

**ADDIS ABABA UNIVERSITY**  
**ADDIS ABABA INSTITUTE OF TECHNOLOGY**  
**SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING**



**Evaluation of Vehicle Overload Control System on Major Road Corridors  
in Ethiopia**

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**A Thesis in Road and Transport Engineering**

By Sara Behailu

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A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science

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## UNDERTAKING

I certify that research work titled Evaluation of Vehicle Overload Control System on Major Road Corridors in Ethiopia is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources, it has been properly acknowledged / referred.

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## ABSTRACT

In order to protect the road assets from premature failure caused by overloading, axle load controls in Ethiopia have been operational and undertaken by Ethiopian Roads Authority at the ten static Control Stations and two mobile weighbridges. However, these stations have problem to cop up with the current freight transportation and technological advancement. This research is then done aiming to develop recommendations to improve efficiency and effectiveness of axle load controlling system by evaluating the current locations of control stations and operational management performance. A series of factors directly related to vehicle loading like heavy vehicle traffic, axle load, distance to ports, and the existence of by-pass routes have been used in order to do the evaluation for location. These factors have been rated based on criteria developed for the study referring different studies and literatures. Evaluation for operational management used queue analysis to study the checking time, congestion at the control station and losses in terms of times and measurement accuracy at control systems. Availability of relevant facilities and existing weighing system versus regulation have been done using questionnaire analysis and computation of overloaded axle mass from the collected axle load data respectively. The result shows that the selected stations are located on a place where high occurrence of overloading and their presence have a significant importance in protecting roads adjacent to the station. Though, some stations need extra weighbridge to make their role effective enough. And also some stations, mainly located at town sections, need traffic congestions mitigation plan to minimize congestion outside the station. On the other hand, the management operation evaluation analysis shows that the selected stations have problem in data quality, staff composition, modernized equipment, and organised operation. Finally, the research concludes with some recommendations for a well organised management, operation and maintenance.

Key words: Location of Weighbridge, facility location determination, Vehicle overload control, Performance measurement, Queue analysis

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**ABBREVIATIONS**

|         |   |
|---------|---|
| AXL     | Axle load                                     |
| AADT    | Annual Average Daily Traffic                  |
| COMESA  | Common Market for Eastern and Southern Africa |
| EAC     | East African Community                        |
| ERA     | Ethiopian Road Authority                      |
| ESAL    | Equivalent Standard Axle Load                 |
| ETB     | Ethiopian Birr                                |
| FDRE    | Federal Democratic Republic of Ethiopia       |
| GDP     | Gross Domestic product                        |
| GVW     | Gross Vehicle Weight                          |
| HV      | heavy vehicle                                 |
| MOFED   | Minister of Finance and Economic Development  |
| MUTCD   | Manual on Uniform Control Devices             |
| OLC     | Overload Control                              |
| OLCI    | Overload Control Index                        |
| PMS     | Pavement Management System                    |
| RAM DDG | Road Asset Management Deputy Director General |
| RAM     | Road Asset Management                         |
| RF      | Road Fund                                     |
| RMT     | Road Management Team                          |
| RSDP    | Road Sector Development Program               |
| SADC    | Southern Africa Development Community         |
| VWSC    | Vehicle Weight and Size control               |

## CHAPTER 1 INTRODUCTION

### 1.1 Background

Transportation is vital to the social and economic aspects of a society<sup>1,2</sup> and transportation systems generally use huge physical infrastructures such as railways, ports, highways, and bridges<sup>3</sup>. Road is one of the major transport infrastructures in Ethiopia which handles about 98% of the country's freight and passenger transportation<sup>4</sup>. Road is the largest national asset so that, it is required to maintain, improve, replace and preserve these assets<sup>5</sup>. To improve, replace and/or preserve road assets, it is necessary to know the factors for the roads to deteriorate before planning for intervention. The main factors that speed up the rate of pavement deteriorations are traffic loading condition, and environment<sup>6</sup>.

Among the factors, traffic is observed as the main parameter in road assets deterioration. For this reason, it is necessary to understand its composition in terms of traffic volume (Annual Average Daily Traffic/AADT), Axle load, axle configuration, contact pressure and a number of repetitions<sup>6</sup>.

In order to preserve roads, it is necessary to minimize the above mentioned factors that increase the rate of road pavement deteriorations. Roads are designed to withstand certain wheel loading over their life time. For this reason, controlling traffic loading condition is one of the ways of minimizing premature road and bridge deterioration<sup>7</sup>. Hence, the damaging effect to the pavement by vehicles depends largely on the axle loads applied by the vehicles<sup>8</sup>.

The damage to pavements by heavy vehicles loading increases as the extent of loading increases<sup>8</sup>. This becomes a big problem when heavy vehicles are overloaded and it is a major concern to Ethiopian Roads Authority. In order to protect the road assets from premature failure caused by overloading, axle load controls in the country have been operational and undertaken by Ethiopian Roads Authority at the ten static Control Stations and two mobile weighbridges<sup>9</sup>.

This research looked up the location of current vehicle weight and size control stations and evaluated the locations of selected weighbridge stations (Awash, Modjo, Sululta, Holota and Sandafa static weigh Control Stations) as per the intended purpose. It also evaluated the effectiveness and efficiency of the operation and management performance of the stations in controlling heavy traffic overloading. Then the report provided a series of recommendations in regard to location of Control Stations and provided ideas for the preparation of guideline for efficient and effective operation of Control Stations.

### 1.2 Statement of the problem

The existing vehicle weight and size control system have the challenges in coverage of overload control, overload controlling system, effectiveness and efficiency of operational management, lack of guideline which will advise detail of all aspects of the implementation of the Axle Load Control System operations, procedures and management to cop up with the current freight transportation and technological advancement:

### 1.3 Objectives

The main objective of this thesis was to evaluate the current overload and vehicle size control system and management performance by Ethiopian Roads Authority and develop recommendations to improve efficiency and effectiveness of axle load controlling system and the specific objectives of the research were to:

- Evaluate the locations of control stations
- Study the management performance, including checking time, congestion at the control station and losses in terms of times and measurement accuracy at control systems
- Evaluate the availability of relevant facilities and equipment at control stations
- Evaluate the existing weighing system as per the regulations
- Study procedures for the axle load control and team composition
- Develop recommendation for the efficient management performances at the control stations

### 1.4 Research questions

The main research questions that are expected to be addressed by this thesis are:

- ⇒ Are current locations of overload control stations optimal?
- ⇒ Are overload and vehicle size control stations performing properly?
- ⇒ Are vehicle size and weight control stations fully equipped?
- ⇒ Does the existing axle load control operation go along with the regulation?
- ⇒ Do axle load control stations follow professional procedures? Is the team composition sufficient enough?

## CHAPTER 2 LITERATURE REVIEW

### 2.1 Road Transport in Ethiopia

After World War II, road transport grew very fast since countries continue expanding their road networks and building new roads which in turn provide access to communities and country's development<sup>1</sup>. Roads are one of the main transportation modes for national freight transport in East Africa having very important role in the social and economic development of many developing countries<sup>7</sup>.

Ethiopia is a landlocked developing country which is located in the horn of Africa bordered by Eritrea, Sudan, South Sudan, Kenya, Somalia and Djibouti<sup>10</sup>. The country's most dominant transportation mode is road<sup>1</sup>.

Due to the fact that Ethiopia is a landlocked country, geographical diverse terrain, and dispersed settlement pattern, the importance of road transport in Ethiopia is high. It also plays an important role in international transport (import and export) and the major international route where high traffic observed is Addis Ababa –Djibouti. Road transport has great importance in fulfilling the Gross Product/GDP<sup>1</sup>.

### 2.2 Road Network

Roads can be deteriorated mainly by traffic volume, induced loading from traffic and environment (climate). It is well known that pavement design and performance are influenced by traffic loading, which is the key factor for deterioration of road, and it includes traffic volume (AADT), axle loads, axle configuration, loads contact pressure, and a number of repetitions. In line with this, heavy vehicles have high contribution when compared with that of light vehicles to pavement deterioration<sup>6</sup>.

For roads to reach acceptable levels of transport efficiency, setting management and maintenance strategies of road infrastructure are significant. It is known that huge investment was/is/will be needed for road infrastructures so that it is required to protect this investment from damage<sup>7</sup>. Figure 2-1 shows that the controllable and uncontrollable factors related to saving investment on road infrastructures<sup>11</sup>.



Figure 2-1. Framework for sustainable provision of roads<sup>11</sup>

As a result of RSDP the federal road network coverage, which administered by ERA, has grown to 27,606 km out of which about 49% is paved while 51% is unpaved which are classified under five functional classification namely Trunk, Link, Main Access, Collector, and Feeder<sup>9</sup>.

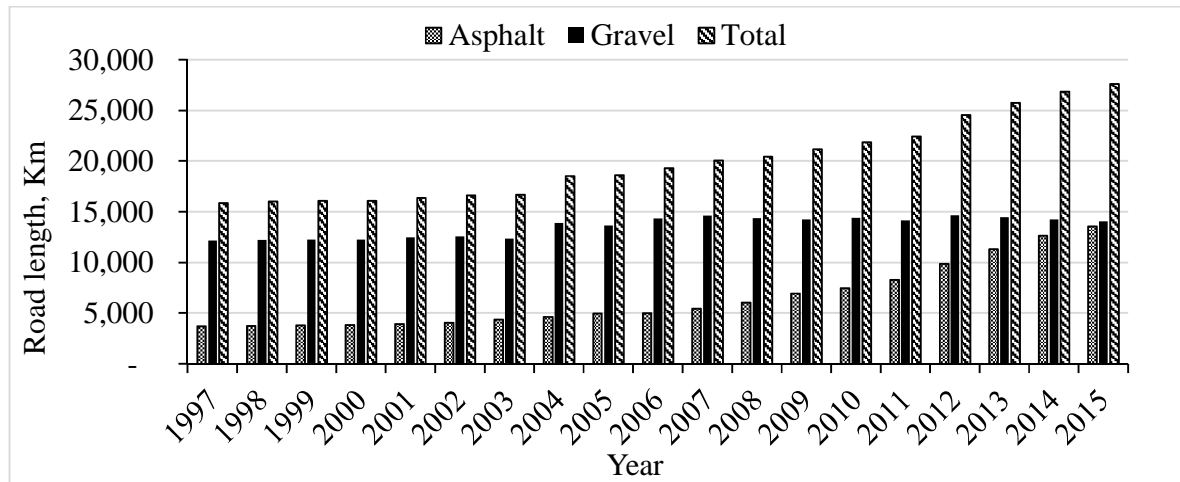


Figure 2-2. Federal road network growth in Ethiopia<sup>9</sup>

Overall, the road network in Ethiopia has been increasing on the average by 3.2% between 1997 and 2015<sup>12</sup>.

Table 2-1. Federal Road Network as per their functional classification (2015)<sup>9</sup>

| Category    | Paved (km)    | Unpaved (km)  | Total (km)    |
|-------------|---------------|---------------|---------------|
| Trunk       | 5,631         | 91            | 5,722         |
| Link        | 3,867         | 3,924         | 7,791         |
| Main Access | 2,007         | 3,912         | 5,919         |
| Collector   | 601           | 2,915         | 3,516         |
| Feeder      | 1,446         | 3,213         | 4,658         |
|             | <b>13,551</b> | <b>14,055</b> | <b>27,606</b> |

Road can be classified as per their functional classification or according to their socio-economic function. In order to classify roads as the trunk, link, main access, collector, and feeder, two approaches can be followed. The first approach is more traditional which involves ranking of roads using a multi-criteria analysis, and the second approach is a method of classifying roads based on the link and/or intended link to Traffic Generating Areas /TGA/. ERA’s road functional classification is based on the second approach, Traffic Generating Areas /TGA/<sup>13</sup>.

As set forth in ERA’s road functional classification manual, the extent factors for traffic generation influenced by either demography, Agriculture including livestock, mines and quarries, industry, services, and international road transport connection<sup>13</sup>.

The main international road transport connections or boarder points from where traffic possibly flows are Humera, Mereb river/Adi Abun, and Zalambesa on North of Ethiopia/ Eretria border, Galafi and Dewele on East of Ethiopia/ port of Djibouti, Togo-chale at the east side of Jijiga and Dolo at East of Negele along South-East of Ethiopia/ Somalian border, Moyale on South of

Ethiopia/Kenyan Border, Kurmuk at North of Asosa along West of Ethiopia/Sudan border and Metema at the west of Gondar on North-West of Ethiopia/Sudan border<sup>13</sup>.

### 2.3 Road Maintenance and Construction Budget

Ministry of Finance used to allocate budget for road maintenance works in order to maintain or preserve the road assets. Later on, the financier changed and Office of Road Fund has become the only maintenance works financier<sup>12</sup>.

The proportion of budget allocation for road maintenance was 70% for federal roads, 20% for regional roads and 10% for municipal roads. However, despite the fact of continuous federal road network increment, the road maintenance budget in 2015 has dropped to 65% for federal roads which are administered by Ethiopian Roads Authority<sup>12</sup>.

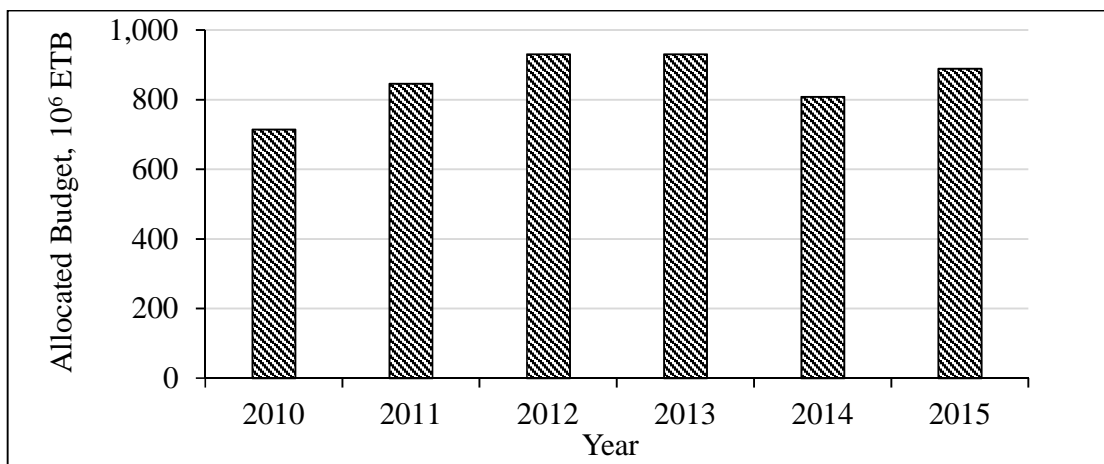


Figure 2-3. Road Maintenance Budget (Routine and Periodic)<sup>9</sup>

On the contrary, FDRE has been allocating billions of ETB for each year to construct/upgrade/rehabilitate the road asset.

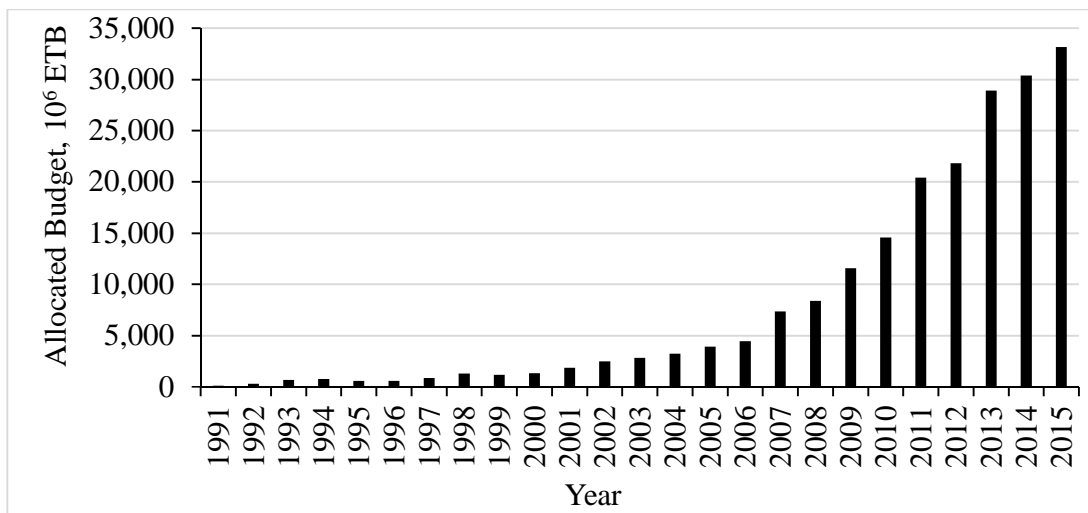


Figure 2-4. Road Construction/Rehabilitation Budget<sup>14</sup>







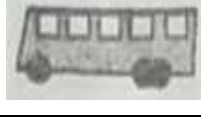

**2.4 Road damage and factors for road damage**

**2.4.1 Traffic**

As set forth under ERA’s Pavement Design Manual<sup>15</sup>, “the deterioration of paved roads caused by traffic results from both the magnitude of the individual wheel loads and the number of times these loads are applied. It is necessary to consider not only the total number of vehicles that will use the road but also the wheel loads (or, for convenience, the axle loads) of these vehicles.”

ERA has been conducting traffic counting in three cycles per year at the selected spots using the under shown traffic count template as shown in Table 2-2 below<sup>9</sup>.

*Table 2-2. Traffic Count Template<sup>9</sup>*

| Vehicle Description and types   | Vehicle Capacity                     | Vehicle Description and types  | Vehicle Capacity                                 |
|---|--------------------------------------|--|--|
| Car          | Small cars up to 4 passenger seats   | Small Truck        | Small and light trucks up to 3.5 tons load       |
| Land Rover  | Medium cars up to 12 passenger seats | Medium Truck      | Medium sized trucks from 3.5 up to 7.5 tons load |
| Small Bus  | Small Bus up to 27 passenger seats   | Heavy Truck      | Trucks from 7.5 up to 12 tons load               |
| Large Bus  | Large Bus over 27 passenger seats    | Truck & Trailer  | Trucks trailers above 12 tons load               |

**2.4.2 Axle Load**

Vehicle axle overload predominantly affects road durability which reduces pavement life and over stresses bridges and culverts<sup>16</sup>. As TRL<sup>8</sup> mentioned, “the relationship between axle load and road damage is a power relationship which means that doubling the axle load will not simply double the damaging effect, but will increase it by over 22 times”. Thus, the damage of pavement caused by overloaded vehicles is in excess of what legally loaded vehicles cause and by reducing overloading, a significant road maintenance cost saving can be achieved<sup>16</sup>.

In all calculations, the equivalent standard axle loads (ESALs) or E80s are calculated using the following formula<sup>15,16</sup>.

As per ERA flexible pavement design manual, 2013;

$$\text{Equation 2-1: } EF = (L/8160)^n \dots\dots\dots \text{ (For loads in Kg)}$$

$$\text{Equation 2-2: } EF = (L/80)^n \dots\dots\dots \text{ (For loads in KN)}$$

Where; EF = Equivalency factor or damage factor /DF/, L = Axle load, and n = Damage exponent ('n' commonly ranges between 4 and 4.5 depending on pavement strength, hence, ERA manual uses 4.5)<sup>15</sup>

*Table 2-3. Average equivalency factors for different vehicle types<sup>15</sup>*

| Class | Type                 | No of axles | Average ESA per vehicle - all loaded | Average ESA per vehicle - half loaded <sup>(1)</sup> |
|-------|----------------------|-------------|--------------------------------------|--|
| 1     | Car                  | 2           | -                                    | -  |
| 2     | 4-wheel drive        | 2           | -                                    | -  |
| 3     | Minibus              | 2           | 0.3                                  | 0.15   |
| 4     | Bus/coach            | 2           | 2.0                                  | 1.0  |
| 5     | Small truck/PU       | 2           | 1.5                                  | 0.7  |
| 6     | Medium truck         | 2           | 5                                    | 2.5  |
| 7     | Large 2-axled truck  | 2           | 10                                   | 5  |
| 8     | 3-axled truck        | 3           | 12                                   | 3.5  |
| 9     | 4-axled truck        | 4           | 15                                   | 7.5  |
| 10    | 5-axled truck        | 5           | 17                                   | 8.5  |
| 11    | 6-axled truck        | 6           | 17                                   | 8.5  |
| 12    | 2-axled trailer      | 2           | 10                                   | 5  |
| 13    | 3 or 4-axled trailer | 3/4         | 12                                   | 6  |

Most researches in the world show that 60% (approximately) of road damage is the effect of overloading heavy vehicles<sup>7</sup>. A problem of overloading is a major issue in most of Sub-Saharan African countries which is not only expedite the road damage rate but also increases road maintenance/rehabilitation funding. It has high contribution to impaired road condition as well as extreme cost of transport. The estimated cost of overloading were found to be more than US\$4 billion per year in East and Southern Africa. These cost can be avoided by implementing effective heavy overload control<sup>17</sup>.

Thus, overload control is necessitated to protect the road infrastructure from damage, ensure a level of service, minimize the extent of maintenance required, and improve safety<sup>7</sup>. Therefore, the aim of weighbridges is "to prevent overloaded vehicles from operating on the road network"<sup>7</sup>.

