4424		167	208	178	195	3676	0.63		2.77	2.58	1.77	1.74	1.71			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		3.4	6.0	7.8	9.5	11.2			
%fm total weighed			3.8%	4.7%	4.0%	4.4%	83.1%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	2.6%		33.0%	33.0%	3.8%	3.4%	2.4%	Weighted Mean		4.8		11.0					

10.1-11 ton 13.14%
 11.1-12 ton 0.44%
 12.1-13 ton 0.57%
 13.1-14 ton 1.25%
 14.1-15 ton 0.37%
 15.1-16 ton 0.09%
 16.1-17 ton 0.05%
 >17 ton 0.03%
 All axles 15.94%

AWASH
 PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
1.0-2	0	0	0	0	0	0	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.5	0.00
2.1-3	8	0	0	2	3	1	6	0.04	0.00	0.00	0.01	0.01	0.00	0.03	2.5	0.00	
3.1-4	160	2	3	6	21	8	6	3.47	0.04	0.07	0.13	0.46	0.17	0.13	3.5	0.02	
4.1-5	927	7	54	136	78	33	52	62.28	0.47	3.63	9.14	5.24	2.22	3.49	4.5	0.07	
5.1-6	4861	4	304	414	290	181	312	805.74	0.66	50.39	68.62	48.07	30.00	51.72	5.5	0.17	
6.1-7	10332	0	779	1075	753	1170	1119	3631.89	0.00	273.83	377.88	264.69	411.28	393.35	6.5	0.35	
7.1-8	11481	0	2268	3405	2398	3902	3360	7684.10	0.00	1517.95	2278.93	1604.95	2611.56	2248.81	7.5	0.67	
8.1-9	266	0	7512	9316	8668	8074	7228	312.68	0.00	8830.36	10950.96	10189.24	9490.99	8496.52	8.5	1.18	
9.1-10	108	0	13343	10426	11807	10308	9883	209.42	0.00	25873.03	20216.76	22894.62	19987.95	19163.85	9.5	1.94	
10.1-11	28	0	1211	721	678	636	699	85.18	0.00	3684.12	2193.44	2062.62	1934.85	2126.51	10.5	3.04	
11.1-12	3	0	418	573	588	870	450	13.74	0.00	1914.94	2625.02	2693.74	3985.63	2061.53	11.5	4.58	
12.1-13	0	0	437	482	657	665	326	0.00	0.00	2913.49	3213.51	4380.24	4433.58	2173.45	12.5	6.67	
13.1-14	0	0	563	497	681	350	282	0.00	0.00	5306.99	4684.85	6419.29	3299.19	2658.21	13.5	9.43	
14.1-15	0	0	616	336	380	137	185	0.00	0.00	8008.93	4368.51	4940.57	1781.21	2405.28	14.5	13.00	
15.1-16	0	0	394	207	168	55	95	0.00	0.00	6915.55	3633.29	2948.76	965.37	1667.45	15.5	17.55	
16.1-17	0	0	169	92	29	23	62	0.00	0.00	3930.09	2139.46	674.39	534.86	1441.81	16.5	23.25	
17.1-18	0	0	80	32	6	1	9	0.00	0.00	2424.37	969.75	181.83	30.30	272.74	17.5	30.30	
18.1-19	0	0	17	11	0	3	4	0	0	661.544958	428.0585019	0	116.7432278	155.6576371	18.5	38.91	
19.1-20	0	0	1	5	0	2	0	0	0	49.32	246.5831634	0	98.63326534	0	19.5	49.32	
20.1-21	0	0	2	4	0	1	0	0	0	123.526471	247.0529422	0	61.76323555	0	20.5	61.76	
21.1-22	0	0	3					0	0	229.578909	0	0	0	0	21.5	76.53	
Total	28174	13	28174	27740	27205	26420	24081	12809	1	72712	58652	59309	49776	45321			
	28174		434	535	785	2339	24081	0.45		2.58	2.11	2.18	1.88	1.88			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		3.0	5.1	7.3	9.2	11.1			
%fm total weighed			1.5%	1.9%	2.8%	8.3%	85.5%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	1.4%		13.9%	10.7%	11.7%	10.4%	8.8%	Weighted Mean		4.2		10.8					