## 2.5 Vehicle weight control

The effectiveness of vehicle weight control is highly influenced by location, design and infrastructure, and Operations and Management<sup>18</sup>.

### 2.5.1 Location of vehicle weight control stations

As set forth in the report of study made by COMESA-EAC-SADC for the development of tripartite Regional Weighbridge location plan for east African countries<sup>18</sup>, "A well-designed weighbridge, equipped with state- of-the-art weighing and computer systems and being operated by highly capable personnel, will not be efficient if it is located at the wrong position" so that location is the most critical aspect. For this reason, as mentioned in Botswana Axle Load Surveys<sup>6</sup>, the choice of

location have a significant impact on the success of Control Station and location “should be on a road stretch with good visibility so the traffic will be aware of the survey well in advance and provide ample time to slow down and stop”.

In other words, TRL<sup>8</sup> mentioned that the safety, ease and accuracy axle load measuring will depend on very largely on the choice of the site.

There are three important aspects that should be considered while the determination of optimum location for vehicle overload control stations. These are economic viability, strategic matters, and local aspects. Strategic matters that should be considered are location of existing control station, port of entry, traffic generating areas, by-pass routes to avoid a weighbridge and roads with high traffic volumes. The matters that include topography of the site, geometric standards, and the presence of services (like electricity, water, ICT), the nearness of existing weighing bridges, cost of land and environmental impacts will be considered as local aspects<sup>18</sup>.

“A weighbridge is economical if the saving in pavement maintenance is greater than the costs of the weighbridge. The saving depends on the length of road that the weighbridge controls.”<sup>19</sup> The selection criteria for strategic weighbridge location/weighbridge network on the road network are<sup>20</sup>;

1. Traffic volume of heavy vehicle along the road section
2. Availability of necessary facilities to reduce inconvenience for both heavy vehicle operators and the overload control personnel
3. Future road network growth and heavy vehicle traffic generation; and
4. The presence of weighing facilities across the border in case of cross-border traffic.

Besides this criterion set above, there is two methods of weighbridge evaluation location tools<sup>7</sup>. These are, “the overload control index method (OLCI) and “First order” weighbridge location curve which is a plot of the OLCI against different ranges of location”.

First order weighbridge location curve is an evaluation method used to point toward weighbridges preliminary optimal location/Spacing which will need some adjustments to go along with the strategic aspects of selection for weighbridge location. It is obtained from a plot of OLCI and different ranges of road lengths<sup>7</sup>.

*Table 2-4. “First-order” weighbridges locations<sup>7</sup>*

| <b>Length of Road (km)</b> | <b>No. of weighbridges</b> | <b>Location</b>                                |
|----------------------------|----------------------------|--|
| < 200                      | 0                          |  |
| 200 - 500                  | 1                          | Middle of the road                             |
| 500 - 750                  | 2                          | Either end of the road                         |
| 750 - 900                  | 3                          | Either end of the road and in the middle       |
| 900 - 1,150                | 4                          | Either end of the road and two in the middle   |
| > 1,150                    | 5                          | Either end of the road and three in the middle |

Locating frequent weighbridges along any road corridors at relatively close intervals will cause substantial delays to heavy vehicle traffic which contribute to additional transportation cost. On the other hand, vehicles may stay for hours which may lead to traffic congestion in and near the station. For this reason, it is necessary to optimize number and location of weighbridges to increase the effectiveness of overload control<sup>7</sup>.

In addition to the location of the weighing stations, the weighing system should have two weighing pad to make the system more comprehensive when the traffic flow is from medium to high i.e. freight vehicles per hour in both road directions is over 30,. Whereas, for road section having low traffic volume in which the heavy vehicles volume is less than 30 vehicles per hour, one set of weighing equipment is enough<sup>8</sup>.

### *Location of existing Weighbridges*

Currently, there are ten weighbridges under ERA Road Asset Management vehicle weight and size control team which are operational for 24/7. They are located at Modjo, Awash, Dengego, Shashemene, Holota, Alemgena, Sululta, Jimma, Combolcha and Sandafa<sup>9</sup>.

*Table 2-5. List of weighbridge locations<sup>9</sup>*

| No | Location   | Launched (Year) | Distance from Addis Ababa (Km) | Trunk roads served by Control Station |
|----|------------|-----------------|--------------------------------|---------------------------------------|
| 1  | Modjo      | 1980/81         | 71                             | Addis-Modjo-Awash                     |
|    |            |                 |                                | Addis-Modjo-Hawassa                   |
| 2  | Awash      | 1980/81         | 226                            | Awash-Mille-Gallafi                   |
|    |            |                 |                                | Awash-Harar/Dire Dawa-Dewelle         |
| 3  | Dengego    | 1993            | 507                            | Harar-Jijiga                          |
|    |            |                 |                                | Dire Dawa-Dewelle                     |
| 4  | Shashemane | 1987/88         | 250                            | Shashemane-Hawassa-Moyale             |
|    |            |                 |                                | Shashemane-Arbaminch-Jinka            |
|    |            |                 |                                | Shashemane-Dodola-Goba                |
| 5  | Holota     | 1988/89         | 24                             | Addis-Nekemt-Assosa                   |
| 6  | Alemgena   | 1980/81         | 19                             | Addis-Welkite-Jimma                   |
| 7  | Sululta    | 1980/81         | 11                             | Addis-D/Markos-Gonder                 |
| 8  | Jimma      | 1993            | 352                            | Jimma-Matu-Kombolcha                  |
|    |            |                 |                                | Jimma-Bonga-Mizan                     |
| 9  | Combolcha  | 1989/90         | 376                            | Addis-Desse-Mekelle                   |
|    |            |                 |                                | Combolcha-Mille                       |
| 10 | Sandafa    | 2006            | 30                             | Addis-Combolcha                       |

## 2.5.2 Vehicle Weight Control Stations Operations and Management

In order to make sure whether goals of ERA in controlling overloaded vehicles are achieved or not, it is necessary to evaluate operations management performance. "Performance evaluation" as it is defined under traffic engineering elements<sup>21</sup>, it is "a means by which engineers can rate the operating characteristics of individual sections of facilities and facilities as a whole in relative section"

Measuring performance is all about confirming a service or work output is being served as per the requirements<sup>22</sup>. "Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of an action"<sup>23</sup>. Besides, performance measures will help us to know the facts that "how well we are doing if we are meeting our goals, if our customers are satisfied, if our processes are in statistical control and if and where improvements are necessary"<sup>22</sup>.

In most cases, performance measures can be categorized in to six common categories. These are, effectiveness: which is "a process characteristic indicating the degree to which the process output (work product) conforms to requirements", efficiency: which is "a process characteristic indicating the degree to which the process produces the required output at minimum resource cost, quality: which is "the degree to which a product or service meets customer requirements and expectations, timeliness: which "measures whether a unit of work was done correctly and on time", productivity is "the value added by the process divided by the value of the labour and capital Consumed" and safety: which "measures the overall health of the organization and the working environment of its employees"<sup>22</sup>.

"An effective axle load control system helps the road management authority in many ways"<sup>24</sup>. These are:

- ✓ It slows down the rate of road deterioration which leads to protection of the investment made for roads and bridges.
- ✓ It helps in saving road maintenance or improvement works cost by delaying periodic maintenance.
- ✓ It contributes a significant role in minimizing road damage at curves by reducing the tractive forces.
- ✓ Protects the road and bridges from premature failure by controlling.
- ✓ Improves the riding quality of roads by minimizing road damage due to overloading which reduces vehicles fuel consumption and VOC.
- ✓ It has a significant role in improving road safety as reduced payloads make weight – engine power ratios are improved and vehicle control becomes easier.

As it is required to set binding law for the enforcement of overload control, Ethiopian Roads Authority/ERA/ has vehicle weight and size control regulation<sup>25,26</sup> which helps it to maintain the system functioning well and meet all the above mentioned importance of vehicle overload control. The regulation clearly sets allowable vehicles axle load and size measures except the Gross vehicle weight /GVW/.

*Table 2-6. Allowable vehicle axel load<sup>25</sup>*

| I.N | Type of axle/group of axles  | Allowable AXL limit (Ton) | Allowable Tolerance |
|-----|--|---------------------------|---------------------|
| 1   | Front axle   | 8                         | -                   |
| 2   | Rear axle with dual tyre   | 10                        | -                   |
| 3   | Tandem axle group (the axle spacing shall not be is greater than 1.3m)   | 17                        | -                   |
| 4   | A group of two axles axle spacing more than 1.3m or group of three axles | 10 (per axle)             | -                   |

Mostly the actual measuring value for vehicles having 'rear axle with dual tyre' will be higher than the allowable axel limit since most of the load is carried by this rear axles. In such cases, unless the vehicle capacity set by Transport Minister is not violated, the vehicles are measured in GVW<sup>25</sup>.

*Table 2-7. Allowable vehicle dimension<sup>25</sup>*

| I.N | Description   | Unit | Dimension |
|-----|---|------|-----------|
| 1   | Overall outside width of motor vehicle, trailer or semi-trailer   | m    | 2.5       |
| 2   | Overall height of motor vehicle, trailer or semi-trailer  | m    | 4.2       |
| 3   | Overall length of single motor vehicle (rigid chassis), including the front and rear bumpers or load  | m    | 12        |
| 4   | Overall length of articulated vehicle or truck tractor and its trailer, including the front and rear bumpers or load  | m    | 17        |
| 5   | Vehicle carrier/a combination of truck tractor and vehicle carrier/a combination of truck tractor and low-bed semi-trailer including the front and rear bumpers as well as its load | m    | 18        |

#### A) Weighbridge and controlling system

The most important part of country's OLC activities is "the selection, installation, and operation of weighbridges". There are different kinds of weighbridges, namely, mobile and stationary/fixed weigh bridge based on the type. On the other hand, weighbridge also can be categorised as static and dynamic weigh bridge based on method of weighing.<sup>20,27</sup>

Table 2-8. Types of weighbridges and their characteristics<sup>27</sup>

| Type of weighbridges<br><br>Method of weighing |   | Fixed weighbridges  | Mobile weighbridges   |
|--|---|---|---|
|  |   |   | <ul style="list-style-type: none"> <li>• Easy to operate</li> <li>• Minimum personnel</li> <li>• Cargo off-loading</li> <li>• High installation costs</li> <li>• Limited placement</li> </ul> |
| <b>Static</b>                                  | <ul style="list-style-type: none"> <li>• More precision</li> <li>• Accepted for legal enforcement</li> <li>• Slower</li> </ul>            | <ul style="list-style-type: none"> <li>• Easiest to operate</li> <li>• Highest level of precision</li> <li>• Can weigh and register axle groups</li> </ul>  | <ul style="list-style-type: none"> <li>• Lowest investment</li> <li>• Optimal for enforcement</li> </ul>  |
| <b>Dynamic</b>                                 | <ul style="list-style-type: none"> <li>• Rapid monitoring</li> <li>• Lower precision</li> <li>• Not acceptable for enforcement</li> </ul> | <ul style="list-style-type: none"> <li>• Rapid monitoring</li> <li>• Requires large installation</li> <li>• Requires careful direction of vehicles</li> <li>• Generally not accepted for enforcement</li> </ul> | <ul style="list-style-type: none"> <li>• Minimum disruption of commercial traffic</li> <li>• Lowest accuracy</li> <li>• Excellent for statistical monitoring</li> </ul>                       |

Fixed Weighbridges; can be grouped as axle unit weighbridge, multi-deck weighbridge and single axle weighbridge which is widely used. Multi-deck weighbridge is very efficient, easy calibration, difficult to manipulate the weighing process, and it is most recommended one<sup>17</sup>.

Mobile Weighbridge; portable weighing equipment which are not accurate and not recommended for penalization/ law enforcement<sup>17</sup>.

Weigh-In-Motion scales/WIM/; system as fixed/dynamic weighing which can be grouped as high speed weigh in motion system and low speed weighing in motion system<sup>20,27</sup>. There are also satellite (virtual) weighing stations which deploy WIM system<sup>27</sup>.

Besides the presence of weighbridges, weighing stations requires an integrated system of weighing, load recordings, administration of overload offence and reporting. This integrated system can be supported by ID tag readers, camera, boom, traffic signals, control loop, and loggers. Procedures should also be followed at overload control stations in relation to weighing, load recordings, administration of overload offence and reporting as well as maintenance and calibration of weighing bridge.<sup>28</sup>

General process of procedures are presented as follows<sup>28</sup>:

1. Traffic signals are located on the main road for drivers of heavy vehicles to be informed about the presence of weighing station ahead.
2. Entrance to the weighing station is located at suitable spot where heavy vehicle drivers can easily slow the vehicle and enter to the station.
3. Details of vehicle like axle configuration and speed will be recorded while vehicle entering the weighing station prior the vehicle stands on the scale.
4. WIM (if there is) may record axle configuration, vehicle speed and length. Accordingly, it may to screen overloaded vehicle and direct to the static weighbridge.
5. For vehicles having ID tag installed, sensor at the station will detect such vehicles detail information. Digital image of vehicle will be captured with camera which also helps to

capture vehicle plate number.

6. All collected information will be linked to a vehicle being checked and will be verified if the vehicle is within legally allowable limit.
7. After being checked the vehicle will be directed back to the main route if it is within legally allowable limit. Or will be directed to holding area if it is beyond the legally allowable limit and prosecution process will continue.
8. Traffic booms safeguards that “vehicles are following the traffic signal instruction”.

Weighing station is expected to have enough space for the traffic in addition to the weighing area. These are holding area, screening area and supplementary area<sup>28</sup>.

- ❖ Weighing area is a space where vehicles weighing scale putted and it is the centre of operations. The approaching pavement to the scale should be well reinforced and prevented from rutting due to overloaded vehicles, should also be straight to the scale and levelled.
- ❖ Holding area is a space designated for overloaded vehicles to be detained until the vehicle corrects the overloaded quantity to the allowable limit and payment made for the overload penalty.
- ❖ Screening area is a space that should be considered for road corridor having traffic arrival rate of medium or high to screen out the overloaded vehicle from traffic stream.
- ❖ Supplementary area is a space where technically loose vehicles park until the problem is solved. It is may be furnished in on nearby site for the weighing station.

#### **B) Staff composition**

There are different professional specialties required for weighbridge management, operation, and maintenance. These specialties should include on areas of legal issues, electronics system, computer systems, mechanical systems, traffic signalling systems, facilities management, staff management, operations management and maintenance management. In addition to the specialities, the weighbridge should have well trained staff having experience on transport environment, legislation and regulations, weighbridge equipment, weighing operations, software operation, and data management, reporting management, staff management, operations management, maintenance management and safety.<sup>27</sup>

**C) Checking time, congestion and measurement accuracy at control station**

Queue can be formed “when demand exceeds the capacity for a period of time” and it can be either a moving queue or a stopped queue. There are five required input elements. The first is the mean arrival value: it is the rate of flow or it is vehicles arrived per hour, the second is mean service value which is also rate of flow or vehicle served per hour, the third and fourth one is arrival distribution and service distribution which can be stated as deterministic/probabilistic distribution, and the last one is the queue discipline which can be represented by First In First Out (FIFO), First In Last Out (FILO), and Served In Random Order (SIDO)<sup>29,30</sup>. Single server queuing model is one of the different types of queuing models which is the simplest kind of queuing system. In this case, the server is the central element of the queuing system that provides service to customer requests. Customer will be served immediately if the server is idle whereas customer will join waiting for line.<sup>31</sup>

The goal is to measure the performance by answering, how likely is it that heavy vehicle operators will have to wait on hold or the probability of being busy or system utilization? and/or the probability of control station being idle? and/or how long can we expect heavy vehicle operators have to wait on hold?<sup>32</sup> and the like.

Queuing Model – Single server system

*Equation 2-3:*  $L = \lambda * W$  ..... Little's Formula<sup>30,31</sup>

*Equation 2-4:*  $Lq = \lambda * Wq$

*Equation 2-5:*  $W = Wq + (1 / \mu)$

*Equation 2-6:* Average number of units in queue,  $L = \lambda / (\mu - \lambda)$

*Equation 2-7:* Average time in system,  $W = 1 / (\mu - \lambda)$

*Equation 2-8:* Average number of units in queue,  $Lq = \lambda^2 / \mu (\mu - \lambda)$

*Equation 2-9:* Average time in queue,  $Wq = \lambda / \mu (\mu - \lambda)$

*Equation 2-10:* System utilization,  $\rho = \lambda / \mu$

Where:

$\lambda$  = Arrival Rate of Vehicles (Veh/hr),

$\mu$  = Service rate of WB (Veh/hr)

In regard to measurement accuracy at control stations, absolute accuracy cannot be attained in any weighing machine. In fact, the weighing system cannot be accurate all the time due to various external factors, for this reason, some tolerances should be applied<sup>27</sup>

**D) Road traffic Safety and road signs**

A method and/or a measure of minimizing a danger of road users, from being killed and/or badly injured is road traffic safety. These road users can be passengers, cyclists, motorists, and pedestrians. Accidents can occur due to one of three reasons, these are vehicle, driver, and environment.<sup>33</sup>

Traffic control devices are the media by which traffic engineers communicate with drives. Virtually every traffic law, regulation, or operating instruction must be communicated through the use of devices that fall in to three categories; these are traffic markings, traffic signed and traffic

signals. The effective communication between traffic engineer and driver is a critical link if safe and efficient traffic operation is to prevail. The MUTCD provides specification and guidelines for the use of literally hundreds of different signs for myriad purposes. In general, traffic signs all in to one of the three major categories. These are regulatory signs, warning signs and guide signs.<sup>21</sup>

Among traffic signs, one each direction are slow down, Men at work, Weigh Bridge ahead, Speed limit (60 or 50 km/hour), Speed limit 30 km/hour, Prepare to stop, Stop sign, and Arrow sign. All the road signs should be reflective. In addition, a minimum of 20 traffic cones shall be used to direct the traffic in a safety manner. All personnel must wear reflecting vests, not only for traffic safety reason but also to promote authority on site. Figure 2-5 shows the standard layout of placing the traffic warning signs.<sup>6</sup>

In order to warn drivers, road signs must be placed in the advance of the axle load survey and “the first sign should be placed at least at 500m before the weighing site and a series of signs should direct the drivers to slow down, whilst informing them that a weighbridge ahead” which is particularly important for portable weighing devices.<sup>8</sup>

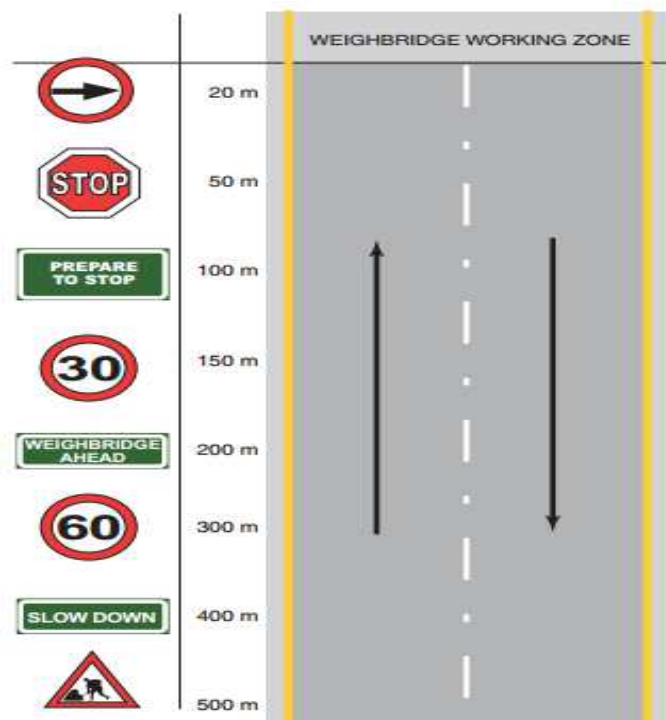


Figure 2-5. Typical road sign layout for axle load control survey sites<sup>8</sup>

Overloading has been recognized as a cost concern to road sector due to the damage that it cause to road/s though it is also a safety concern. Road safety is being threatened by overloaded vehicles operating on the road infrastructure and the same will put people's life, property at risk. The risks that overloaded vehicle can cause are<sup>34</sup>;

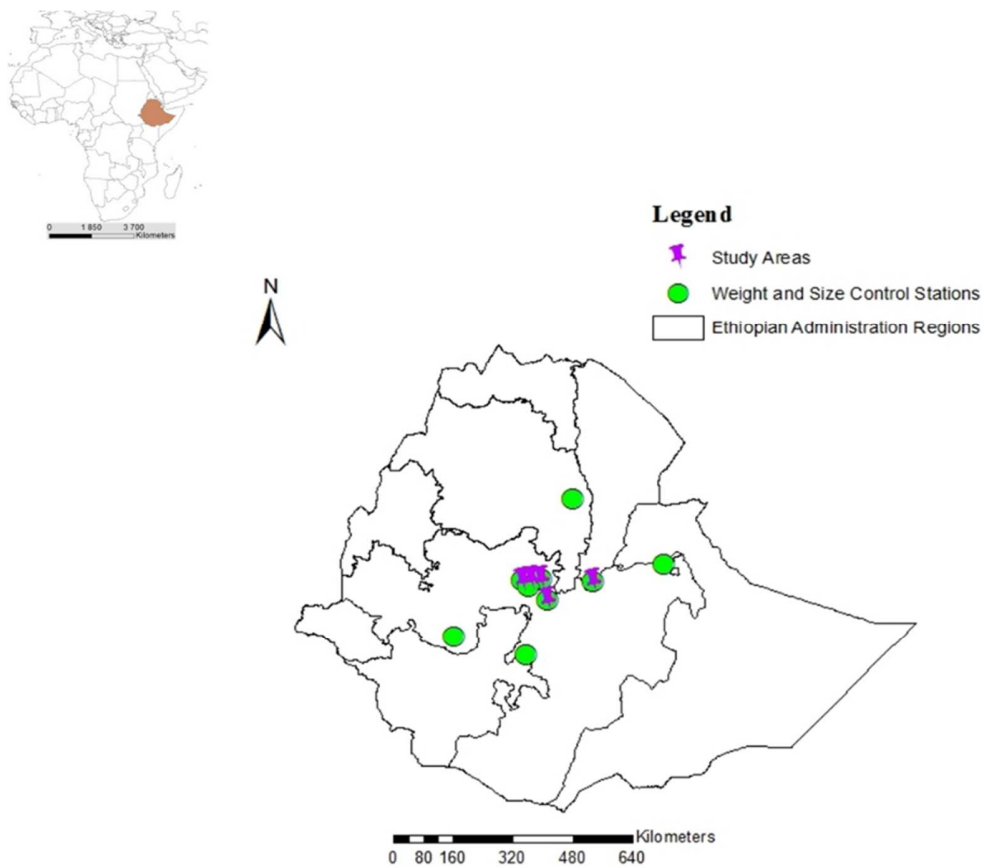
- ⇒ The stability of overloaded vehicle will be less and it will be challenging to steer and take longer distance to stop for drivers as vehicles respond differently when the maximum weights carried exceeds the designed load carrying capacity.

- ⇒ Overheating and rapid wear of tyres can be caused by overloaded which can increase the chance of premature, dangerous and expensive failure or blow-outs.
- ⇒ The operating space and control of the overloaded vehicle will be reduced for drivers will, in turn, increase the chances for an accident to occur.
- ⇒ Overtaking is difficult as the overloaded vehicle cannot accelerate as normal.
- ⇒ During the nights, the headlights of an overloaded vehicle may tilt up, blinding driver's oncoming to possible debris or obstructions on the roadway.
- ⇒ Drivers have to work hard for brakes due to the riding of brakes and because the vehicle is heavier due to overloading. Overheating and lack of effectiveness of brakes may occur to make the vehicle stop.

## CHAPTER 3 MATERIALS AND METHODOLOGY

### 3.1 Site selection, study design, and participants

Awash, Modjo, Sululta, Holota, Alemgena and Sandafa Control Stations were selected for this paper work among the ten static control stations under the Ethiopian Roads Authority which are located at Awash, Modjo, Sululta, Holota, Alemgena, Dengego, Sandafa, Combolcha, Shashemene and Jimma<sup>9</sup> and the assessment is being done for the selected Control Station except Alemgena Control Station which was not included in the assessment since it was closed during the data collection and after data collection is completed.



*Figure 3-1. Locations of the selected stations*

The study included axle load data collection, interviews/questionnaires with stake holders and data analysis has been done for axle load control and operational performance. The participating stake holders' were Ethiopian Roads Authority vehicle size and weight control station staffs, road users, consultants. As road user's/consultant's population is large in number, the selection of participant drivers/professionals were made from the most recognized transport companies and from consulting firms mostly participated in Ethiopian Roads Authority road design project though all population used for vehicle size and weight control station staffs.

### 3.2 Data Collection

The research started by collecting secondary data from the website, books, journal, newspaper, reports and related documents to the subject matter. It then followed by primary data from control stations, interviews/questionnaires of stake holders, from the above mentioned axle load and vehicle size control stations and other countries experience on the subject matter. Summary of collected data is listed in the Table 3-1.

*Table 3-1. Summary of collected data*

| Data   | Data Type      | Duration of Data Collection  | From  |
|--|----------------|--|---|
| Axle load data                                   | Primary data   | Three Weeks Data<br>Week 1: August 1-7, 2015<br>Week 2: August 8-14, 2015<br>Week 3: December 1-7, 2015        | Sululta Vehicle Weight and Size Control station |
|  | Primary data   | Two Weeks Data<br>Week 1: August 17-23, 2015<br>Week 2: January 1-7, 2016                                      | Holota Vehicle Weight and Size Control station  |
|  | Primary data   | Three Weeks Data<br>Week 1: December 12-18, 2015<br>Week 2: December 19-25, 2015<br>Week 3: January 8-14, 2015 | Sandafa Vehicle Weight and Size Control station |
|  | Primary data   | Three Weeks Data<br>Week 1: October 20-26, 2015<br>Week 2: August 24-30, 2015<br>Week 3: September 23-29, 2015 | Modjo Vehicle Weight and Size Control station   |
|  | Primary data   | Three Weeks Data<br>Week 1: July 10-16, 2015<br>Week 2: November 23-29, 2015<br>Week 3: October 12-18, 2015    | Awash Vehicle Weight and Size Control station   |
| Service/Arrival/Departure time of heavy vehicles | Primary data   | One Week Data<br>Week 1: December 1-7, 2015  | Sululta Vehicle Weight and Size Control station |
|  | Primary data   | One Week Data<br>Week 1: January 1-7, 2016   | Holota Vehicle Weight and Size Control station  |
|  | Primary data   | One Week Data<br>Week 1: January 8-14, 2015  | Sandafa Vehicle Weight and Size Control station |
| Questionnaire                                    | Primary data   |  | Consultants<br>Owners/Drivers<br>VWSC personnel |
| 2015 Federal Road Network                        | Secondary Data |  | ERA Road Asset Management                       |
| 2015 Traffic Count                               | Secondary Data |  | ERA Road Asset Management                       |
| 1997 Vehicle Weight and Size Control regulation  | Secondary Data |  | ERA Road Asset Management                       |

### 3.3 Data analysis

In order to address every specific objective of this thesis, different approaches will be followed. These approaches are discussed as follows:

#### 3.3.1 Evaluation of vehicle weight control stations' location

In this section, weighbridge locations were studied and evaluated based on the road network they are covering. Thus, criteria were set to evaluate the same. The selected set of criteria is shown in Table 3-2 below;

*Table 3-2. Criteria considered for evaluation of weighbridge location*

| No | Criteria                        | Score  | Method of analysis  |
|----|---------------------------------|--|---|
| 1  | Volume of heavy vehicle traffic | <ul style="list-style-type: none"> <li>• If the volume of heavy vehicles per hour is less than 30 Veh/hr, it is rated as 1 (low heavy vehicle flow)</li> <li>• If the volume of heavy vehicles per hour is greater than or equal to 30 Veh/hr, it is rated as 2 (medium to high heavy vehicle flow) (Where heavy vehicle/HV/ is <math>\geq 3.5</math> tons)</li> </ul> | <ul style="list-style-type: none"> <li>• Using 2015 traffic count data, volume of heavy vehicle traffic (Medium truck, heavy truck and truck and trailer from ERA Traffic count) grouped in to low and medium to high traffic flow based on TRL's approach<sup>8</sup> (HV &lt;30Veh/hr as low and <math>\geq 30</math>Veh/hr as medium to high heavy traffic flow in relation to axle load survey location and number of weighing facility).</li> </ul>                        |
| 2  | Axle loads                      | <ul style="list-style-type: none"> <li>• If the Damage Factor is <math>\leq 1.5</math>, the rate will be 1</li> <li>• If the Damage Factor is <math>&gt; 1.5</math>, the rate will be 2</li> </ul>   | <ul style="list-style-type: none"> <li>• Using the collected axle load data, the average damaging factor was computed and the distribution of the sample of heavy vehicles using the road sections was determined.</li> <li>• The range (<math>\leq 1.5</math> or <math>&gt; 1.5</math>) was taken considering vehicles having lesser damaging influence as compared with the standard axle according to ERA flexible pavement manual<sup>15</sup></li> </ul>                   |
| 3  | Distance to ports-of-entry      | <ul style="list-style-type: none"> <li>• If distance to ports-of-entry is:<br/> <math>&gt; 500</math>km, rated as = 1<br/> <math>&lt; 200-500</math>km, rated as = 2<br/> <math>\leq 200</math>km, rated as = 3</li> </ul>   | <ul style="list-style-type: none"> <li>• The road length ranges were adopted from the "first-order" weighbridges locations assumptions<sup>18</sup>.</li> <li>• The approach was developed from a curve which was a plot of the Overload Control Index against road length for different ranges of location. "It was used to indicate preliminary optimal location/ spacing of weighbridges in forming a network". (2015 ERA road network data was used<sup>9</sup>)</li> </ul> |

| No | Criteria                                   | Score  | Method of analysis  |
|----|--|--|---|
| 4  | Distance to nearby weighing station        | <ul style="list-style-type: none"> <li>• If there is no weighing station along the stretch and distance to port is <math>\geq 500\text{km}</math>, rated as = 0</li> <li>• If nearby weighing station is at distance:               <ul style="list-style-type: none"> <li><math>\geq 500\text{km}</math>, rated as = 1</li> <li><math>&lt; 200-500\text{km}</math>, rated as = 2</li> <li><math>\leq 200\text{km}</math>, rated as = 3</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>• The same above approach was used and assumption</li> </ul>                   |
| 5  | By-pass routes to avoid a weighing station | <ul style="list-style-type: none"> <li>• Existence of by pass routes               <ul style="list-style-type: none"> <li>= 0 (yes)</li> <li>= 1 (No)</li> </ul> </li> </ul>   | <ul style="list-style-type: none"> <li>• Rating was an assumption and 2015 ERA road network data was used.</li> </ul> |

Grades were given for each weighing station as per the ratings stipulated in Table 3-2 for the evaluation of weighing station location in regard to each criteria. Hence, based on the rates, the percentage score for control station was done by:

$$\text{Equation 3-1: } \% \text{ Score of weighing station} = ((\sum \text{Control station score}) / \text{Total Score}) * 100\%$$

For the percentage comparison, the following assumption were made for contribution of control station location along the road section in controlling vehicle overload.

$< 50\%$  = Unsatisfactory or not enough,  $50 - 70\%$  = Average,  $70 - 90\%$  = Good and  $90 - 100\%$  = Very good.

### 3.3.2 Vehicle Weight Control Operations Management Performance Evaluation

#### A) Effectiveness of vehicle weight control station

The goal was to confirm that all heavy vehicles are legally loaded and sized as per the requirement which in turn the authority will be able to meet the purpose of vehicle weight and size control. So that the axle load data collected from the weighing stations were studied under this section according to the vehicle weight and size control regulation. Whereas, the total number of overloaded vehicles implied by the extent of overloading and, the average overload of overloaded vehicles implied by the degree of overloading.<sup>18</sup> In line with this, the number of penalized heavy vehicles was compared with that of vehicles actually found overloaded. In order to compute for extent and degree of overloading, the following steps are followed;

1. Overload for all types of vehicles at each axle were computed
  - $\Rightarrow$  Overload at an axle = Axle load reading – Allowable axle load
2. Total Overload was computed
  - $\Rightarrow$  Total Overload =  $\sum$  Overload at each axle
3. The range for degree of overloading has been set based on the actual trend on site and regulation.
  - $\Rightarrow$  No over loading (the reading is below or equal to the allowable limit)
  - $\Rightarrow$  The selected overloading ranges used for analysis were 0-1 ton, 1-2.5 ton, 2.5-5 ton, 5-10 ton and over 10 ton.
4. The number of overloaded vehicles based on the set ranges of overload has been done for comparison.

**B) Efficiency of Vehicle Weight Control station**

The firm can achieve its target when it performs by satisfying road users with a great efficiency and effectiveness.<sup>35</sup> Stake holder's satisfaction survey has been made through questionnaires to evaluate how efficiently the weight and size control station is performing.<sup>35</sup> In order to measure resource capacity, quality, and time, response category grouped as poor, good, very good and excellent for resource capacity and quality.

Thus, three types of questionnaires/interview have been prepared for employees, drivers, and consultants. The employers were asked about the availability of necessary facilities for the achievement of the overall target and the drivers and consultants questioned on the quality and time of work. The performance of stations in relation to time, will be dealt by queuing analysis.

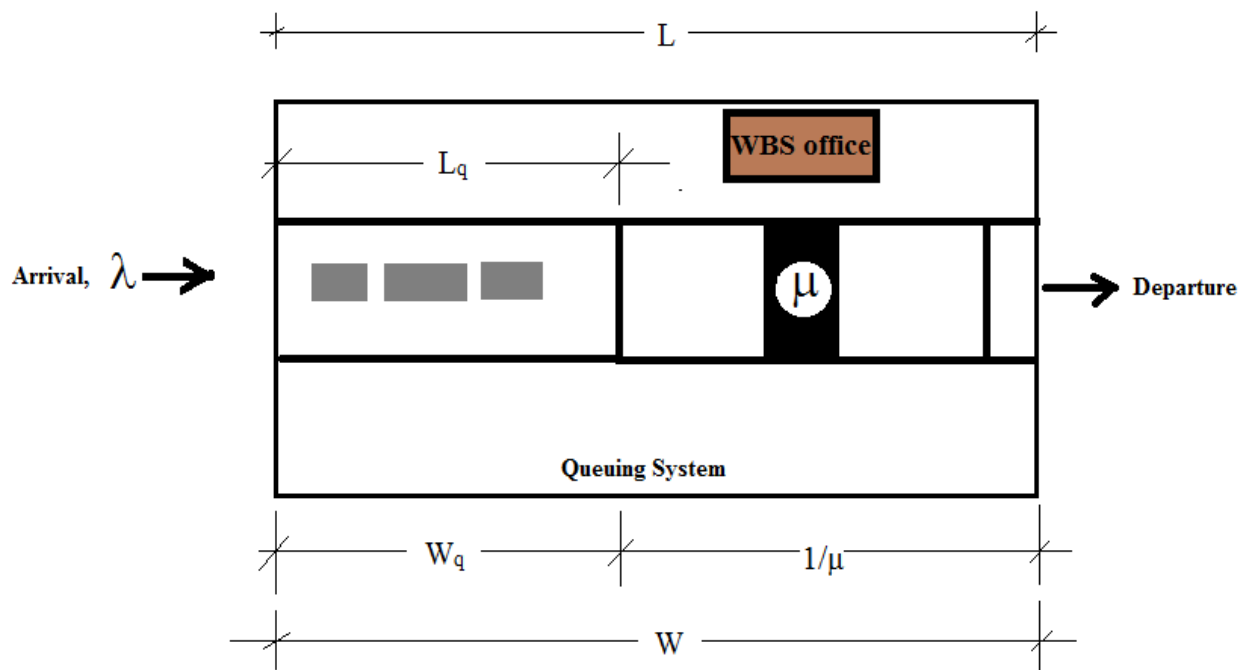


Figure 3-2. Queuing model

## CHAPTER 4 RESULTS

### 4.1 Evaluation of control stations' location

The existing weight control stations locations are evaluated based on the selected main factors related to the effectiveness of weight control stations. The overall evaluation result for all selected stations is presented in Table 4-1 as per the evaluation rating stipulated in Table 3-2. Detailed explanation of volume of heavy vehicle traffic (vehicles capacity  $\geq 3.5$  tons), overloading trend (axle loads), distance to ports-of-entry and/or TGA, distance to nearby weighbridge and by-pass routes to avoid a weighbridge as well as the data used to describe the rating is presented below under section 4.1.1, 4.1.2, 4.1.3, 4.1.4 and 4.1.5.

Table 4-1. Summary of location evaluation

| No                 | Criteria                              | Max. Score  | WBS        |            |            |                 |                      |                   |                 |
|--------------------|---------------------------------------|-------------|------------|------------|------------|-----------------|----------------------|-------------------|-----------------|
|                    |                                       |             | Sululta    | Holeta     | Sendafa    | Modjo           |                      | Awash             |                 |
|                    |                                       |             |            |            |            | Awash Direction | Shashemene Direction | Dengego Direction | Modjo Direction |
| 1                  | Volume of heavy vehicle traffic       | 2           | 2          | 2          | 1          | 2               | 2                    | 2                 | 2               |
| 2                  | Overloading trend                     | 2           | 2          | 2          | 2          | 2               | 2                    | 2                 | 2               |
| 3                  | Distance to ports-of-entry and/or TGA | 3           | 1          | 1          | 1          | 1               | 1                    | 1                 | 1               |
| 4                  | Distance to nearby weighbridge        | 3           | 0          | 0          | 2          | 3               | 3                    | 2                 | 3               |
| 5                  | By-pass routes to avoid a weighbridge | 1           | 0          | 0          | 1          | 0               | 1                    | 0                 | 0               |
| <b>WBS Score</b>   |                                       | <b>11</b>   | <b>5</b>   | <b>5</b>   | <b>7</b>   | <b>8</b>        | <b>9</b>             | <b>7</b>          | <b>8</b>        |
| <b>Total Score</b> |                                       | <b>11</b>   | <b>11</b>  | <b>11</b>  | <b>11</b>  | <b>11</b>       | <b>11</b>            | <b>11</b>         | <b>11</b>       |
| <b>% Score</b>     |                                       | <b>100%</b> | <b>45%</b> | <b>45%</b> | <b>64%</b> | <b>73%</b>      | <b>82%</b>           | <b>64%</b>        | <b>73%</b>      |

As shown above, Sululta and Holota scores less than 50% which shows that the contribution of the station for overload control considered as unsatisfactory as per the assumption made under section 3.3.1. Whereas, the rest falls under from average to good. From the result, all station needs improvements in relation to the considered factors and the detailed evaluation is presented as follows:

#### 4.1.1 Sululta vehicle weight and size control station

##### A) Volume of heavy vehicle traffic

Sululta vehicle weight and size control station is located at about 11km km from Addis Ababa and the average daily number of vehicle served by the station during the study was 48. According to ERA's 2015 AADT data, even though hourly traffic flow for some sections is less than 30 veh/hr considering the road sections served by the station, Sululta control station considered as a medium to high (rate = 2). Vehicles stipulated as 'total HV/day from total traffic' in Table 4-2 are vehicles that supposed to be measured at the station (vehicles capacity  $\geq 3.5$  tons).

Table 4-2. Nature of traffic flow on the road sections served by Sululta weighbridge station

| Trunk roads served by control station | Road length (km) | 2015 AADT           |                                 |       | Relative Road Class. |
|---------------------------------------|------------------|---------------------|---------------------------------|-------|----------------------|
|                                       |                  | Total Traffic Count | Total HV/day from total traffic | HV/hr |                      |
| Addis Ababa-Comando                   | 113              | 3,578               | 1,708                           | 71    | MH-HV                |
| Comando-Dejen                         | 116              | 1,783               | 751                             | 31    | MH-HV                |
| Dejen-D/Markos                        | 70               | 1,511               | 591                             | 25    | L-HV                 |
| D/Markos-Burie                        | 112              | 1,539               | 538                             | 22    | L-HV                 |
| Burie-Dangila                         | 74               | 1,420               | 502                             | 21    | L-HV                 |
| Dangila-Bahirdar                      | 78               | 3,468               | 981                             | 41    | MH-HV                |
| Bahirdar-Wereta                       | 57               | 2,362               | 992                             | 41    | MH-HV                |
| Wereta-A/Zemen                        | 25               | 1,653               | 598                             | 25    | L-HV                 |
| A/Zemen-Azezo Air Port                | 78               | 1,152               | 379                             | 16    | L-HV                 |
| Azezo Airport-Gonder                  | 15               | 432                 | 94                              | 4     | L-HV                 |
| Chancho-Muger                         | 23               | 2,569               | 2,035                           | 85    | MH-HV                |
| Injibara-Chagne                       | 57               | 634                 | 233                             | 10    | L-HV                 |
| Chagine-Guba                          | 182              | 591                 | 343                             | 14    | L-HV                 |
| Wereta-Weldiya                        | 300              | 836                 | 332                             | 14    | L-HV                 |
| Azezo-Metema                          | 185              | 732                 | 127                             | 5     | L-HV                 |

### B) Axle loads

The average damage factor for all types of vehicle was computed from Axle loads of vehicles operating along the road sections served by the weighbridge,  $DF = 13.17$  (where 90% of vehicles axles were found beyond the legally allowable limit).