10.1-11 ton 2.95%
 11.1-12 ton 2.17%
 12.1-13 ton 1.92%
 13.1-14 ton 1.78%
 14.1-15 ton 1.24%
 15.1-16 ton 0.69%
 16.1-17 ton 0.28%
 >17 ton 0.14%
 All axles 11.16%

Jimma
 PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
	1.0-2	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
2.1-3	1	0	0	1	0	0	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.5	0.00
3.1-4	6	0	0	2	0	3	2	0.13	0.00	0.00	0.04	0.00	0.07	0.04	0.04	3.5	0.02
4.1-5	83	0	0	2	4	4	1	5.58	0.00	0.00	0.13	0.27	0.27	0.07	0.07	4.5	0.07
5.1-6	595	0	3	5	18	37	22	98.62	0.00	0.50	0.83	2.98	6.13	3.65	5.5	0.17	
6.1-7	1147	0	10	13	37	92	113	403.19	0.00	3.52	4.57	13.01	32.34	39.72	6.5	0.35	
7.1-8	837	0	49	68	137	314	354	560.19	0.00	32.80	45.51	91.69	210.16	236.93	7.5	0.67	
8.1-9	92	0	436	444	469	627	625	108.15	0.00	512.52	521.92	551.31	737.04	734.69	8.5	1.18	
9.1-10	2	0	1434	1310	900	528	363	3.88	0.00	2780.63	2540.18	1745.16	1023.83	703.88	9.5	1.94	
10.1-11	0	0	346	337	182	74	56	0.00	0.00	1052.61	1025.23	553.68	225.12	170.36	10.5	3.04	
11.1-12	1	0	222	189	15	3	0	4.58	0.00	1017.02	865.84	68.72	13.74	0.00	11.5	4.58	
12.1-13	0	0	117	78	4	6	2	0.00	0.00	780.04	520.03	26.67	40.00	13.33	12.5	6.67	
13.1-14	0	0	83	78	5	2	0	0.00	0.00	782.38	735.25	47.13	18.85	0.00	13.5	9.43	
14.1-15	0	0	28	20	3	3	0	0.00	0.00	364.04	260.03	39.00	39.00	0.00	14.5	13.00	
15.1-16	0	0	20	8	0	0	0	0.00	0.00	351.04	140.42	0.00	0.00	0.00	15.5	17.55	
16.1-17	0	0	9	4	0	0	0	0.00	0.00	209.29	93.02	0.00	0.00	0.00	16.5	23.25	
17.1-18	0	0	6	3	0	0	0	0.00	0.00	181.83	90.91	0.00	0.00	0.00	17.5	30.30	
18.1-19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18.5	38.91	
19.1-20	0	0	1	0	0	0	0	0	0	49.32	0	0	0	0	19.5	49.32	
20.1-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.5	61.76	
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53	
Total	2764	0	2764	2562	1774	1693	1539	1184	0	8118	6844	3140	2347	1903			
	2764		202	788	81	154	1539	0.43		2.94	2.67	1.77	1.39	1.24			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		3.4	6.0	7.8	9.2	10.4			
%fm total weighed			7.3%	28.5%	2.9%	5.6%	55.7%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	3.4%		30.1%	28.0%	11.8%	5.2%	3.8%	Weighted Mean		5.5		10.2					

10.1-11 ton 9.63%
 11.1-12 ton 4.15%
 12.1-13 ton 2.00%
 13.1-14 ton 1.63%
 14.1-15 ton 0.52%
 15.1-16 ton 0.27%
 16.1-17 ton 0.13%
 >17 ton 0.10%
 All axles 18.43%