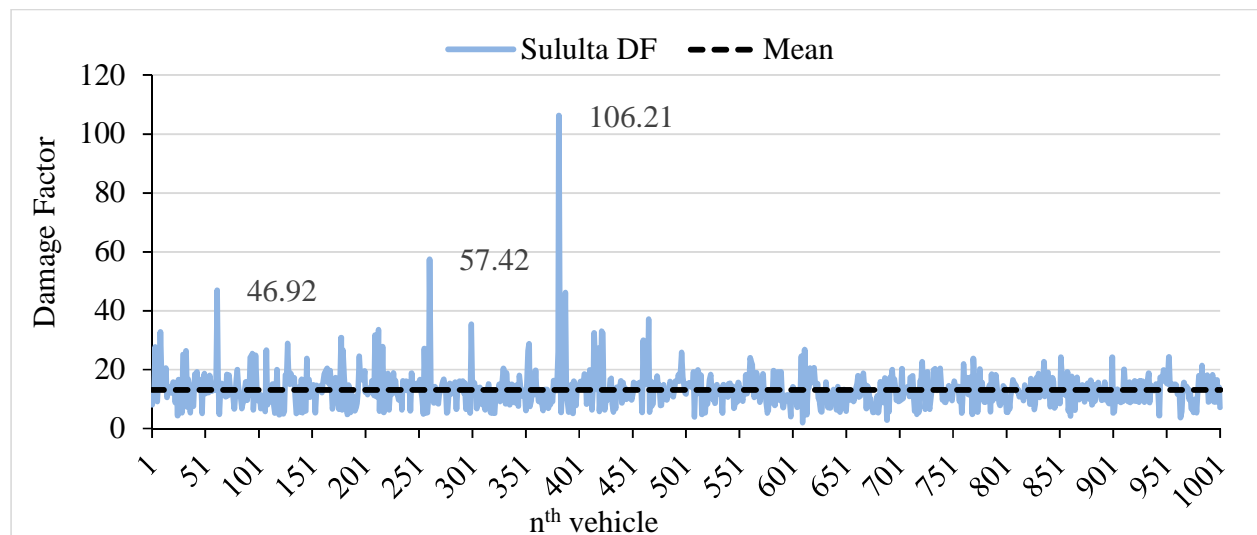


Figure 4-1. Damage factor vs vehicle (for both direction) at Sululta Control Station

As shown from Figure 4-1, most damage factors were around the mean. Even though, only 7% of heavy traffic (vehicles capacity  $\geq 3.5$ ) is weighed at control station, the damage factor is significant (13.17). Where the percentage of heavy traffic computed by dividing vehicles weighed to average traffic along road sections. So that, Sululta Control Station is rated as 2 as the traffic on road sections served by the weighbridge has damaging effect greater than 1.5 (see section 2.4.2 Table 2-3).

**C) Distance to ports-of-entry/Traffic Generating area**

Sululta weight and size control station is located at 11 km from Addis Ababa and 717km, 889km, and 965km from Gondar, Metema and Humera respectively which are possible traffic generating areas<sup>13</sup>. As the Station covers the longer length of the road section,  $\geq 500$ km, it is given 1.

**D) Distance to nearby weighing station**

No weighbridge is located neither in the vicinity of station nor at any section of the road after the station so it is rated as zero.

In regard to vehicles travelling through Addis Ababa and heading to other ports, the station importance were evaluated in relation to vehicles damaging effect presented under axle load analysis.

**E) By-pass routes to avoid a weigh bridge;**

Heavy vehicles travelling from Gondar/Metema/Humera to Woldia-Mekele can easily by pass the station through Woreta-Woldia. Thus, the station rated as zero.

The overall evaluation of the effectiveness of Sululta weight and size control station, 45% of the criteria is met.

### 4.1.2 Holota vehicle weight and size control station

#### A) Volume of heavy vehicle traffic

Holota vehicle weight and size control station is located at about 24km from Addis Ababa and the average daily number of vehicle served by the station during the study was 85. According to ERA's 2015 AADT data, even though hourly traffic flow for an intermediate road sections is less than 30 veh/hr, the road sections served by Holota control station considered as a medium to high (rate = 2) as there is high traffic flow from/to Muger and Dangote Cement Factory. Vehicles stipulated as 'total HV/day from total traffic' in Table 4-3 are vehicles that supposed to be measured at the station (vehicles capacity  $\geq 3.5$  tons).

*Table 4-3. Nature of traffic flow on the road sections served by Holota Control Station*

| Trunk roads served by control station | Road length (km) | 2015 AADT           |                                 |       |                      |
|---------------------------------------|------------------|---------------------|---------------------------------|-------|----------------------|
|                                       |                  | Total Traffic Count | Total HV/day From total traffic | HV/hr | Relative Road Class. |
| A.A-Ambo                              | 126              | 5,371               | 2,658                           | 111   | MH-HV                |
| Ambo-Bako                             | 125              | 1,646               | 677                             | 28    | L-HV                 |
| Bako-Nekemte                          | 81               | 1,178               | 407                             | 17    | L-HV                 |
| Nekemte-Gimbi                         | 113              | 764                 | 360                             | 15    | L-HV                 |
| Gimbi-Mekenajo                        | 14               | 1,048               | 535                             | 22    | L-HV                 |
| Mekenajo-Asossa                       | 220              | 506                 | 208                             | 9     | L-HV                 |
| Asossa-Kurmuk                         | 96               | 251                 | 75                              | 3     | L-HV                 |
| Holota-Muger                          | 73               | 4,883               | 2,951                           | 123   | MH-HV                |

#### B) Axle loads

The average damage factor for all types of vehicle is computed from Axle loads of vehicles operating along the road sections served by the control station (Addis Ababa – Ambo – Nekemte – Assosa DF = 12.20 and Holota – Muger DF = 12.10) where 94% of the weighed vehicles axles where found beyond the legally allowable limit.

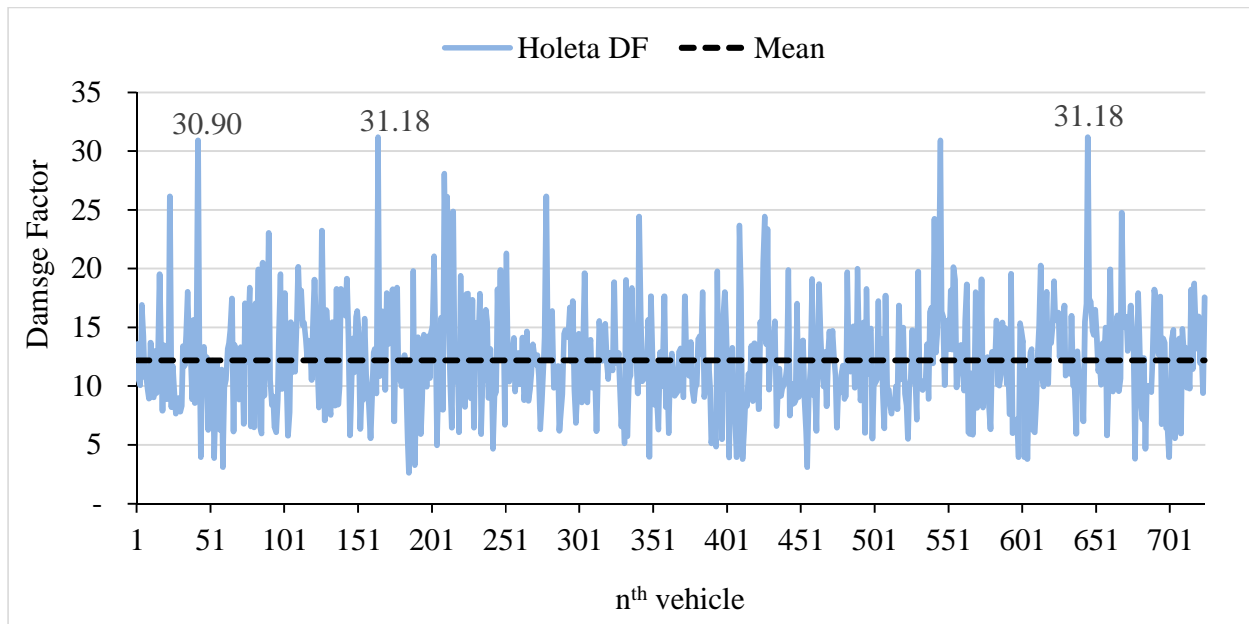


Figure 4-2. Damage factor vs vehicle (for A.A-Holota-Muger direction) at Holota Control Station

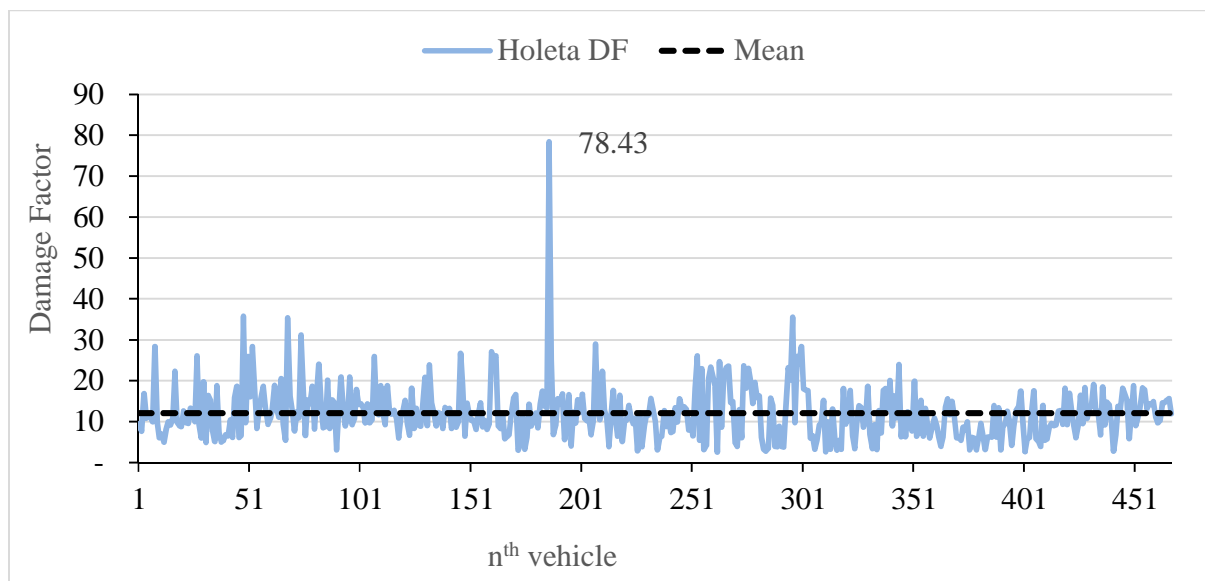


Figure 4-3. Damage factor vs vehicle (for A.A-Ambo-Nekemte-Asossa direction) at Holota Control Station

As shown from Figure 4-2 and Figure 4-3, most damage factors is around the mean. Even though, only 9% of heavy traffic (vehicles capacity  $\geq 3.5$ ) is weighed at control station, the damage factor is significant. Where the percentage of heavy traffic computed by dividing vehicles weighed to average traffic along road sections. Holota weighbridge station is along the road/s section where heavy vehicles have a significant damaging effect (rate = 2).

### C) Distance to ports-of-entry/Traffic Generating area

Holota weight and size control station is located at 24 km from Addis Ababa and 680km from Assosa which is possible traffic generating areas<sup>13</sup>. As the longer section of the road length kept unprotected from upcoming traffic  $\geq 500$ km, it is rated as 1.

### D) Distance to nearby weighing station

No weighbridge is located neither in the vicinity of station nor at any section of the road after the station so it is rated as zero.

In regard to vehicles travelling through Addis Ababa and heading to other ports, the station importance were evaluated in relation to vehicles damaging effect presented under axle load analysis.

### E) By-pass routes to avoid a weigh bridge;

Heavy vehicles travelling from Assosa to Bedele or Assosa to Bure can easily by passing the station through Nekemte-Bedele and Nekemte-Bure. Thus, the station is rated as zero.

The overall evaluation of the effectiveness of Holota weight and size control station, 45% of the criteria are met.

## 4.1.3 Sandafa vehicle weight and size control station

### A) Volume of heavy vehicle traffic

Sandafa vehicle weight and size control station is located at about 30km from Addis Ababa and the average daily number of vehicle served by the station during the study was 42. According to ERA's 2015 AADT data, the hourly traffic flow on the road sections served by Sandafa Control Station considered as low (rate = 1) since it is less than 30 veh/hr on the road sections. Vehicles stipulated as 'total HV/day from total traffic' in Table 4-4 are vehicles that supposed to be measured at the station (vehicles capacity  $\geq 3.5$  tons).

*Table 4-4. Nature of traffic flow on the road sections served by Sandafa Control Station*

| Trunk roads served by control station | Road length (km) | 2015 AADT           |                                 |       | Relative Road Class. |
|---------------------------------------|------------------|---------------------|---------------------------------|-------|----------------------|
|                                       |                  | Total Traffic Count | Total HV/day From total traffic | HV/hr |                      |
| A.A-Debre Berhan                      | 130              | 1,821               | 669                             | 28    | L-HV                 |
| Debre Berhan-Karakore                 | 153              | 1,445               | 548                             | 23    | L-HV                 |
| Karkore-Combolcha                     | 93               | 1,326               | 367                             | 15    | L-HV                 |
| Debre Berhan-Jihur                    | 86               | 535                 | 233                             | 10    | L-HV                 |

### B) Axle loads

The average damage factor for all types of vehicle is computed from Axle loads of vehicles operating along the road sections served by the control station (DF = 10.55) where 97% of vehicles axles were found beyond legally allowable limit.

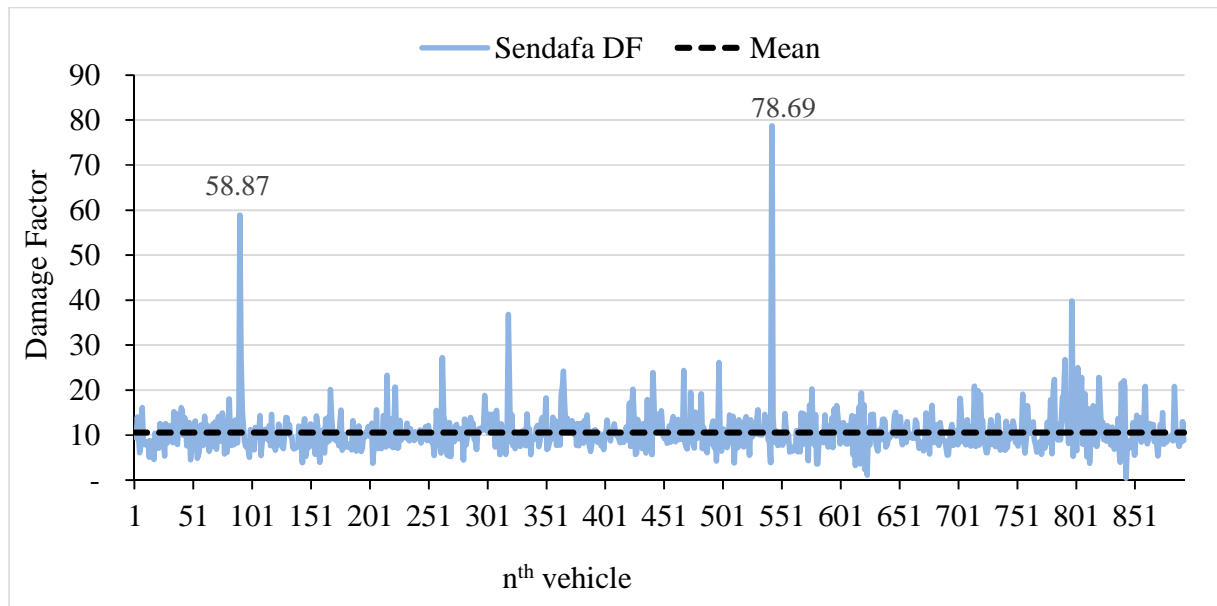


Figure 4-4. Damage factor vs vehicle (All directions) at Sandafa Control Station

As shown from Figure 4-4, most damage factors were around the mean. Even though, only 9% of heavy traffic (vehicles capacity  $\geq 3.5$ ) is weighed at control station, the damage factor is significant. Where the percentage of heavy traffic computed by dividing vehicles weighed to average traffic along road sections. Sandafa weighbridge station is along the road/s section where heavy vehicles significant damaging effect (rate = 2).

#### C) Distance to ports-of-entry

Sandafa weight and size control station is located at 30 km from Addis Ababa and 756km from Mekele,  $\geq 500$ km, it is rated as 1.

#### D) Distance to nearby weighing station

Combolcha weight and size control station is located at about 346km from Sandafa Control Station, which is between 200km and 500km so that it is rated as 2.

In regard to vehicles travelling through Addis Ababa and heading to other ports, the station importance were evaluated in relation to vehicles damaging effect presented under axle load analysis.

#### E) By-pass routes to avoid a weigh bridge;

No major by-pass route exists until the road section arrives at Combolcha control station which is in between 200km and 500km. Thus, the station rated as 1.

The overall evaluation of the effectiveness of Sandafa weight and size control station was 64% of the criteria.

### 4.1.4 Modjo vehicle weight and size control station

#### A) Volume of heavy vehicle traffic

Modjo vehicle weight and size control station is located at about 71 km from Addis Ababa and average number of vehicle served by the station during the study was 430veh/day. According to ERA’s 2015 AADT data, the hourly traffic flow on all road sections served by Modjo weighbridge is from medium to high (rate = 2) as it is greater than 30 veh/hr on both Awash and Shashemene direction. Vehicles stipulated as ‘total HV/day from total traffic’ in Table 4-5 are vehicles that supposed to be measured at the station (vehicles capacity ≥ 3.5 tons).

Table 4-5. Nature of traffic flow on the road sections served by Modjo Control Station

| Trunk roads served by control station | Road length (km) | 2015 AADT           |                                 |       | Relative Road Class. |
|---------------------------------------|------------------|---------------------|---------------------------------|-------|----------------------|
|                                       |                  | Total Traffic Count | Total HV/day From total traffic | HV/hr |                      |
| Addis Ababa - Akaki                   | 24               | 6,667               | 3,402                           | 142   | MH-HV                |
| Akaki-D/Zeit                          | 32               | 9,791               | 4,390                           | 183   | MH-HV                |
| D/Zeit - Adama                        | 51               | 12,817              | 5,927                           | 247   | MH-HV                |
| Modjo-Shashemene                      | 180              | 3,454               | 1,391                           | 58    | MH-HV                |

#### B) Axle loads

The average damage factor for all types of vehicle is computed from Axle loads of vehicles operating along the road sections served by the control station (Addis Ababa – Modjo – Adama DF = 8.31 and Modjo – Shashemene DF = 8.52) where 67% of vehicles axles where found beyond legally allowable limit.

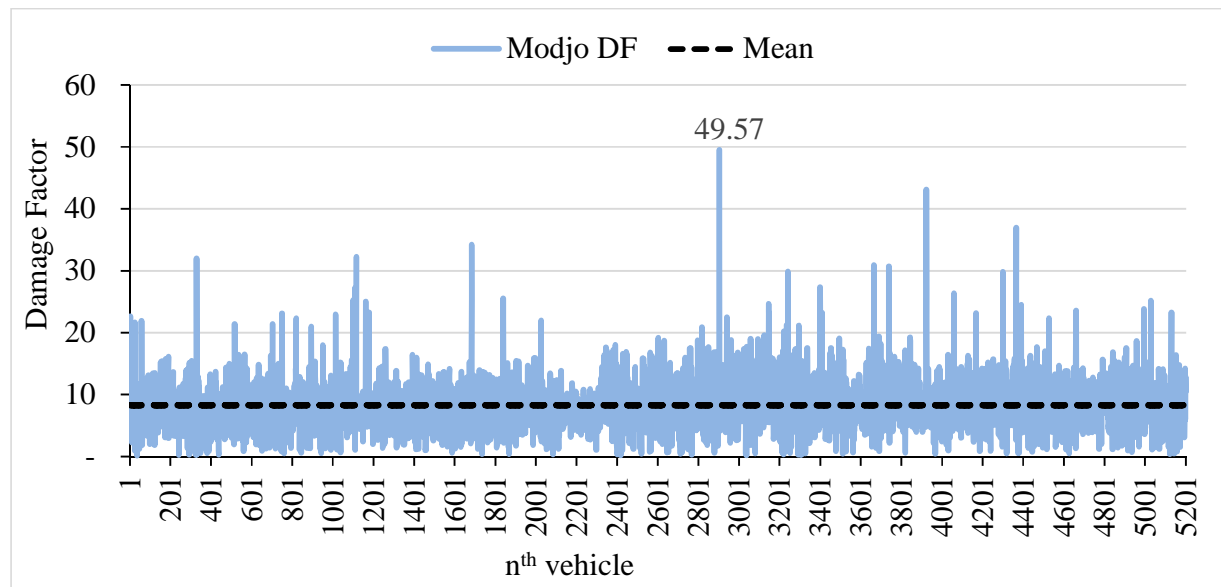


Figure 4-5. Damage factor vs vehicle (AA-Modjo-Adama direction) at Modjo Control Station

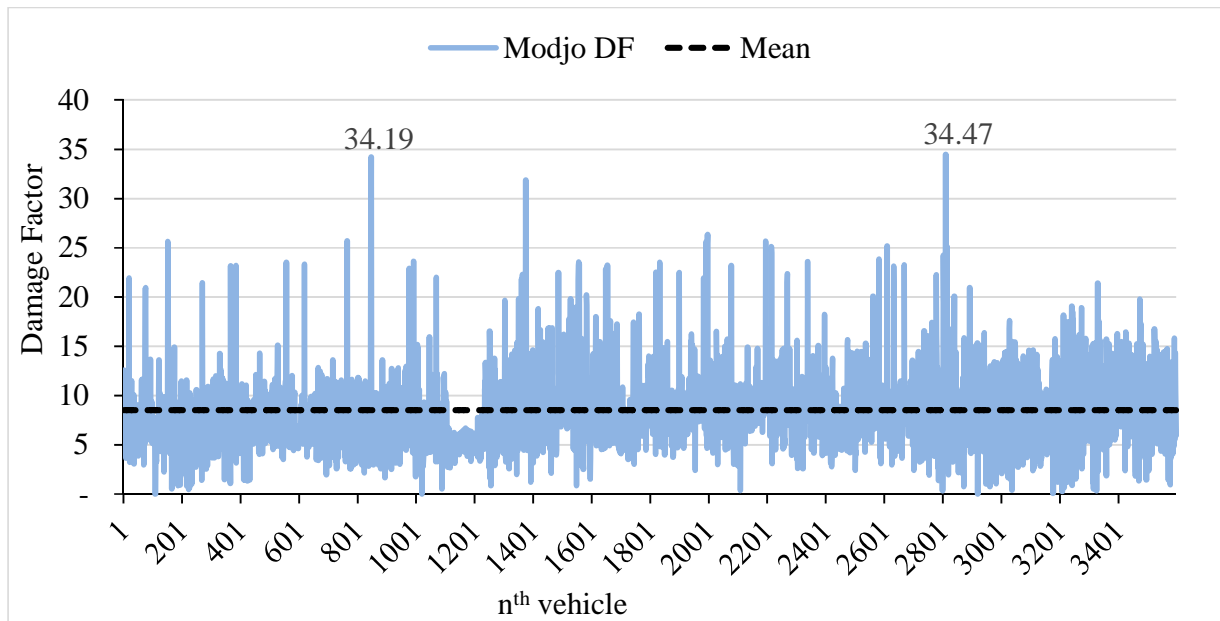


Figure 4-6. Damage factor vs vehicle (Modjo-Shashemene direction) at Modjo Control Station

As shown from Figure 4-5 and Figure 4-6, most damage factors lie around the mean. Even though, only 11% of heavy traffic (vehicles capacity  $\geq 3.5$ ) is weighed at control station, the damage factor is significant. Where the percentage of heavy traffic computed by dividing vehicles weighed to average traffic along road sections. So that, Modjo Control Station is along the road/s section where heavy vehicles significant damaging effect (rate = 2).

### C) Distance to ports-of-entry

Modjo weight and size control station is located at 71 km from Addis Ababa and 606km and 688km from Galafi and Moyale respectively which are possible traffic generating areas<sup>13</sup>,  $\geq 500$ km, it is rated as 1.

### D) Distance to nearby weighing station

Both Awash and Sheshemene weight and size control station are located at about 155km and 179kmm from Modjo Control Station respectively, in which both are at a distance  $\leq 200$ km so that it is rated as 3.

In regard to vehicles travelling through Addis Ababa and heading to other ports, the station importance were evaluated in relation to vehicles damaging effect presented under axle load analysis.

### E) By-pass routes to avoid a weigh bridge;

Drivers from Adama uses the expressway get away path from Modjo control station because, sometimes, the expressway let the HV pass as per the interview made from axle load control station. On the other hand, vehicles from Adama to Dodola never gets the controlling station.

The overall evaluation of the effectiveness of Modjo weight and size control station, 73% of the criteria are met while evaluated on Awash direction and 82% along Shashemene direction.

#### 4.1.5 Awash vehicle weight and size control station

##### A) Volume of heavy vehicle traffic

Awash vehicle weight and size control station is located at about 226 km from Addis Ababa and average number of vehicle served by the station during the study was 266veh/day. According to ERA's 2015 data, the hourly traffic flow on all road sections served by Awash control station is from medium to high (rate = 2) as it is greater than 30 veh/hr. Vehicles stipulated as 'total HV/day from total traffic' in Table 4-6 are vehicles that supposed to be measured at the station (vehicles capacity  $\geq$  3.5 tons).

*Table 4-6. Nature of traffic flow on the road sections served by Awash control station*

| Trunk roads served by control station | Road length (km) | 2015 AADT           |                                 |       | Relative Road Class. |
|---------------------------------------|------------------|---------------------|---------------------------------|-------|----------------------|
|                                       |                  | Total Traffic Count | Total HV/day From total traffic | HV/hr |                      |
| Adama - Awash                         | 125              | 6,441               | 3,727                           | 155   | MH-HV                |
| Awash-Mille                           | 308              | 1,847               | 1,584                           | 66    | MH-HV                |
| Mille-Bure (Mille-Gallafi)            | 368              | 962                 | 713                             | 30    | L-HV                 |
| Awash - Mieso                         | 74               | 902                 | 346                             | 14    | L-HV                 |
| Mieso-Asebeteferi                     | 24               | 762                 | 263                             | 11    | L-HV                 |
| Asebeteferi-Kobo                      | 111              | 981                 | 348                             | 15    | L-HV                 |
| Kobo-Kulubi                           | 27               | 879                 | 305                             | 13    | L-HV                 |
| Kulubi-Dengego                        | 31               | 2,149               | 953                             | 40    | MH-HV                |

##### B) Axle loads

The average damage factor for all types of vehicle is computed from Axle loads of vehicles operating along the road sections served by the control station (Addis Ababa – Awash – Mille – (DF = 15.28 and Awash – Dire Dawa/Harar – (DF = 15.72)) where 92% of vehicles weighed found to have axles more than legally allowable limit.

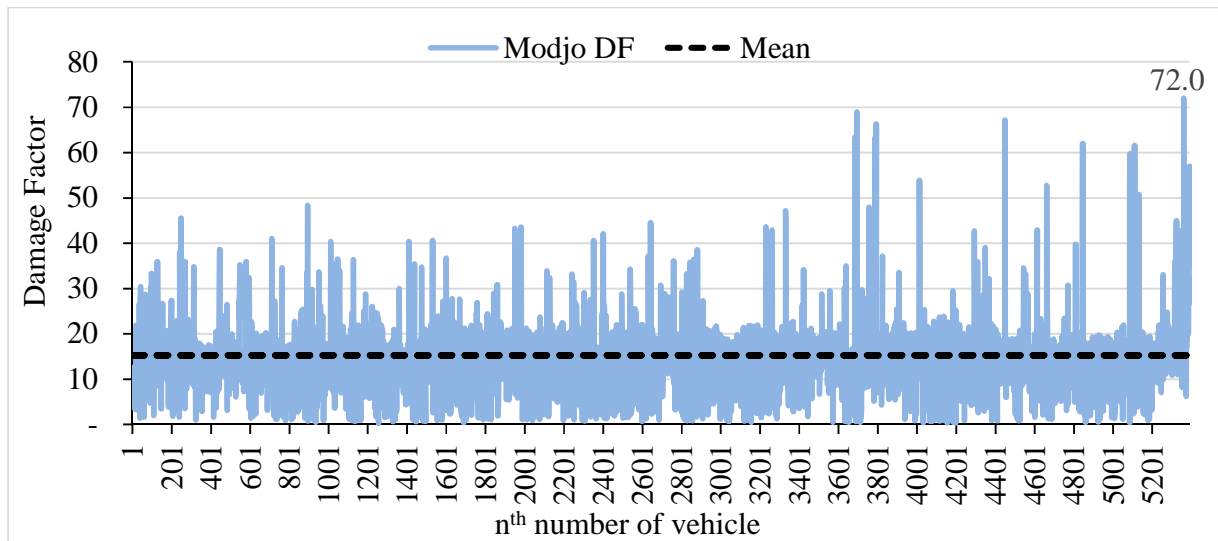


Figure 4-7. Damage factor vs vehicle (AA-Mille direction) at Awash control station

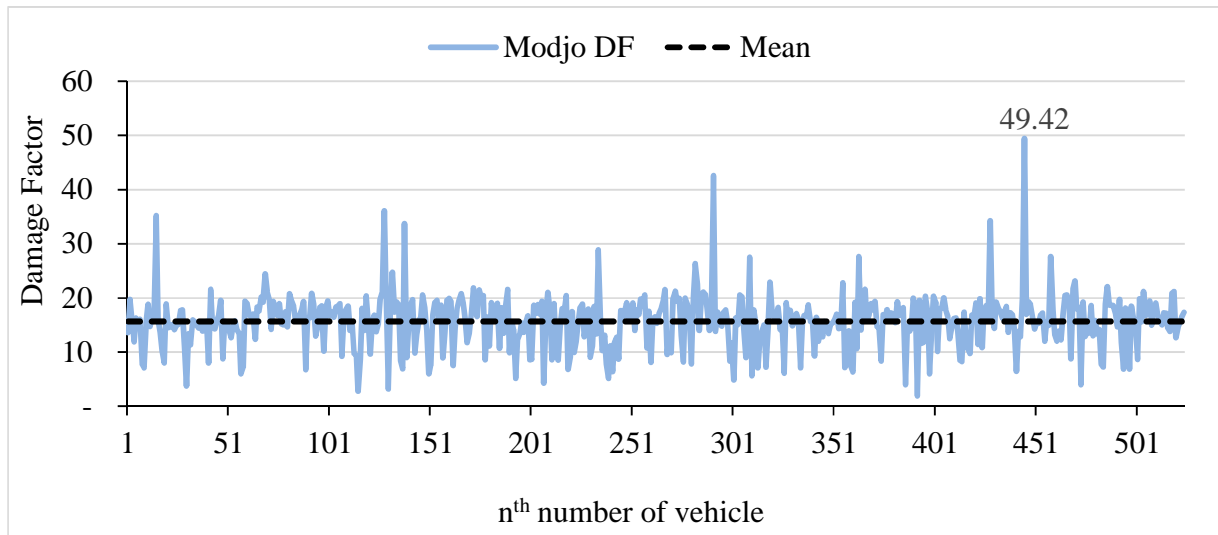


Figure 4-8. Damage factor vs vehicle (Awash-Dengego-Dire Dawa/Jijiga direction) at Awash control station

As shown from Figure 4-7 and Figure 4-8, most damage factors lie around the mean. Even though only 26% of heavy traffic (vehicles weighed/average traffic) is weighed on all directions. Awash control station is along the road/s section where heavy vehicles have a significant damaging effect (rate = 2).

**C) Distance to ports-of-entry**

Awash weight and size control station are located at 226 km from Addis Ababa and 451 km from Galafi which are possible traffic generating areas<sup>13</sup>. And the distance is between 200 and 500km, it is rated as 2.

#### D) Distance to nearby weighing station

Awash Control Station is located at about 281km from Dengego weight and size control station which is between 200km and 500km so that it is rated as 2. On the other hand, Modjo weighing station is located at 155km, which is  $\leq 200$ km so that it is rated as 3.

In regard to vehicles travelling through Addis Ababa and heading to other ports, the station importance were evaluated in relation to vehicles damaging effect presented under axle load analysis.

#### E) By-pass routes to avoid a weigh bridge;

HV from Djibouti to Woldia turns at Mille before they get in to Awash control station. In addition, vehicles from Adama to Dodola never gets the controlling station per the interview made from station staff and 2015 federal road network data. Thus, as there is rout to by-pass the station it is rated as zero.

The overall evaluation of the effectiveness of Awash weight and size control station, 64% of the criteria are met while evaluated on Dengego direction and 73% along Modjo direction.

### 4.2 Vehicle weight and size control Operations Management Performance Evaluation

#### 4.2.1 Effectiveness

Based on the collected primary axle load data the effectiveness of axle load control stations is being assessed as per the allowable legal limit.

#### A) Sululta Vehicle Weight and Size Control Station (21 days data)

Total of 1,001 heavy vehicles were served by Sululta weight and size control station during data collection period of the study. The overloading scheme, degree, and extent of overloading, observed at Sululta control stations is summarised in Table 4-7

*Table 4-7. Summary of Overloading at Sululta control station*

| Description | Total, % | 0 -1 Tonne, % | 1-2.5 Tonne, % | 2.5-5 Tonne, % | 5-10 Tonne, % | $\geq 10$ Tonne, % |
|-------------|----------|---------------|----------------|----------------|---------------|--------------------|
| TOL/TNV     | 90       | 17            | 23             | 42             | 7             | 1                  |
| LL/TNV      | 10       | -             | -              | -              | -             | -                  |
| POL/TOL     | 8        | 0             | 0              | 1              | 76            | 100                |
| FOL/TOL     | 92       | 100           | 100            | 99             | 24            | 0                  |

Where; TOL = Total number of overloaded vehicles beyond the legal limit

LL = Legally loaded vehicles

POL = Number of penalized vehicles among the overloaded vehicles

FOL = Number of freely passed overloaded vehicles

TNV = Total number of vehicles weighed

The Figure 4-9 will show daily variation during the survey period.

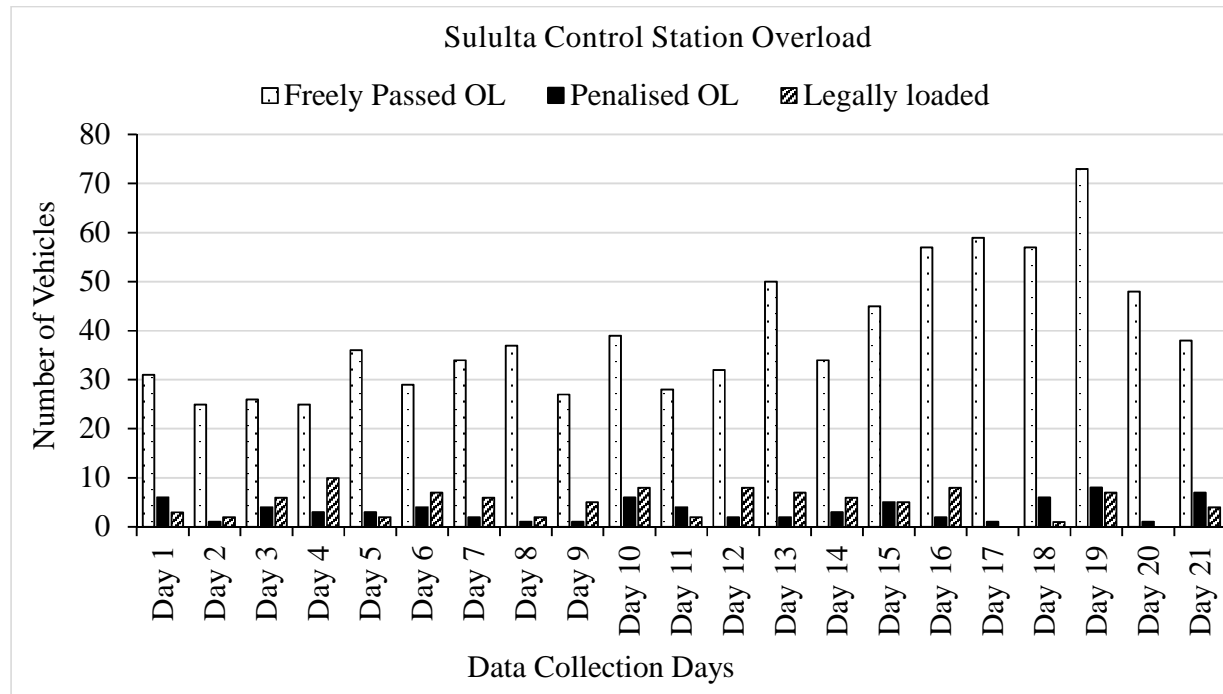


Figure 4-9. Comparison between TOL, POL and legally loaded

**B) Holota Vehicle Weight and Size Control Station (14 days data)**

Total of 1,191 heavy vehicles were served by Holota weight and size control station during data collection time of the study. The overloading scheme, degree, and extent of overloading, observed at Holota control stations is summarised in Table 4-8;

Table 4-8. Summary of Overloading at Holota control station

| Description | Total, % | 0 -1 Tonne, % | 1-2.5 Tonne, % | 2.5-5 Tonne, % | 5-10 Tonne, % | ≥ 10 Tonne, % |
|-------------|----------|---------------|----------------|----------------|---------------|---------------|
| TOL/TNV     | 94       | 24            | 21             | 37             | 11            | 1             |
| LL/TNV      | 6        | -             | -              | -              | -             | -             |
| POL/TOL     | 6        | 0             | 0              | 1              | 43            | 60            |
| FOL/TOL     | 94       | 100           | 100            | 99             | 57            | 40            |

Where; TOL = Total number of overloaded vehicles beyond the legal limit

LL = Legally loaded

POL = Number of penalized vehicles among the overloaded vehicles

FOL = Number of freely passed overloaded vehicles

TNV = Total number of vehicles weighed

The Figure 4-10 will show daily variation during the survey period.

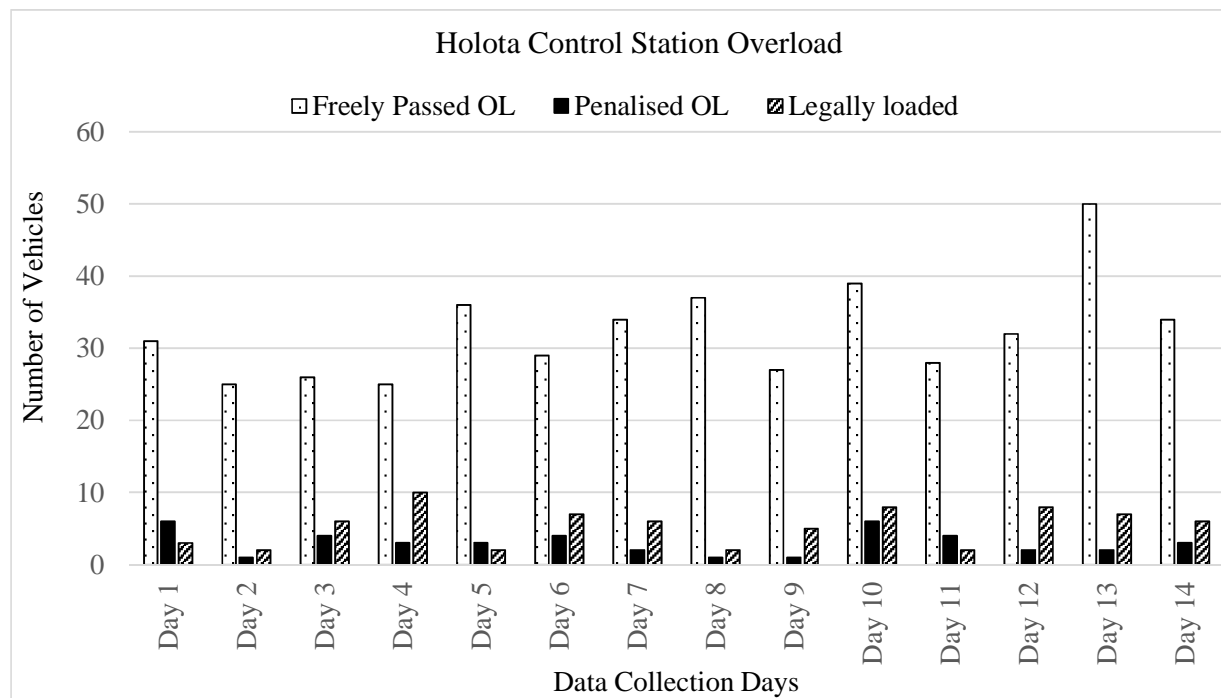


Figure 4-10. Comparison between TOL, POL and legally loaded at Holota Station

**C) Sandafa control station (21 days data)**

Total of 892 heavy vehicles were served by Sandafa weight and size control station during data collection time of the study. The overloading scheme, degree, and extent of overloading, observed at Sandafa control stations is summarised in Table 4-9;

Table 4-9. Summary of Overloading at Sandafa control station

| Description | Total, % | 0 -1 Tonne, % | 1-2.5 Tonne, % | 2.5-5 Tonne, % | 5-10 Tonne, % | ≥ 10 Tonne, % |
|-------------|----------|---------------|----------------|----------------|---------------|---------------|
| TOL/TNV     | 97       | 5             | 37             | 46             | 8             | 1             |
| LL/TNV      | 3        | -             | -              | -              | -             | -             |
| POL/TOL     | 3        | 0             | 0              | 1              | 29            | 100           |
| FOL/TOL     | 97       | 100           | 100            | 99             | 71            | 0             |

Where; TOL = Total number of overloaded vehicles beyond the legal limit

LL = Legally loaded

POL = Number of penalized vehicles among the overloaded vehicles

FOL = Number of freely passed overloaded vehicles

TNV = Total number of vehicles weighed

The Figure 4-11 will show daily variation during the survey period.