SHASHEMENE

PERIOD: From July 1, 2011-June 30, 2012

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
1.0-2	0	0	0	7	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.5	0.00
2.1-3	0	0	0	5	0	2	0	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	2.5	0.00
3.1-4	9	0	0	15	0	10	4	0.20	0.00	0.00	0.33	0.00	0.22	0.09	0.00	3.5	0.02
4.1-5	135	0	2	4	11	26	43	9.07	0.00	0.13	0.27	0.74	1.75	2.89	0.00	4.5	0.07
5.1-6	755	0	7	16	61	256	235	125.15	0.00	1.16	2.65	10.11	42.43	38.95	0.00	5.5	0.17
6.1-7	2805	0	135	81	416	1096	695	986.01	0.00	47.45	28.47	146.23	385.26	244.31	0.00	6.5	0.35
7.1-8	2317	0	456	296	750	1134	1032	1550.74	0.00	305.20	198.11	501.97	758.97	690.71	0.00	7.5	0.67
8.1-9	20	0	969	1287	1579	1129	1324	23.51	0.00	1139.06	1512.87	1856.12	1327.14	1556.36	0.00	8.5	1.18
9.1-10	4	0	3838	3689	1656	545	595	7.76	0.00	7442.16	7153.24	3211.10	1056.79	1153.75	0.00	9.5	1.94
10.1-11	0	0	418	249	63	20	13	0.00	0.00	1271.64	757.51	191.66	60.84	39.55	0.00	10.5	3.04
11.1-12	0	0	28	88	37	10	2	0.00	0.00	128.27	403.14	169.50	45.81	9.16	0.00	11.5	4.58
12.1-13	1	0	83	72	21	12	1	6.67	0.00	553.36	480.03	140.01	80.00	6.67	0.00	12.5	6.67
13.1-14	0	0	52	53	3	8	0	0.00	0.00	490.17	499.59	28.28	75.41	0.00	0.00	13.5	9.43
14.1-15	0	0	18	21	1	1	0	0.00	0.00	234.03	273.03	13.00	13.00	0.00	0.00	14.5	13.00
15.1-16	0	0	21	5	0	0	0	0.00	0.00	368.60	87.76	0.00	0.00	0.00	0.00	15.5	17.55
16.1-17	0	0	13	5	0	0	0	0.00	0.00	302.31	116.27	0.00	0.00	0.00	0.00	16.5	23.25
17.1-18	0	0	4	0	0	0	0	0.00	0.00	121.22	0.00	0.00	0.00	0.00	0.00	17.5	30.30
18.1-19	0	0	1	0	0	0	0	0	0	38.9144093	0	0	0	0	0	18.5	38.91
19.1-20	0	0	1	0	0	0	0	0	0	49.32	0	0	0	0	0	19.5	49.32
20.1-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.5	61.76
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53
Total	6046	0	6046	5893	4598	4249	3944	2709	0	12493	11513	6269	3848	3742			
	6046		153	1295	349	305	3944	0.45		2.07	1.95	1.36	0.91	0.95			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		2.5	4.5	5.8	6.7	7.7			
%fm total weighed			2.5%	21.4%	5.8%	5.0%	65.2%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	0.4%		10.6%	8.4%	2.7%	1.2%	0.4%	Weighted Mean		4.3		7.5					

- 10.1-11 ton 3.09%
- 11.1-12 ton 0.67%
- 12.1-13 ton 0.76%
- 13.1-14 ton 0.47%
- 14.1-15 ton 0.17%
- 15.1-16 ton 0.11%
- 16.1-17 ton 0.07%
- >17 ton 0.02%
- All axles 5.35%