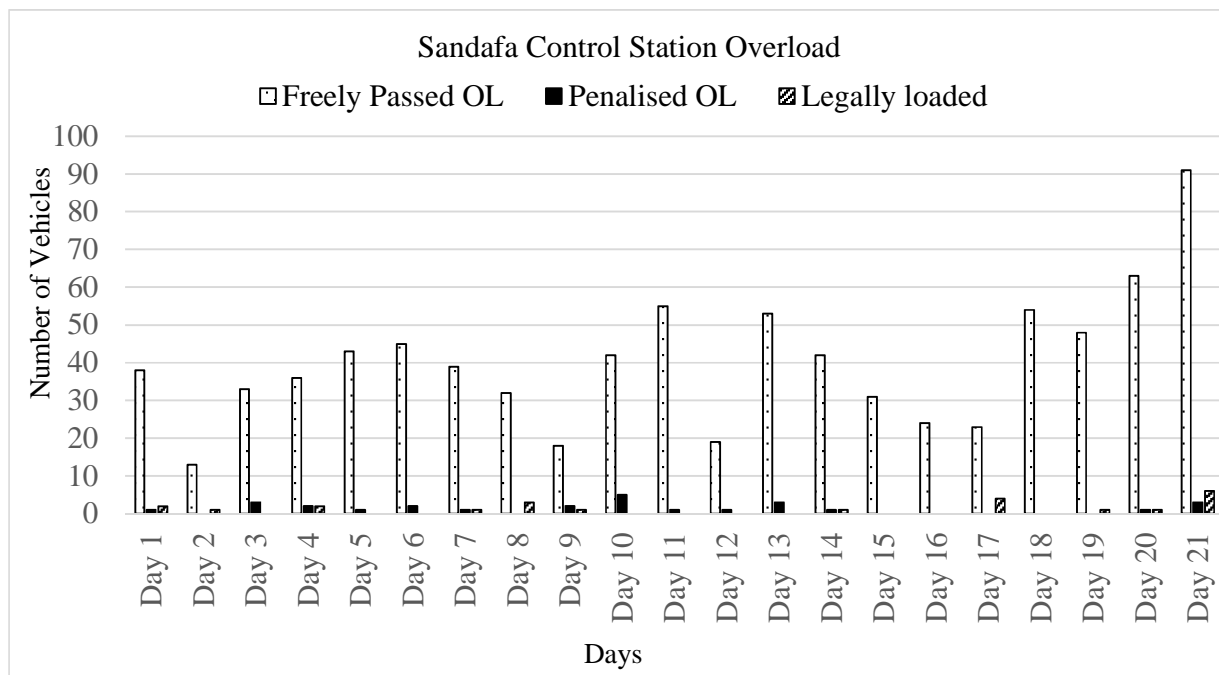


Figure 4-11. Comparison between TOL, POL and legally loaded at Sandafa Station

**D) Modjo control station (21 days data)**

Total of 9026 heavy vehicles were served by Modjo weight and size control station during data collection time of the study. The overloading scheme, degree, and extent of overloading, observed at Modjo control stations is summarised in Table 4-10;

Table 4-10: Summary of Overloading at Modjo control station

| Description | Total, % | 0 -1 Tonne, % | 1-2.5 Tonne, % | 2.5-5 Tonne, % | 5-10 Tonne, % | ≥ 10 Tonne, % |
|-------------|----------|---------------|----------------|----------------|---------------|---------------|
| TOL/TNV     | 67       | 22            | 21             | 22             | 2             | 0.06          |
| LL/TNV      | 33       | -             | -              | -              | -             | -             |
| POL/TOL     | 2        | -             | -              | -              | 64            | 80            |
| FOL/TOL     | 98       | 100           | 100            | 100            | 36            | 20            |

Where; TOL = Total number of overloaded vehicles beyond the legal limit

LL = Legally loaded

POL = Number of penalized vehicles among the overloaded vehicles

FOL = Number of freely passed overloaded vehicles

TNV = Total number of vehicles weighed

The Figure 4-12 will show daily variation during the survey period.

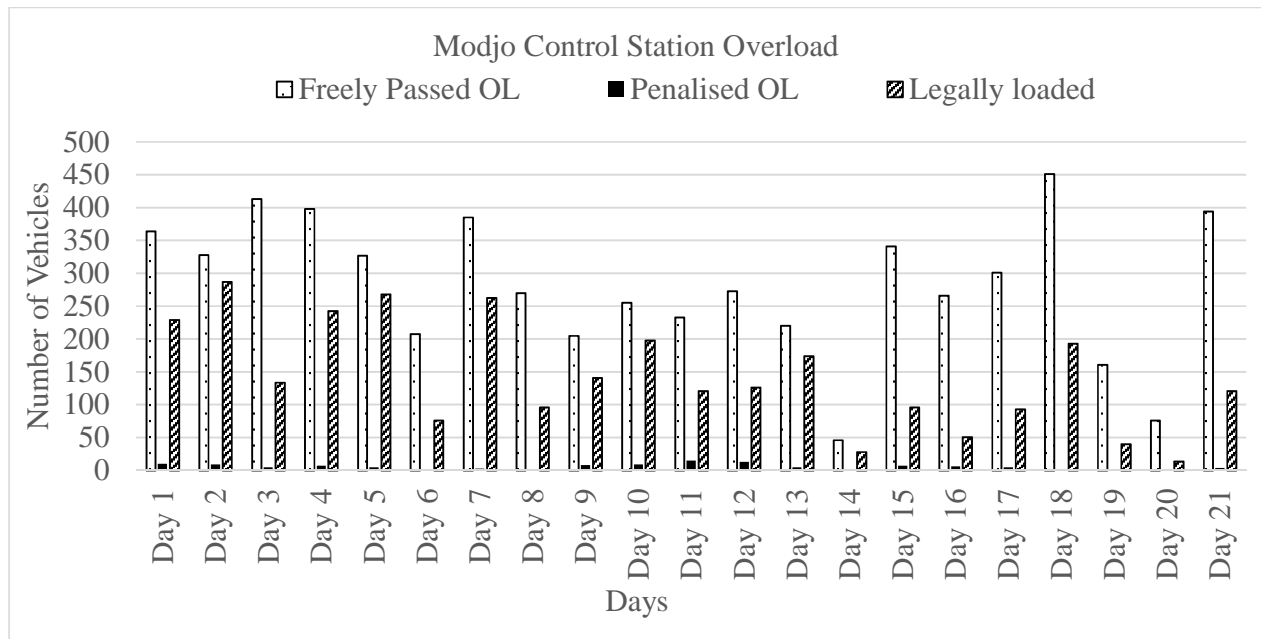


Figure 4-12: Comparison between TOL, POL and legally loaded at Modjo station

**E) Awash control station (21 days data)**

Total of 5587 heavy vehicles were served by Awash weight and size control station during data collection time of the study. The overloading scheme, degree, and extent of overloading, observed at Awash control stations is summarised in Table 4-11 ;

Table 4-11: Summary of Overloading at Awash control station

| Description | Total, % | 0 -1 Tonne, % | 1-2.5 Tonne, % | 2.5-5 Tonne, % | 5-10 Tonne, % | ≥ 10 Tonne, % |
|-------------|----------|---------------|----------------|----------------|---------------|---------------|
| TOL/TNV     | 92       | 6             | 20             | 53             | 12            | 1             |
| LL/TNV      | 8        | -             | -              | -              | -             | -             |
| POL/TOL     | 2        | -             | -              | -              | 8             | 88            |
| FOL/TOL     | 98       | 100           | 100            | 100            | 92            | 12            |

Where; TOL = Total number of overloaded vehicles beyond the legal limit

LL = Legally loaded

POL = Number of penalized vehicles among the overloaded vehicles

FOL = Number of freely passed overloaded vehicles

TNV = Total number of vehicles weighed

The Figure 4-12 will show daily variation during the survey period.

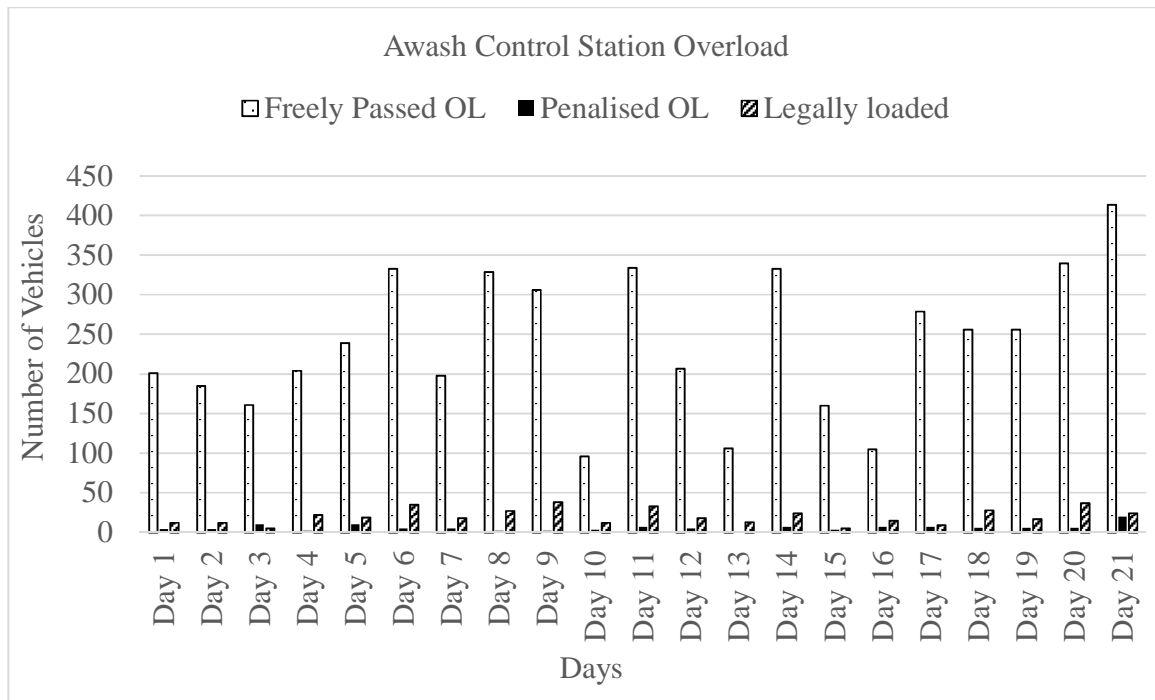


Figure 4-13: Comparison between TOL, POL and legally loaded Awash Station

### 4.2.2 Efficiency

#### A) Employee's evaluation on availability of essential facilities

The Educational background of respondents is from primary school to degree with age ranging from 25 to 50 and among the number of respondents of all study area only 8% are women. The total population is selected for this study. The total number of respondent (control station axle load control staff) were 42 out of which 9 were from Sululta, 9 from Holota, 7 from Sandafa, 8 from Modjo and 9 form Awash control station. The essential facilities considered where modern data recording system equipment (Computers, vehicle size controlling mechanism, and traffic control devises), office furniture and resting rooms, and maintenance workshop.

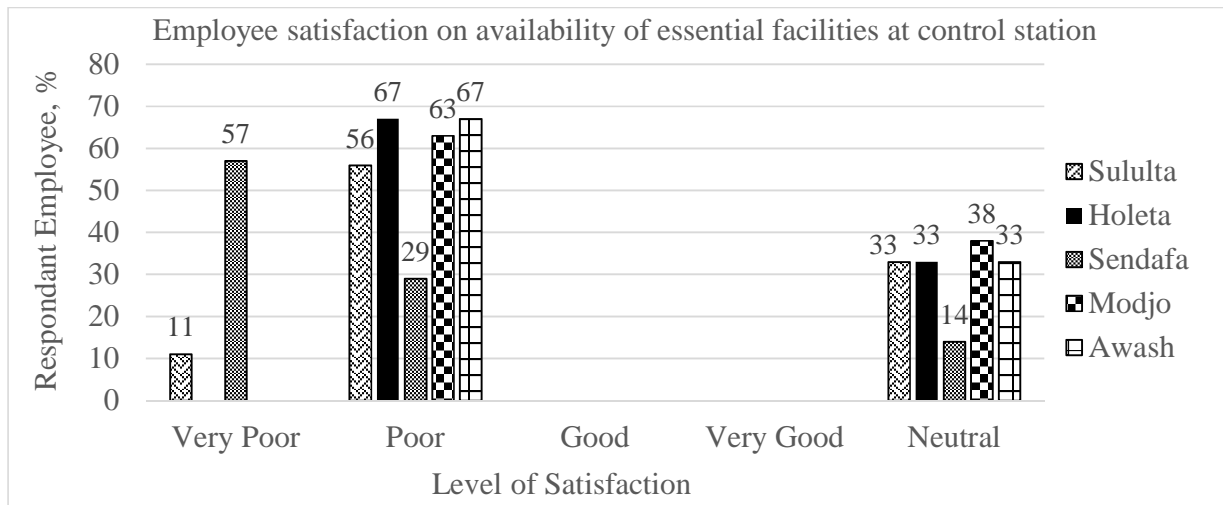


Figure 4-14. Employee satisfaction on availability of essential facilities at control station

There were no employee that replied with “Good” or “Very good” under the selected stations. Meanwhile, the employees, which replied as very poor and poor, with the availability of facilities is significant in study areas.

**B) Drivers’ evaluation on service delivery performance**

21 (twenty one) respondents were taken from most recognized freight transport companies as population of road user’s is large and all respondents are Male. All respondents used for analysis are only whoever used all the control stations and the analysis done as a whole. The aspects considered for this analysis were delay of service provision, penalty administration process and accountability of station’s staff.

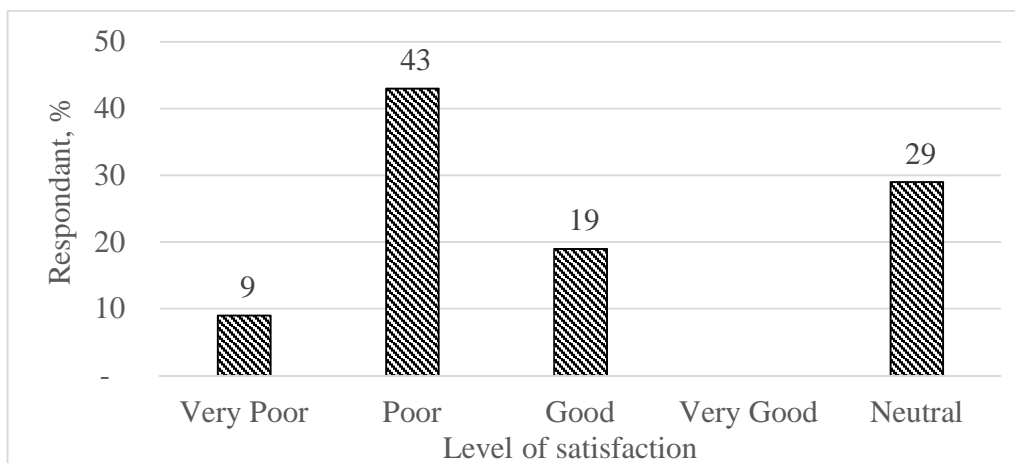


Figure 4-15. Driver’s satisfaction on service delivery performance at control stations

The quality of the service delivered measured as very poor, poor, good, very good and neutral is related to how the control station manages the overloading heavy vehicles and penalization process. In this regard, a significant number (43%) of drivers responded as the service is poor full of bribery actions.

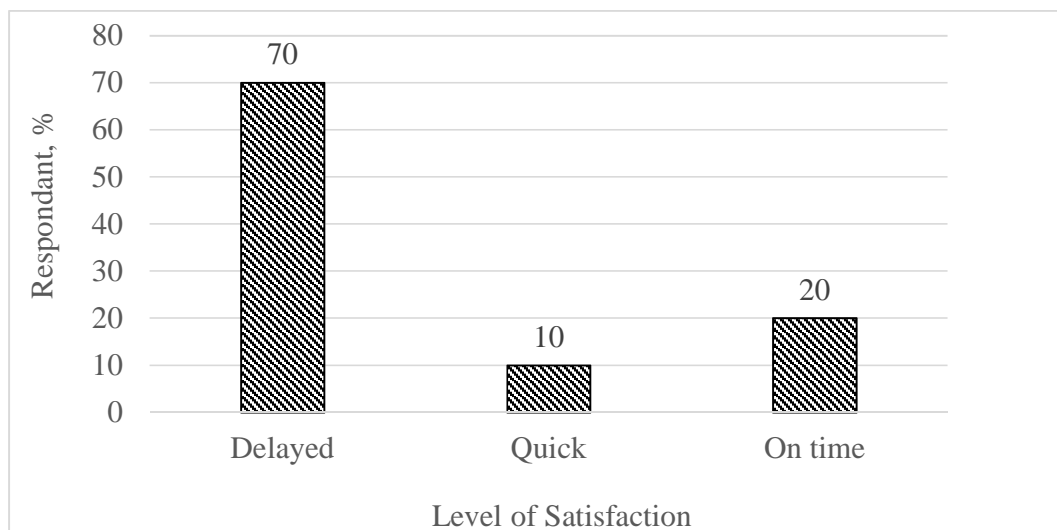
**C) Consultants' evaluation on service delivery performance**

20 (twenty) respondents were taken from different consulting firms mostly participated in Ethiopian Roads Authority road design projects and out of total respondents five (5) were female. The educational background of respondents is from Bachelor degree to Ph.D. with an experience in the road sector from 25-50. The aspects considered for service delivery performance analysis were ERA's axle controlling system (whether the data that consultants collect from ERA can manipulated or not). The response



*Figure 4-16. Consultant's response on quality of service by control stations*

On the other hand, respondents from consultants were asked about the quickness of the data delivery system when consultants requested ERA for axle load data for design purpose.



*Figure 4-17. Consultant's response on quickness of data*

#### D) Queue Performance Measures

Result of queue analysis summarised in Table 4-12 below where the arrival and service rate were computed using formula stipulated in Equation 4-1 and Equation 4-2.

*Equation 4-1:* Arrival rate = Number of vehicle served each day/Survey duration per day

*Equation 4-2:* Service rate = Number of vehicle served each day/ Total time at service per day

Where, survey duration were time taken for a whole day (time when stations were busy including idling time)

The average arrival or service rate was computed by taking the average of rates during survey duration (days of survey). The other measuring parameters in Table 4-12 were computed based on analysis formula stipulated under section 2.5.2 using Equation 2-3 up to Equation 2-10.

*Table 4-12. Summary of Queue Performance*

| Measuring Parameters                  | Unit   | Control Station |        |         |       |       |
|---------------------------------------|--------|-----------------|--------|---------|-------|-------|
|                                       |        | Sululta         | Holota | Sandafa | Modjo | Awash |
| Average Arrival Rate                  | Veh/hr | 10              | 13     | 17      | 18    | 11    |
| Average Service Rate                  | Veh/hr | 107             | 128    | 147     | 21    | 12    |
| System utilization                    | %      | 10%             | 10%    | 11%     | 84%   | 87%   |
| Average number of units (L)           | Veh    | 0.11            | 0.11   | 0.13    | 5.17  | 6.45  |
| Average time in system (W)            | Hr     | 0.01            | 0.01   | 0.01    | 0.29  | 0.58  |
|                                       | Min    | 0.62            | 0.52   | 0.46    | 17.30 | 34.89 |
| Average number of units in queue (Lq) | Veh    | 0.01            | 0.01   | 0.01    | 4.33  | 5.58  |
| Average time in queue (Wq)            | Hr     | 0.00            | 0.00   | 0.00    | 0.24  | 0.50  |
|                                       | Min    | 0.06            | 0.05   | 0.05    | 14.50 | 30.21 |
| Probability of idel time (P)          | %      | 90%             | 90%    | 89%     | 16%   | 13%   |

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## CHAPTER 5 DISCUSSIONS

### 5.1 Evaluation of control stations' location

The overall goal of overload control is to prevent the national road assets from overloaded vehicles operating on the road network. As the location of control station is one of the aspects that influence the effectiveness of vehicle weight control station, it is the most important decision in overload control system<sup>7</sup>. As seen in Table 2-5, the existing Control Station located were placed to cover road network with an average radius of 187km from Addis<sup>9</sup>. The main objective of this study is to evaluate the selected existing stations. Hence, the location of weighbridge is evaluated based on criteria set in relation to the purpose of overload control stations by referring studies made in relation to control stations location.

As set forth under ERA flexible pavement design manual, paved road deterioration caused not only by traffic volume that will use the road but also the wheel loads. Road damage caused by heavy vehicles is highly dependent on vehicles axle loads which are related to a standard axle (8.16 metric tons). To this effect, traffic volume and axle load taken as the main criteria since the primary aim of the concept of axle load control is to minimize road deterioration caused by overloaded vehicles and it is necessary to take in to account the repetition of traffic and axle load distribution of a sample of the heavy vehicles using the road.

Since the road maintenance saving depends on the length of road section that the control station serves, the next criteria considered was the length of the road controlled/served by the control station. This leads to taking in to account strategic aspects of overload control stations which are the distance to port-of-entry and road length between control stations. The other criteria considered is also a strategic aspect which evaluates whether there is the escape route to avoid the axle load checking<sup>18</sup>.

Generally, control stations supposed to be located on road stretch where there is high traffic heavy traffic and loading so that whichever station located along the road side having high traffic and over load is ranked as high since it was the more likely station controlling overloaded heavy vehicles. The traffic volume grouped as medium to high in this study according to TRL's study for axle load survey site whereas the load distribution of traffic and overloading trend was done as per ERA's flexible design manual and study made on vehicle axle load regulation and management on Odisha/India road network<sup>24</sup> by International consultants and Technocrats Pvt Ltd with Garant Thornton Advisory Pvt Ltd and ARKITECHNO consultants Pvt Ltd.

"First-order" weighbridges locations plan<sup>7</sup> (see section 2.5.1 Table 2-4 of this study) for preliminary optimal location. Though, the study is all about developing weighbridge network rather than evaluating the existing locations. In line with this, the relationship between length of road sections and preliminary optimal location of weighbridges from the prior study has been customized for the evaluation purpose of this particular study by developing rating system (protected road length  $\leq$  200km rated as 3, 200km < protected road length  $\leq$  500km rated as 2 and protected length > 500km rated as 1) for both distances to port the inter-weighbridge distance and distance between weighbridges based on the road section which is remained protected.