Holleta
 PERIOD: From July 1, 2010-June 30, 2011

AXLE LOAD IN Ton	AXLE DISTRIBUTIOIN OF VEHECLIES															Axle load ton(mean)	EF
	F1	F2	R1	R2	R3	R4	R5	F1	F2	R1	R2	R3	R4	R5			
1.0-2	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.5	0.00
2.1-3	0	0	0	8	1	2	8	0.00	0.00	0.00	0.04	0.00	0.01	0.04	2.5	0.00	
3.1-4	139	0	0	5	2	7	8	3.01	0.00	0.00	0.11	0.04	0.15	0.17	3.5	0.02	
4.1-5	1771	0	1	3	13	37	21	118.99	0.00	0.07	0.20	0.87	2.49	1.41	4.5	0.07	
5.1-6	5023	0	10	21	69	255	56	832.59	0.00	1.66	3.48	11.44	42.27	9.28	5.5	0.17	
6.1-7	5253	0	35	144	263	975	323	1846.52	0.00	12.30	50.62	92.45	342.73	113.54	6.5	0.35	
7.1-8	8317	0	118	1148	689	1513	1124	5566.47	0.00	78.98	768.34	461.14	1012.63	752.28	7.5	0.67	
8.1-9	209	0	792	1524	3786	3655	3103	245.68	0.00	931.00	1791.46	4450.45	4296.45	3647.58	8.5	1.18	
9.1-10	37	0	18124	12381	6656	2240	1886	71.75	0.00	35143.74	24007.65	12906.46	4343.52	3657.09	9.5	1.94	
10.1-11	7	0	147	45	82	30	136	21.30	0.00	447.21	136.90	249.46	91.27	413.74	10.5	3.04	
11.1-12	1	0	396	63	86	43	29	4.58	0.00	1814.15	288.61	393.98	196.99	132.85	11.5	4.58	
12.1-13	0	0	501	111	71	57	33	0.00	0.00	3340.18	740.04	473.36	380.02	220.01	12.5	6.67	
13.1-14	0	0	204	187	40	40	19	0.00	0.00	1922.96	1762.71	377.05	377.05	179.10	13.5	9.43	
14.1-15	1	0	136	152	17	15	7	13.00	0.00	1768.20	1976.23	221.03	195.02	91.01	14.5	13.00	
15.1-16	0	0	94	46	1	3	3	0.00	0.00	1649.90	807.40	17.55	52.66	52.66	15.5	17.55	
16.1-17	0	0	115	29	1	0	0	0.00	0.00	2674.32	674.39	23.25	0.00	0.00	16.5	23.25	
17.1-18	0	0	65	6	2	0	0	0.00	0.00	1969.80	181.83	60.61	0.00	0.00	17.5	30.30	
18.1-19	0	0	18	0	0	0	0	0	0	700.459367	0	0	0	0	18.5	38.91	
19.1-20	0	0	2	0	0	0	0	0	0	98.63	0	0	0	0	19.5	49.32	
20.1-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.5	61.76	
21.1-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.5	76.53	
Total	20758	0	20758	15873	11779	8872	6756	8724	0	52554	33190	19739	11333	9271			
	20758		4885	4094	2907	2116	6756	0.42		2.53	2.09	1.68	1.28	1.37			
			2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	Truck Factor		3.0	5.0	6.7	8.0	9.4			
%fm total weighed			23.5%	19.7%	14.0%	10.2%	32.5%	Type		2-Axle	3-Axle	4-Axle	5-Axle	6-Axle			
% over LL	1.2%		8.1%	4.0%	2.5%	2.1%	3.4%	Weighted Mean		3.9		8.5					

10.1-11 ton 0.69%
 11.1-12 ton 0.96%
 12.1-13 ton 1.21%
 13.1-14 ton 0.77%
 14.1-15 ton 0.51%
 15.1-16 ton 0.23%
 16.1-17 ton 0.23%
 >17 ton 0.15%
 All axles 4.73%

Weighing station- AWASH

TRUCK FACTOR COMPUTATION(Actual loading case)