### **5.1.1 Sululta vehicle weight and size control station**

According to TRL's study<sup>8</sup>, it categorize road segments from medium to high when hourly heavy traffic served by control station is greater 30 veh/hr and low heavy traffic flow if it is less than 30 veh/hr. Thus, the hourly heavy traffic volume along the road sections that was served by Sululta control station ranges from low to high traffic volume. Although, the nearby road section (Addis Ababa-Dejen) was greater than 30 veh/hr which implies that the road section has medium to high heavy traffic (Derba cement factory is located nearby) so that it rated as it is located in good spot in regard to controlling heavy traffic operating on the adjacent road section. When it comes to the axle loads, the analysis was done according to ERA's flexible pavement design for damage factors. Hence, based on the calculation made the average damage factor computed is 13.17 which is obviously greater than 1.5 (damaging effect of loaded small truck<sup>15</sup>). Among the weighted vehicles axle distribution of heavy vehicles along the adjacent road was medium truck and above having the effect of damaging the road 13.37 times than the standard axle. Besides, even though the extent and degree of overloading are in different ranges, 90% of the vehicles whose axle measured at control station (which are only 7% of heavy vehicles was measured among total heavy vehicles) during the study period, were found to be beyond the legal limit. Taking in to account the fact that the overloading trend along the stretch adjacent to the weight control station is high, the station is given a high score.

Sululta vehicle weight and size control station is the only control station along Addis Ababa – Gondar, Addis Ababa – Metema, and Addis Ababa – Humera. Considering the fact that the road section along the weighing station is susceptible for heavy traffic transporting agricultural products (like teff, Sesame, and Cotton), petroleum from Sudan, construction materials and equipment's. Sululta station is not enough for the whole road section so that it has been given the lowest score in regard to both distance to port-of-entry and distance to the nearby weighing station. The station is located nearer to Addis Ababa and it is the only station along the road stretch which leads heavy vehicles to operate in intermediate road sections without being controlled so that the station also has been given the lowest rate as there are routes for vehicle freely transporting.

Sululta control station location is mainly protecting one lane /direction/ that is the road from Addis Ababa. Whereas, vehicles heading to Addis Ababa from borders are left to travel freely until they reach at the station. On the other hand, it is located where they can catch heavy traffic generators nearby (Derba cement factories). The reason why the overall evaluation percentage (45%) being low is that the station is not sufficient enough to protect road section along the corridor as most of road sections left unprotected.

### **5.1.2 Holota vehicle weight and size control station**

Following the same method as Sululta vehicle weight and size control station, the heavy traffic along the adjacent road segments to the control station have a volume of heavy traffic is high (on Addis Ababa – Ambo road segment). Whereas, it is relatively low in the intermediate road segments. The station is located at the junction where it can catch heavy traffic from Muger (where Muger and Dangote cement factory located) and heavy traffic to Ambo. In this regard, the station is located in a good location that's why it has been given the highest rate.

Based on the computation for damaging factor/DF/ and degree/extent of overloading via previously used method, the average DF implies that the axle load distribution was from medium truck and above having pavement damaging power of 12.2 and 12.1 times the damage caused by the standard axle along Addis Ababa – Assosa and Holota – Muger respectively. On the other hand, among the vehicles whose axle load measured during the data collection period are only 9% of heavy vehicles volume was measured. Though, 94% is found beyond the legal limit. Overloading is high along the road stretches therefore the location has a significant effect in controlling overloaded vehicles. So that it has been rated as the highest score. However, there is no control station that is located anywhere after Holota weighing station till Assosa thus it is rated on the lowest score for both inter-weighbridge distance and distance to port criteria considering the length of the road remained unprotected while heavy traffic traveling from border/adjoining route to Addis Ababa.

As heavy vehicles from Assosa to Bedele or Assosa to Bure can easily pass through Nekemte without being checked for their axle as per the allowable axle limit the weighbridge is lowest rate has been given in regard to escape route.

Generally, Holota control station location is mainly effective in protecting one lane /direction/ that is the road from Addis Ababa whereas vehicles heading to Addis Ababa are left to travel freely until they reach the mentioned weighing station since there is no control station except Holota. On the other hand, it is located where they can catch heavy traffic generators nearby (Muger, and Dangote cement factories). The reason why the overall evaluation percentage (45%) dropped down mainly because the unprotected length of road is significant.

### **5.1.3 Sandafa vehicle weight and size control station**

As prior stations, the same is done for Sandafa vehicle weight and size control. The volume of heavy traffic along the adjacent road segments to the control station is found to be relatively lower so that rated as low. However, the distribution of measure heavy traffic at the station is from the medium truck and above in which 97% of the vehicles are found to be overloaded in a different range of overloading. The vehicle also contributes road deterioration for 10.55 times. Therefore, the station is rated lower score for the traffic volume but high for loading condition.

Even though traffic volume at Sandafa control station is not as high as the other corridors, the overloading trend along the road routes served by the station is the same as others. Besides, the station is currently located far from town section having enough space for heavy vehicles to operate in the station and park until the drive finishes paper work if there is an overloading issue.

Additionally, due to the presence of weighing station at Combolcha the length of the road protected is satisfactory and there is no escape routes along the road stretch between Combolcha and Sandafa control station, for this reason, the highest score is given to the same. Generally, the station has met 64% of criteria which makes the effectiveness of location in averagely fulfilled.

### **5.1.4 Modjo vehicle weight and size control station**

Modjo vehicle weight and size control station is one of control station located on main import and export corridor (Addis Ababa – Djibouti) at which heavy traffic flow is high. The measured axle load of heavy vehicles has an average damage factor of 8.31 and 8.52 for Addis Ababa – Modjo – Adama and Modjo – Shashemene respectively out of which 67% vehicles axles found to be loaded

beyond the legal limit. Besides, only 11% of heavy traffic axle were measured. Thus, both the magnitude of traffic and axle loading trend is rated as high on both routes. Modjo control station is distant from both ports-of-entries namely Galafi and Moyale, whereas, it is located near enough to be given the highest rate with the inter-mediate stations, Awash and Shashmene. Considering the possibility of heavy vehicles by passing routes, it has been given the lowest mark in regard to the criteria of by-pass routes.

Modjo vehicle weight and size control station have met 73% of the overall criteria along Awash control station and 82% along Shashemene control station in which it is relatively at a good spot in the contribution of protecting adjacent road section in both direction. However, the station has a problem of being a source of heavy traffic congestion on the adjacent road while heavy vehicles diverging to the station or merging to the main road from the station as Modjo control station is located on town section.

### **5.1.5 Awash vehicle weight and size control station**

Awash vehicle weight and size control station are located at the junction on the way to Djibouti and Dengego (which is another junction to Dire Dawa and Harar). The traffic is high on the road section along the main import-export corridor so as the station is located at the place where it will be able to control heavy traffic and it has been given the highest rate. In addition to this, only 26% of heavy traffic axle is measured at the control station where 92% of measured vehicles axle were found to be beyond the legal limit. Based on the computation for DF, the axle load distribution for the measured heavy vehicles falls from a medium truck and above besides the vehicles have damaging effect 15 times than the standard axle. The Awash control station has been given medium rate along Dengego control station direction and maximum rate along Modjo control station direction according to criteria for both inter-weighbridge. Medium rate for port-of-entry distance and the lowest rate for the existence of by-pass routes in both directions.

However, as the station is located at a junction in charge of controlling overloaded vehicles from three routes (Addis Ababa, Dire Dawa/Harar and Galafi), traffic congestion on the adjacent road section is obvious to occur. TRL study<sup>8</sup> for the location of axle load survey recommends for the road sections having medium to high heavy traffic flow to have two weighing devise in each direction and also recommends that the site should not be located at the junction. On the other hand, the Ethiopian Revenues and Customs Authority (ERCA) control station is also located nearby to the vehicle weight and size control station which increases the possibility of the adjacent road to be even more congested.

Awash vehicle weight and size control station have met 64% of the overall criteria along Dengego control station and 73% along Modjo control station which ranges from average to good respectively in the contribution of protecting adjacent road section in both direction.

Finally, from origin destination of the axle load data of all control stations, it is clear that heavy vehicles travel from one end of the country to the other passing though Addis Ababa and according to the analysis the occurrence of overloading is unpredictable, can be from any direction. Even if a heavy vehicle checked at one station, it can be found overloaded on the next station due to various reasons such as control stations low enforcement problem. For this reason, it is obvious that it is important to have stations near to the capital, Addis Ababa, to protect road segments ahead whereas according to the evaluation result road segments from other ends of the road to the capital are not

well protected especially heavy vehicles from borders/traffic generation areas. Besides the factors that are directly related to controlling overloading (factors studied under this thesis), there are factors that affect the adjacent road section traffic flow while vehicles left/right turning to enter to control station and/or merging traffic exiting the station. The effect will be even more if the control station is located at town section.

## **5.2 Vehicle Weight and Size Control Stations Operations Management Performance Evaluation**

According to the hand book of techniques and tools by US department of Energy<sup>22</sup>, six performance measures are listed which are the effectiveness, efficiency, quality, timeliness, productivity, and safety. The five measures, except productivity, have been aspects considered for evaluation to this particular study depending on the type of the service that vehicle weight and size control station is providing.

A measure taken to evaluate whether the right amount of inputs/resources are used to make sure that a service has been achieved or delivered, is efficiency whereas effectiveness all about measuring whether the particular objective is achieved. In this regard, in order to become efficient one has to be effective<sup>36</sup>. Bearing this concept in mind, this study evaluated efficiency based on the input resources like qualified people, right facility/equipment and proven methods which can be evaluated whether a the work was done correctly and on time with the right quality as safe as possible. On the other hand, effectiveness was measured based on how well the control stations is working to meet the allowable axle load limits.

Road infrastructure plays a vital role in the socio-economic development thus as mentioned under literature section of this study, the federal road network has been growing by 3.2% each year<sup>12</sup>. The Federal Democratic Republic of Ethiopian government allocates billions of Ethiopian Birr in order to expand the network even more. The allocated budget for the construction/upgrading of road infrastructure shows 31% of increment in each year<sup>14</sup>. On the contrary, even if the government is working on expanding the country's road network, the budget to keep those expanded assets is lower than the need. Hence, it is necessary to work on controllable factors (traffic, road safety, maintenance, construction and green environment) that affect road assets to deteriorate even before their service time.

### **5.2.1 Effectiveness of control stations**

As mentioned in the earlier sections, the goal is to control overloaded vehicles as per the requirement, allowable legal limit. In addition to this, as set forth in best practice for commercial vehicle monitoring facilities design by US Department of Transportation Federal Highway Administration Office of motor carriers, one major component of commercial vehicle weight and size control is the measure of the effectiveness of enforcement<sup>37</sup>. Effectiveness is an external measure of process output<sup>38</sup>.

The evaluation started by computing the overloaded amount in quintals (later changed to tonnes) with respect to the allowable legal limit stipulated under

Table 2-6. Followed by doing the extent/degree of overloading. In addition, the regulation mentioned that controlling unit/station is expected to control vehicles dimension (see Table 2-7). Unfortunately, the stations are not equipped to measure vehicle dimensions so no data is recorded.

This study followed the same method of computation for extent/degree of overloading by International Consultants and Technocrats pvt ltd with Grant Thomton Advisory and ARKITECHNO consultants on vehicle axle load and regulation and management for Odisha state roads. However, the consultant has done the percentage of extent/degree of overloading with respect to Gross Vehicle Weight/GVW/ under its study. Though, it has been done based on the axle load since the current ruling regulation only includes the axle load limitation instead of GVW.

The regulation does not include GVW limit as well as tolerance to which extent overloaded vehicle should be tolerated. On the other hand, as it is difficult to find vehicles always with in the legal limit reduce overloading 100 percent, it is necessary to provide some tolerance.

The regulation do not include ranges of overload fines and there also no legally governing rule how the penalties were executed so local courts were decision bodies for fines.

#### **A) Sululta Vehicle Weight and Size Control Stations (21 days data)**

A total number of vehicles measured during the data collection time were 1,001. Among these measured vehicles with different axle configuration, only 10% were found whose axle load below the axle load limit, the rest, which is 90% of the total measured vehicles, were beyond the legal limit. Though, all vehicles do not have the same degree of over loading so that different ranges of overloading (zero overloading, 0-1 ton, 1-2.5 ton, 2.5-5 ton, 5-10 ton and overload greater than 10 ton (1 Quintal = 100 kg = 0.1 tonne)) have been developed. The overload is the total overload found on each axle of a particular vehicle summed up together. According to data collected and analysed, most of the overloaded heavy vehicles falls under the 2.5-5, 1-2.5, and 0-1 ton range respectively in their descending order. There is also vehicles measured whose total overload on axles load is under 5-10 ton and above 10 ton range. In addition to the overloading range, the overloading is noticed on the rear axles. The highest overloaded ton of vehicle mostly ranges 2.5-5 ton because default tolerance that the station used was between this ranges so that vehicles tend to take it as legal limit.

From vehicles measured Sululta control station, only 1% of total overloaded heavy vehicles were penalised among the overloading range from 2.5 to 5 ton, 76% from the range 5-10 ton, whereas 100% of total overloaded heavy vehicles were penalized whose total overload exceeds 10 ton and the rest kept going without being penalised.

The important issue is what decision will be made by the axle load control inspector/s in charge when a vehicle is found to be overloaded. As it is seen from the comparison between the vehicles overloaded and the ones being penalized, most vehicles found overloaded kept going without further action based on the allowable limit. Besides, on site tolerance or allowance depends on the inspector in charge whether to penalize the overloaded vehicles as the system is unmodernised and easy to bend the rule. The recordings are all manual which is open for data manipulation and there is no system to control this kind of deeds. For this reason, mostly vehicles will be penalized when they are in the highest range of overloading.

The goal of establishing vehicle weight and size control is to control overloaded as well as oversized vehicles and controlling process will be done based on some requirements. In this case, the requirements are the allowable legal limit which is derived from economic analysis considering goods transportation cost. Well, in this regard Sululta Control station is not effective enough in achieving the target as per the requirement.

**B) Holota control station (14 days data)**

Comparison between the overloaded verses the penalised has been made for Holota control station and the result was the same as Sululta control station except the figures are different. And there are vehicles found to be overloaded under the range above 10 ton (only 60% of the overloaded vehicles penalised). In fact, the penalized overloaded heavy vehicles are lesser than actually overloaded heavy vehicles under all ranges.

Only 6% of measured vehicles (1,191) free of overloading the rest falls under one of the ranges mainly in 2.5-5 ton. The highest overloaded ton of vehicle mostly ranges 2.5-5 ton because the same reason as Sululta control station. From the daily penalized data, the tolerance that axle load control station gives to vehicles is different depending on the axle load control inspector in charge.

**C) Sandafa control station (21 days data)**

892 vehicles were measured during 21 days of data collection time, and 97% of these vehicles found to have overloaded tons in different ranges and only 3% of the vehicles found free of over loading. The same as the above two stations penalizing the overloaded vehicles and the tolerance taken for overload highly depends on the axle load control inspector in charge so that it is different in most of the days.

**D) Modjo control station (21 days data)**

9,026 vehicles were measured during 21 days of data collection time, and 67% of these vehicles found to have overloaded tons in different ranges and only 33% of the vehicles found free of over loading.

Unlike the other stations mentioned above, percent of overloading is relatively less and degree of over loading is also evenly in stipulated ranges (22% in 0-1 ton, 21% in 1-2.5 ton and 22% in 2.5-5 ton). On the other hand, all vehicles up to 2.5-5 ton range left free to operate on the adjacent main road.

**E) Awash control station (21 days data)**

5,587 vehicles were measured during 21 days of data collection time, and 92% of these vehicles found to have overloaded tons in different ranges and only 8% of the vehicles found free of over loading. The same as the above stations penalizing the overloaded vehicles and the tolerance taken for overload highly depends on the axle load control inspector in charge so that it is different in most of the days and all vehicles up to 2.5-5 ton range left free to operate on the adjacent main road.

Generally, the weight and size control stations are not established just to penalize vehicles, it is because to preserve road assets from premature failure due to overloading. All studied station have a problem of uniform way of using the regulation. In addition to minimizing premature failure of

road infrastructures, overload control has vital influence securing road safety as the overloaded heavy vehicle can cause various safety risks.

### **5.2.2 Efficiency**

#### **A) Employee's evaluation on availability of essential facilities**

Employee's evaluation on the availability of essential facilities like uninterrupted electric supply/lack of generator, modernized weighing system (integrated uses of Computers, software, vehicle size controlling mechanism, and traffic control devises), office furniture's, employees resting rooms, which is directly or indirectly related to the overload control station's delivery of service.

The result showed that the majority of employees were dissatisfied and labelled the availability of facility either poor or very poor. On the other hand, there is also employees stays neutral. The majority of the employees were dissatisfied about the facilities related to office furniture's and/or comfortability of the working space. In addition to this, besides the comfortability of the working environment, the respondent also put their dissatisfaction on the lack of uninterrupted electricity /Generators/, modernized systems and lack of enough personals. Stations may also stop being operational for longer period when weighbridge is malfunctions as there is no maintenance crew as well as equipment at the station.

In regard to the presence of an uninterrupted supply of electricity, Holota control station is the only one with generator among the evaluated stations though it doesn't mostly use it even if electricity is interrupted.

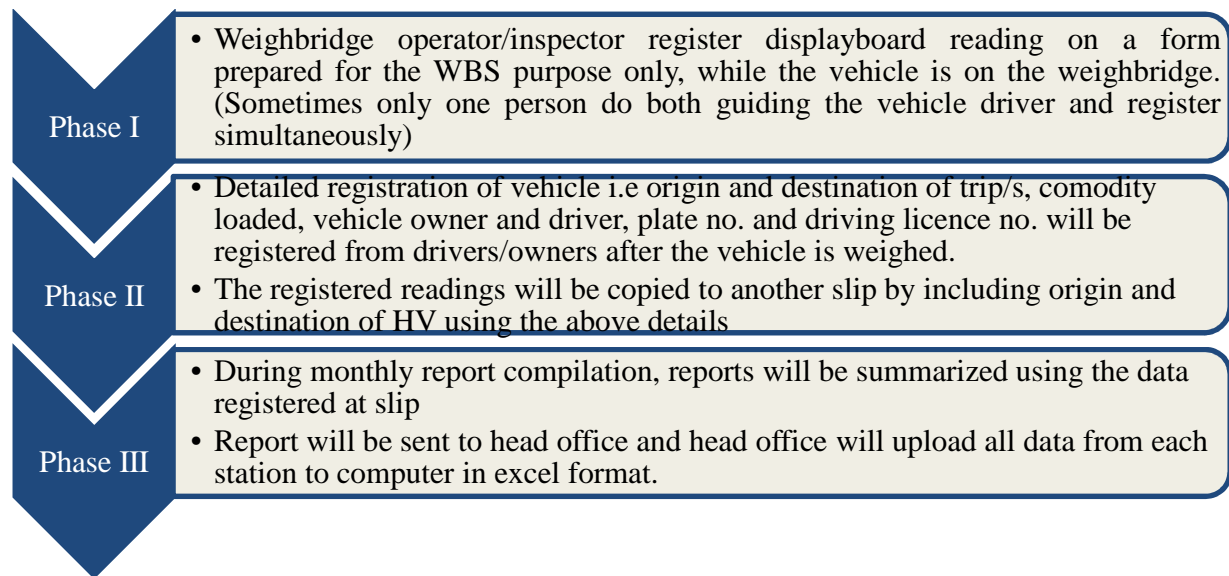
#### **B) Drivers' evaluation on service delivery performance**

Driver/owner's evaluation of service quality of service delivered and time they spent on getting the service which is related to the delivery of the goal to control overload. The majority of the respondents (10% very poor and 43% poor) responded that stations are full of corrupt inspectors who bother them taking their time while negotiating the price to pass the station without being penalized, 29% of respondents remain neutral whereas the remaining 19% believe that stations as doing things right.

#### **C) Consultants' evaluation on service delivery performance**

Consultant's evaluation on service quality of service delivered which is related to the delivery of the goal to control overload. The respondents are professionals who involved most of ERA's road construction/rehabilitation/overlay/upgrading projects and having most of their experience in road projects and who will be obliged to use vehicle axle load for design purpose. For this reason, respondents will need historical axle load data from ERA. In this regard, the quality of data they mostly collected from ERA is evaluated as poor, good, very good or excellent. The result shows that 70% of the respondents labelled the data quality as poor and the rest 30% responded as good.

Besides, the control stations has weight registration procedure susceptible to the data to be incorrectly registered as every registration is manual which leads to lack of data quality.



*Figure 5-1. Current axle load data registration procedure*

The other evaluation done by the consultants is the timing of the data. Even though, the consultants who have been hired to design a particular road is obliged to collect real-time data at a present time as per ERA's flexible road design axle load survey criteria, historical axle load data is necessary to get more precise and representative data of different seasons for the design. Based on the result, the majority of respondents (70%) response was the data has delayed.