PERIOD: From July 1, 2006-June 30, 2011

		AXLE DISTRIBUTION OF VEHECLIES																	
AXLE LOAD IN TON		F1	F2	R1	R2	R3	R4	R5	R6	F1	F2	R1	R2	R3	R4	R5	R6	Axle ton(mean)	8.16
1	2	82	0	0	5	0	14	13	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.00
2.1	3	275	0	545	135	33	54	43	0	1.3	0.0	2.7	0.7	0.2	0.3	0.2	0.0	2.5	0.00
3.1	4	1,005	3	525	253	199	107	75	1	22.3	0.1	11.6	5.6	4.4	2.4	1.7	0.0	3.5	0.02
4.1	5	4,456	17	360	1340	775	327	244	0	306.1	1.2	24.7	92.0	53.2	22.5	16.8	0.0	4.5	0.07
5.1	6	21,403	10	658	1796	2469	731	493	0	3626.6	1.7	111.5	304.3	418.4	123.9	83.5	0.0	5.5	0.17
6.1	7	49,130	0	1615	3841	5235	6163	2264	0	17654.3	0.0	580.3	1380.2	1881.1	2214.6	813.5	0.0	6.5	0.36
7.1	8	54,034	1	4980	7501	11504	10968	12004	0	36968.9	0.7	3,407.2	5,132.0	7,870.8	7,504.1	8,212.9	0.0	7.5	0.68
8.1	9	1378	0	13000	13779	23493	20279	16337	0	1655.9	0.0	15,621.5	16,557.6	28,230.5	24,368.3	19,631.4	0.0	8.5	1.20
9.1	10	441	0	37535	38865	53592	47135	36750	0	874.2	0.0	74,402.4	77,038.7	106,230.8	93,431.7	72,846.4	0.0	9.5	1.98
10.1	11	108	0	41932	43099	21115	18359	10977	0	335.9	0.0	130,404.2	134,033.5	65,665.5	57,094.6	34,137.3	0.0	10.5	3.11
11.1	12	38	0	16953	10244	5677	4659	2276	0	178.0	0.0	79,392.8	47,973.8	26,586.0	21,818.6	10,658.8	0.0	11.5	4.68
12.1	13	13	0	6069	3508	1982	2459	893	0	88.6	0.0	41,362.5	23,908.3	13,508.1	16,759.0	6,086.1	0.0	12.5	6.82
13.1	14	3	0	2672	2271	1361	1405	598	0	28.9	0.0	25,747.4	21,883.3	13,114.6	13,538.6	5,762.3	0.0	13.5	9.64
14.1	15	0	0	2446	1892	1048	705	434	0	0.0	0.0	32,509.2	25,146.1	13,928.7	9,370.0	5,768.2	0.0	14.5	13.29
15.1	16	0	0	1657	975	666	394	287	0	0.0	0.0	29,731.0	17,494.1	11,949.8	7,069.4	5,149.5	0.0	15.5	17.94
16.1	17	0	0	831	469	385	263	171	0	0.0	0.0	19,754.8	11,149.2	9,152.4	6,252.1	4,065.1	0.0	16.5	23.77
17.1	18	0	0	365	164	218	114	80	1	0.0	0.0	11,307.3	5,080.5	6,753.4	3,531.6	2,478.3	31.0	17.5	30.98
18.1	19	0	0	130	26	92	77	52	0	0.0	0.0	5,171.4	1,034.3	3,659.8	3,063.1	2,068.6	0.0	18.5	39.78
19.1	20	0	0	77	4	47	29	20	0	0.0	0.0	3,881.9	201.7	2,369.5	1,462.0	1,008.3	0.0	19.5	50.41
20.1	21	0	0	41	2	31	17	14	0	0.0	0.0	2,588.6	126.3	1,957.3	1,073.3	883.9	0.0	20.5	63.14
21.1	22	0	0	25	1	22	11	9	0	0.0	0.0	1955.7	78.2	1721.0	860.5	704.1	0.0	21.5	78.23
TOTAL		132,366	31	132,416	130,170	129,944	114,270	84,034	2	61,741.0	3.6	477,968.8	388,620.6	315,055.3	269,560.5	180,376.9	31.0		
	Total	132,366	31	2,246	226	15,674	30,236	84,032	2.00	0.5	0.1	3.6	3.0	2.4	2.4	2.1	15.5		
				2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	7-Axle	TF.	0.5	4.08	7.06	9.49	11.84	13.99	29.49		
										Type		2AXLE	3AXLE	4AXLE	5AXLE	6AXLE	7AXLE		
										MEAN		4.35		12.95					

Weighing location -Metehara





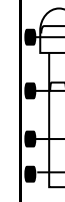
TRUCK FACTOR COMPUTATION(only from Metehara-to Addis Ababa side)

PERIOD: From April 5/2011-April 8/2011

		AXLE DISTRIBUTION OF VEHECLIES																	
AXLE LOAD IN TON		F1	F2	R1	R2	R3	R4	R5	R6	F1	F2	R1	R2	R3	R4	R5	Axle load ton(mean)	8.16	
0	1	0	0	2	1	0	2			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.00	
1	2	32	0	22	5	5	4	3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.00	
2.1	3	37	0	26	13	6	5	4		0.2	0.0	0.1	0.1	0.0	0.0	0.0	2.5	0.00	
3.1	4	40	0	43	18	23	15	6		0.9	0.0	1.0	0.4	0.5	0.3	0.1	3.5	0.02	
4.1	5	83	0	30	36	32	20	7		5.7	0.0	2.1	2.5	2.2	1.4	0.5	4.5	0.07	
5.1	6	131	0	47	41	34	28	17		22.2	0.0	8.0	6.9	5.8	4.7	2.9	5.5	0.17	
6.1	7	100	0	50	64	48	44	23		35.9	0.0	18.0	23.0	17.2	15.8	8.3	6.5	0.36	
7.1	8	52	0	63	57	48	30	24		35.6	0.0	43.1	39.0	32.8	20.5	16.4	7.5	0.68	
8.1	9	23	0	47	54	53	34	29		27.6	0.0	56.5	64.9	63.7	40.9	34.8	8.5	1.20	
9.1	10	3	0	50	33	44	33	40		5.9	0.0	99.1	65.4	87.2	65.4	79.3	9.5	1.98	
10.1	11	0	0	40	35	32	32	21		0.0	0.0	124.4	108.8	99.5	99.5	65.3	10.5	3.11	
11.1	12	0	0	24	34	36	30	23		0.0	0.0	112.4	159.2	168.6	140.5	107.7	11.5	4.68	
12.1	13	0	0	31	20	12	31	21		0.0	0.0	211.3	136.3	81.8	211.3	143.1	12.5	6.82	
13.1	14	0	0	15	10	12	15	19		0.0	0.0	144.5	96.4	115.6	144.5	183.1	13.5	9.64	
14.1	15	0	0	9	8	12	12	12		0.0	0.0	119.6	106.3	159.5	159.5	159.5	14.5	13.29	
15.1	16	0	0	4	1	7	6	6		0.0	0.0	71.8	17.9	125.6	107.7	107.7	15.5	17.94	
16.1	17	0	0	1	1	0	2	5		0.0	0.0	23.8	23.8	0.0	47.5	118.9	16.5	23.77	
17.1	18	1	0	0	0	1	1	2		31.0	0.0	0.0	0.0	31.0	31.0	62.0	17.5	30.98	
18.1	19	0	0	0	0	2	0	1		0.0	0.0	0.0	0.0	79.6	0.0	39.8	18.5	39.78	
19.1	20	0	0	0	0	0	0	2		0.0	0.0	0.0	0.0	0.0	0.0	100.8	19.5	50.41	
20.1	21	0	0	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5	63.14	
21.1	22	0	0	0	0	0	1	0		0.0	0.0	0.0	0.0	0.0	78.2	0.0	21.5	78.23	
TOTAL		502	-	504	431	407	345	265		165	-	1,036	851	1,071	1,169	1,230			
	Total	502	-	73	24	62	80	265	-	0.33		2.1	2.0	2.6	3.4	4.6			
				2-Axle	3-Axle	4-Axle	5-Axle	6-Axle	7-Axle	TF.		2.38	4.36	6.99	10.38	15.02			
										Type		2AXLE	3AXLE	4AXLE	5AXLE	6AXLE			
										MEAN		2.87			12.88				

ESA Computation (8 ton front axle 8 ton rear axle case)

Year	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	Truck & Trailer	Year	S/Bus	L/Bus	S/Truck	M/Truck	H/Truck	Truck & Trailer	ESA/Day	ESA/Year Both dir	ESA/Year One-dir
1999	82	48	90	89	114	419	1999	8	120	27	45	135	1447	1781	650,191	325,095.53
2000	96	54	164	127	141	539	2000	10	135	49	64	167	1861	2285	834,111	417,055.66
2001	90	43	118	86	91	448	2001	9	108	35	43	108	1547	1849	675,051	337,525.51
2002	92	63	111	97	89	557	2002	9	158	33	49	105	1923	2277	831,120	415,560.25
2003	129	91	186	141	181	644	2003	13	228	56	71	214	2224	2805	1,023,650	511,825.23
2004	152	102	194	199	191	579	2004	15	255	58	100	226	1999	2653	968,391	484,195.42
2005	274	141	181	422	267	905	2005	27	353	54	211	316	3125	4086	1,491,385	745,692.49
2006	191	79	142	229	155	835	2006	19	198	43	115	183	2883	3440	1,255,685	627,842.62
2007	246	153	225	276	248	1000	2007	25	383	68	138	294	3453	4359	1,591,004	795,501.88
2008	233	138	186	319	298	1007	2008	23	345	56	160	353	3477	4413	1,610,840	805,420.18
2009	461	209	224	454	387	1584	2009	46	523	67	227	458	5469	6790	2,478,372	1,239,185.88
2010	380	216	256	433	361	1248	2010	38	540	77	217	427	4309	5608	2,046,792	1,023,395.81
2011	366	135	352	445	378	1,319	2011	37	338	106	223	447	4554	5704	2,081,893	1,040,946.60
2012	407	150	392	495	421	1468	2012	41	376	118	248	498	5069	6348	2,317,147	1,158,573.56
2013	453	167	436	551	468	1634	2013	45	418	131	276	554	5642	7066	2,578,985	1,289,492.38
2014	505	186	485	614	521	1819	2014	50	465	146	307	617	6279	7864	2,870,410	1,435,205.02
2015	562	207	540	683	580	2024	2015	56	518	162	341	687	6989	8753	3,194,766	1,597,383.18
2016	625	231	601	760	646	2253	2016	63	576	180	380	764	7778	9742	3,555,775	1,777,887.48
2017	696	257	669	846	719	2507	2017	70	642	201	423	850	8657	10843	3,957,578	1,978,788.77
2018	774	286	745	942	800	2791	2018	77	714	223	471	947	9636	12068	4,404,784	2,202,391.90
2019	862	318	829	1048	890	3106	2019	86	795	249	524	1054	10724	13432	4,902,524	2,451,262.18
2020	959	354	923	1166	991	3457	2020	96	885	277	583	1173	11936	14949	5,456,510	2,728,254.81
2021	1068	394	1027	1298	1103	3848	2021	107	985	308	649	1305	13285	16639	6,073,095	3,036,547.60
2022	1188	438	1143	1445	1227	4282	2022	119	1096	343	722	1453	14786	18519	6,759,355	3,379,677.48
2023	1323	488	1272	1608	1366	4766	2023	132	1220	382	804	1617	16457	20611	7,523,162	3,761,581.04
2024	1472	543	1416	1790	1520	5305	2024	147	1357	425	895	1799	18317	22940	8,373,279	4,186,639.69
2025	1638	604	1576	1992	1692	5904	2025	164	1511	473	996	2003	20387	25533	9,319,460	4,659,729.98
2026	1824	673	1754	2217	1883	6572	2026	182	1682	526	1109	2229	22690	28418	10,372,559	5,186,279.47
2027	2030	749	1952	2468	2096	7314	2027	203	1872	586	1234	2481	25254	31629	11,544,658	5,772,329.05
2028	2259	833	2173	2746	2333	8141	2028	226	2083	652	1373	2761	28108	35203	12,849,204	6,424,602.23
2029	2514	927	2418	3057	2597	9061	2029	251	2318	725	1528	3073	31284	39181	14,301,165	7,150,582.28
2030	2798	1032	2691	3402	2890	10084	2030	280	2580	807	1701	3420	34820	43609	15,917,196	7,958,598.08
2031	3114	1149	2995	3787	3217	11224	2031	311	2872	899	1893	3807	38754	48537	17,715,839	8,857,919.66
2032	3466	1279	3334	4215	3580	12492	2032	347	3196	1000	2107	4237	43133	54021	19,717,729	9,858,864.59
2033	3858	1423	3711	4691	3985	13904	2033	386	3558	1113	2345	4716	48008	60126	21,945,833	10,972,916.28
2034	4294	1584	4130	5221	4435	15475	2034	429	3960	1239	2610	5249	53432	66920	24,425,712	12,212,855.82

CAR	PICK-UP - 4WD	S/bus ≤ 27 seats	L/bus > 27 seats					
0	0.001	0.1	2.5	0.3	0.5	1.183545228		3.4527952

For vehicle class Car up to M/Truck, TF taken from previous data.

For vehicle class H/Truck and T/T, TF taken from axle load data(2006-2011)

Historic Growth in Traffic (1999-2011)

AADT Type	Growth in %	
H/Trucks	ADAMA-Awash	12.6
T&T		11.1
All Trucks		11.3
All AADT		12.0