#### **D) Queue Performance Measures**

According to the result, that three stations (Sululta, Holota and Sandafa) found to be idle most of their time (i.e 90%, 90% and 89% respectively) than being busy according to the collected data. On contrary, Modjo and Awash control station were busy in most of their time (i.e 84% and 87% respectively). The time that heavy vehicle operators have to wait on hold while the station serving another vehicle is 0.06 min, 0.05 min, 0.05 min, 14.5 min and 30 min for Sululta, Holota, Sandafa, Modjo and Awash control station respectively. The time lost at the stations is as high as the volume of heavy vehicle waiting in line at the stations especially at Modjo and Awash stations.

Though, a different result might be gained if it is done for a longer period of time including different seasons because heavy traffic flow may depend on the season, for instance, during agricultural product harvesting period, construction works (like Great Renaissance Dam) and the like which highly depend on the harvesting and/or construction period.

Besides, heavy traffic that merges and/or diverges to/from the adjacent road have effect on through vehicles which is especially an issue for stations having high heavy traffic and/or located at town sections. In addition to this, the available space at the station is also has contribution for queue to occur while vehicles found to be over loaded and required to stay in the station until process of prosecution was finished. Moreover, as this analysis were made to evaluate the overall performance of stations, data was collected for a time when the stations were busy and/or idle and queue might occur during the time while stations were busy.

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## CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusion

After evaluating the overall overload and vehicle size control stations in regards to location of weighbridge, infrastructure, operations and management. The following conclusion has been drawn:

- The overall percentages that the stations scores based on the criteria (see Table 4-1) were highly dependent on the road length that should be protected. In addition to this, as per the origin-destination of vehicles, it is found that heavy vehicles travel from one end of the country to the other passing through Addis Ababa and the average damage effect of these heavy vehicles operated on the road section served by the control stations have a significant road damage. In this regard, the current location of stations have a great importance in controlling overloaded vehicles and found to be good. However, it required to work on improving the limitations in relation to inter-station distance, distance to port of entry (traffic generation areas) and escape route.
- The effectiveness of control stations in the enforcement of the ruling regulation were minimal which depended on the personal judgement of the inspector in charge (overload control tolerance was not constant, it differed from inspector to inspector, even if the regulation did not allow any tolerance). Majority of overloaded vehicles were sent free to operate on adjacent road without being penalized or being corrected. So that, control stations have a problem of following the regulation. For instance, 99% of vehicles with overload 2.5-5 ton and 24% of vehicles with overload 5-10 ton left to pass the station freely at Sululta control station, 99% of vehicles with overload 2.5-5 ton, 57% of vehicles with overload 5-10 ton and 40% of vehicles with overload more than 10 ton left to pass the station freely Holota control station, and 99% of vehicles with overload 2.5-5 ton, and 71% of vehicles with overload 5-10 ton left to pass the station freely Sandafa control station.
- Sometimes, the axle load exceeded the legal limit even though the vehicle were loaded based on its allowable carrying capacity.
- No clearly defined procedure for each work performed by the station (checking tolerance, law enforcement, control equipment inspection and maintenance)
- Not all heavy vehicles were checked for overload at the station. For instance, 11% and 26% of heavy traffic were checked at Modjo and Awash control station respectively. This showed that there is a problem of measurement accuracy according to the regulation.
- Three control stations were idle most of their time during the study period (90% at Sululta and Holota whereas 89% of time for Sandafa Control station) and the time that heavy vehicle operators have to wait on hold while the station serving another vehicle is 0.06 min, 0.05 min, 14.5 min and 30 min for Sululta, Holota and Sandafa, Modjo and Awash control station respectively.
- Drivers' time, lost at control station, depended on the volume of heavy vehicle arrived to be checked. The higher the volume, the high the time lost during the time when the station was not idle.
- No heavy vehicles dimension and Gross vehicle weight measuring equipment, Computers, traffic signals/sings in regards to safety, office furniture, optional backup for electric interruption, nor maintenance equipment.

- Except weighing activity, everything were done manually, no computerised system, which would in turn take time, decrease data quality/accuracy and vulnerable to corruption/fraud.
- Neither there were regular weighbridge maintenance/inspection, maintenance facility/unit nor technician/s at the control stations.
- Lawless behaviour of road users (do not care about the consequence of overloading). As the results showed, major percentage of weighed vehicles found to be overloaded.
- As per control station staff composition found via questionnaire survey, vehicle weight and size control system lacks labour composition and compliance in management, operation, and maintenance.
- It was also noted that merging and/or diverging (or left/right turning) heavy vehicles from/to control stations interrupt traffic flow on adjacent road especially at control stations located at town sections and adjacent to high traffic flow, mostly at Modjo and Awash control stations.
- Some control stations, like Modjo and Awash, have no enough holding area where overloaded vehicles detained until the overload were corrected to the legislated legal limit and prosecution form prepared.

## 6.2 Recommendation

In order to make overload and vehicle size control more effective and efficient, the following should be taken in to account;

- According to the evaluation made, improving weighing stations network is necessary to safeguard road length that should be protected. In order to acquire this, provision of additional stations is required to be effective enough especially near to boarder (Djibouti, Moyale, and Metema) and at intermediate (between Sululta control station and Gondar, Holota control station and Assosa) with reasonable distance from nearby control station where there is no escape routes for heavy vehicles from adjoining road segments route. To spot the exact location, detailed analysis on traffic generating areas should be revised.
- Economic viability of weighbridges as a network should be checked while selecting additional location.
- Stations should have enough holding area where overloaded vehicles detained until the overload is corrected to the legislated legal limit without interrupting other vehicles waiting to be weighed and/or vehicles operating on adjacent road.
- Provide weighbridge for each direction for road sections having high heavy traffic flow like Awash control station.
- Develop a non-editable computerised system that captures the checked vehicle weight and size from the weighbridge and use one universal tolerance for all stations. This system should be able to avoid manipulation of data and provide real-time data base at head office level.
- Provision of vehicle dimension/axle spacing checking facilities.
- All heavy vehicles should enter and be checked at control stations unless they have special permit (Special permit which is studied in detail prier checking and allowed to pass).
- Considering advanced system, stations need staff composition of disciplines like electrical engineering, mechanical engineering, and information technology to maintain system sustainability. Additionally, composition shall include like legal, human resource, civil engineering at central level. The Civil Engineering professionals will have the responsibility of studying special permits, studies in relation to overloading and other works in relation to road/road bridge maintenance.

- Replace single-platform weighbridge by multi-platform weighbridge and screening equipment /WIM/ in order to minimize time spent at control station and increase accuracy of measurement.
- Provide weighbridge maintenance workshop, perform regular service for weighbridge and avail facility for personnel. Also, regular weighbridge inspection (daily based visual inspection) should be done at the end of each shift with uniform check list along with its procedure.
- Regulatory and guilder traffic signals/signs at the station and nearby road section at least within 500m (for example; weighbridge ahead, speed limit, on the road side where as signals at the station)
- Licence for maximum allowable carrying capacity of heavy vehicles must be studied along with vehicle's axle load before issuance as axle load and carrying capacity differs from vehicle to vehicle.
- Evaluating the effectiveness and efficiency of weighbridge operations and locations to be carried out on regular basis (at least yearly basis).
- Awareness creation for all stakeholders, workshops and trainings, use billboards, fliers is necessary.

***Recommended studies for future;***

- Develop traffic congestion mitigation strategy nearby control station resulted from the location of the control station. Congestion may occur due to slow moving heavy vehicles merging and/or diverting to enter in to and exit from the station.
- Assessment of road damage cost due to overloading/ESAL-Km cost for Ethiopian road network which is also necessary to identify whether a weighbridge network is economically viable or not and which may also help to develop a uniform penalty fees.
- Development of computerized system compatible to overload and vehicle size control in order to overcome fraud and corrupt behaviour.
- Calibration of ERA's Pavement management system /PMS/ to use Axle load in put along with the traffic volume.

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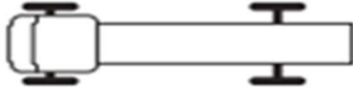
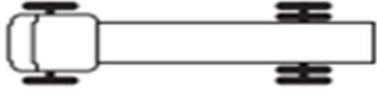

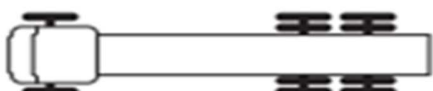



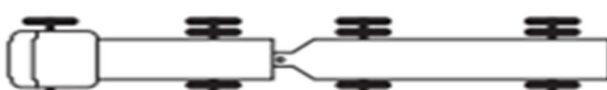

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**ANNEX 1: TYPICAL TYPES OF VEHICLES/AXLE CONFIGURATION**

|  |                  |
|--|------------------|
|     | <b>1.1</b>       |
|     | <b>1.2</b>       |
|     | <b>1.21</b>      |
|    | <b>1.22</b>      |
|   | <b>1.2-2</b>     |
|   | <b>1.2-22</b>    |
|   | <b>1.22-22</b>   |
|   | <b>1.2+2.2</b>   |
|  | <b>1.22+2.22</b> |

## ANNEX 2: DETAIL OF AXLE OVER LOAD ON DAILY BASIS

### 2.1 Sululta Control station

| No | Date      | Unit | Axle load |    |       |       |     |     |     |    |    |
|----|-----------|------|-----------|----|-------|-------|-----|-----|-----|----|----|
|    |           |      | F1        | F2 | R1    | R2    | R3  | R4  | R5  | R6 | R7 |
| 1  | 01-Aug-15 | No.  | -         | -  | 37    | 33    | 2   | -   | 3   | -  | -  |
|    |           | ton  | -         | -  | 72.6  | 63.7  | 1.6 | -   | 1.6 | -  | -  |
| 2  | 02-Aug-15 | No.  | -         | -  | 26    | 26    | 6   | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 43    | 39.3  | 1.6 | -   | -   | -  | -  |
| 3  | 03-Aug-15 | No.  | 3         | -  | 28    | 26    | -   | 1   | -   | -  | -  |
|    |           | ton  | 4.9       | -  | 45.3  | 45.1  | -   | 0.3 | -   | -  | -  |
| 4  | 04-Aug-15 | No.  | 1         | -  | 27    | 26    | 4   | -   | -   | -  | -  |
|    |           | ton  | 0.2       | -  | 49.2  | 42.6  | 1.1 | -   | -   | -  | -  |
| 5  | 05-Aug-15 | No.  | 2         | -  | 37    | 39    | 9   | -   | -   | -  | -  |
|    |           | ton  | 2.7       | -  | 60    | 56.7  | 3.6 | -   | -   | -  | -  |
| 6  | 06-Aug-15 | No.  | 3         | -  | 33    | 30    | 2   | -   | -   | -  | -  |
|    |           | ton  | 3.5       | -  | 53.6  | 50.4  | 0.4 | -   | -   | -  | -  |
| 7  | 07-Aug-15 | No.  | 2         | -  | 36    | 32    | 9   | 1   | -   | -  | -  |
|    |           | ton  | 0.3       | -  | 48.6  | 46.6  | 2.6 | 0.2 | -   | -  | -  |
| 8  | 08-Aug-15 | No.  | 1         | -  | 37    | 38    | 8   | -   | 1   | -  | -  |
|    |           | ton  | 1         | -  | 45.6  | 44.8  | 2.4 | -   | 0.3 | -  | -  |
| 9  | 09-Aug-15 | No.  | 1         | -  | 28    | 22    | -   | -   | -   | -  | -  |
|    |           | ton  | 0.8       | -  | 36.5  | 29.8  | -   | -   | -   | -  | -  |
| 10 | 10-Aug-15 | No.  | 3         | -  | 45    | 41    | 7   | 1   | -   | -  | -  |
|    |           | ton  | 2.6       | -  | 77    | 68.4  | 4.3 | 1.2 | -   | -  | -  |
| 11 | 11-Aug-15 | No.  | 2         | -  | 30    | 32    | -   | -   | -   | -  | -  |
|    |           | ton  | 2.1       | -  | 53.5  | 53.0  | -   | -   | -   | -  | -  |
| 12 | 12-Aug-15 | No.  | -         | -  | 34    | 32    | 1   | -   | 1   | -  | -  |
|    |           | ton  | -         | -  | 49.7  | 42.9  | 0.6 | -   | 0.2 | -  | -  |
| 13 | 13-Aug-15 | No.  | -         | -  | 51    | 48    | 12  | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 76.2  | 72.3  | 3.8 | -   | -   | -  | -  |
| 14 | 14-Aug-15 | No.  | 1         | -  | 37    | 29    | 4   | -   | -   | -  | -  |
|    |           | ton  | 0.7       | -  | 49.6  | 42.2  | 1.8 | -   | -   | -  | -  |
| 15 | 01-Dec-15 | No.  | -         | -  | 48    | 47    | 6   | 2   | 5   | -  | -  |
|    |           | ton  | -         | -  | 83.8  | 77    | 1.3 | 0.4 | 1.1 | -  | -  |
| 16 | 02-Dec-15 | No.  | 1         | -  | 58    | 49    | 3   | -   | 1   | -  | -  |
|    |           | ton  | 0.2       | -  | 75.1  | 61.7  | 0.9 | -   | 0.1 | -  | -  |
| 17 | 03-Dec-15 | No.  | 2         | -  | 56    | 57    | 16  | 4   | 6   | -  | -  |
|    |           | ton  | 2.1       | -  | 77.3  | 77.6  | 5.8 | 0.9 | 1.1 | -  | -  |
| 18 | 04-Dec-15 | No.  | 4         | -  | 55    | 60    | 13  | 2   | 3   | -  | -  |
|    |           | ton  | 1.4       | -  | 78.9  | 80.6  | 3.1 | 0.8 | 0.7 | -  | -  |
| 19 | 05-Dec-15 | No.  | 6         | -  | 79    | 80    | 8   | 1   | -   | -  | -  |
|    |           | ton  | 3.2       | -  | 135.4 | 136.2 | 3.7 | 0.1 | -   | -  | -  |
| 20 | 06-Dec-15 | No.  | -         | -  | 48    | 47    | 17  | 4   | 5   | -  | -  |
|    |           | ton  | -         | -  | 64.7  | 62.8  | 6.4 | 1.2 | 1.4 | -  | -  |
| 21 | 07-Dec-15 | No.  | -         | -  | 44    | 44    | 10  | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 66.5  | 58.7  | 1.8 | -   | -   | -  | -  |

## 2.2 Holota Control station

| No | Date      | Unit | Axle load |    |       |       |      |     |      |    |    |
|----|-----------|------|-----------|----|-------|-------|------|-----|------|----|----|
|    |           |      | F1        | F2 | R1    | R2    | R3   | R4  | R5   | R6 | R7 |
| 1  | 17-Aug-15 | No.  | 4         | -  | 72    | 70    | 10   | 1   | -    | -  | -  |
|    |           | ton  | 2.3       | -  | 96.9  | 87.8  | 6.4  | 4.2 | -    | -  | -  |
| 2  | 18-Aug-15 | No.  | -         | -  | 80    | 72    | 6    | -   | -    | -  | -  |
|    |           | ton  | -         | -  | 98    | 86.1  | 3.1  | -   | -    | -  | -  |
| 3  | 19-Aug-15 | No.  | 5         | -  | 99    | 95    | 21   | -   | -    | -  | -  |
|    |           | ton  | 1.2       | -  | 166.4 | 132.5 | 13   | -   | -    | -  | -  |
| 4  | 20-Aug-15 | No.  | 5         | -  | 69    | 66    | 12   | 1   | -    | -  | -  |
|    |           | ton  | 1.8       | -  | 113.9 | 99.9  | 8.3  | 0.9 | -    | -  | -  |
| 5  | 21-Aug-15 | No.  | 14        | -  | 102   | 94    | 4    | 1   | 1    | -  | -  |
|    |           | ton  | 4.9       | -  | 187.9 | 147.4 | 2.2  | 1   | 0.10 | -  | -  |
| 6  | 22-Aug-15 | No.  | 16        | -  | 100   | 96    | 5    | -   | -    | -  | -  |
|    |           | ton  | 5.8       | -  | 162.6 | 127.8 | 2.7  | -   | -    | -  | -  |
| 7  | 23-Aug-15 | No.  | 7         | -  | 73    | 68    | 7    | -   | -    | -  | -  |
|    |           | ton  | 2.3       | -  | 117.7 | 94.1  | 3.6  | -   | -    | -  | -  |
| 8  | 01-Jan-16 | No.  | 11        | -  | 92    | 80    | 6    | 1   | 1    | -  | -  |
|    |           | ton  | 5.2       | -  | 146.8 | 119.9 | 4.6  | 4.2 | 0.4  | -  | -  |
| 9  | 02-Jan-16 | No.  | -         | -  | 84    | 71    | 3    | -   | -    | -  | -  |
|    |           | ton  | -         | -  | 108.9 | 69.2  | 1.4  | -   | -    | -  | -  |
| 10 | 03-Jan-16 | No.  | -         | -  | 75    | 58    | 15   | -   | -    | -  | -  |
|    |           | ton  | -         | -  | 149   | 102.6 | 10.6 | -   | -    | -  | -  |
| 11 | 04-Jan-16 | No.  | 7         | -  | 80    | 65    | 2    | 1   | -    | -  | -  |
|    |           | ton  | 1.9       | -  | 131.6 | 104.1 | 4.8  | 0.9 | -    | -  | -  |
| 12 | 05-Jan-16 | No.  | -         | -  | 88    | 70    | 1    | -   | -    | -  | -  |
|    |           | ton  | -         | -  | 112.3 | 72.5  | 0.1  | -   | -    | -  | -  |
| 13 | 06-Jan-16 | No.  | -         | -  | 73    | 63    | 2    | -   | -    | -  | -  |
|    |           | ton  | -         | -  | 120.5 | 80    | 0.2  | -   | -    | -  | -  |
| 14 | 07-Jan-16 | No.  | 1         | -  | 16    | 15    | 1    | -   | -    | -  | -  |
|    |           | ton  | 0.5       | -  | 27.3  | 22.8  | 0.9  | -   | -    | -  | -  |

### 2.3 Sandafa Control station

| No | Date      | Unit | Axle load |    |       |       |     |     |     |    |    |
|----|-----------|------|-----------|----|-------|-------|-----|-----|-----|----|----|
|    |           |      | F1        | F2 | R1    | R2    | R3  | R4  | R5  | R6 | R7 |
| 1  | 12-Dec-15 | No.  | 8         | -  | 38    | 38    | -   | -   | -   | -  | -  |
|    |           | ton  | 2.9       | -  | 53.1  | 46.2  | -   | -   | -   | -  | -  |
| 2  | 13-Dec-15 | No.  | -         | -  | 12    | 12    | -   | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 17.5  | 14.2  | -   | -   | -   | -  | -  |
| 3  | 14-Dec-15 | No.  | 8         | -  | 36    | 35    | 1   | -   | 1   | -  | -  |
|    |           | ton  | 3.1       | -  | 60.1  | 54.4  | 0.7 | -   | 0.7 | -  | -  |
| 4  | 15-Dec-15 | No.  | -         | -  | 38    | 36    | -   | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 53.3  | 49.5  | -   | -   | -   | -  | -  |
| 5  | 16-Dec-15 | No.  | 4         | -  | 44    | 38    | 1   | -   | -   | -  | -  |
|    |           | ton  | 1.1       | -  | 63.2  | 54.4  | 0.1 | -   | -   | -  | -  |
| 6  | 17-Dec-15 | No.  | -         | -  | 47    | 46    | -   | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 63.5  | 59.7  | -   | -   | -   | -  | -  |
| 7  | 18-Dec-15 | No.  | 8         | -  | 39    | 39    | 1   | -   | -   | -  | -  |
|    |           | ton  | 2.0       | -  | 63.2  | 53    | 0.1 | -   | -   | -  | -  |
| 8  | 19-Dec-15 | No.  | 1         | -  | 31    | 31    | -   | -   | -   | -  | -  |
|    |           | ton  | 0.9       | -  | 50.4  | 48    | -   | -   | -   | -  | -  |
| 9  | 20-Dec-15 | No.  | 3         | -  | 20    | 18    | -   | -   | -   | -  | -  |
|    |           | ton  | 0.4       | -  | 36.7  | 32.3  | -   | -   | -   | -  | -  |
| 10 | 21-Dec-15 | No.  | 2         | -  | 46    | 46    | -   | -   | -   | -  | -  |
|    |           | ton  | 0.4       | -  | 80.7  | 69.8  | -   | -   | -   | -  | -  |
| 11 | 22-Dec-15 | No.  | 6         | -  | 55    | 55    | -   | -   | -   | -  | -  |
|    |           | ton  | 2.9       | -  | 84.1  | 84.9  | -   | -   | -   | -  | -  |
| 12 | 23-Dec-15 | No.  | 1         | -  | 20    | 14    | 2   | -   | -   | -  | -  |
|    |           | ton  | 0.2       | -  | 39.8  | 24.3  | 0.4 | -   | -   | -  | -  |
| 13 | 24-Dec-15 | No.  | 16        | -  | 56    | 54    | 1   | -   | -   | -  | -  |
|    |           | ton  | 6.6       | -  | 89.3  | 80.8  | 1   | -   | -   | -  | -  |
| 14 | 25-Dec-15 | No.  | 2         | -  | 43    | 40    | 1   | 1   | 1   | -  | -  |
|    |           | ton  | 1.6       | -  | 75.6  | 70.9  | 2.5 | 2.7 | 2.7 | -  | -  |
| 15 | 08-Jan-16 | No.  | -         | -  | 30    | 24    | -   | 1   | -   | -  | -  |
|    |           | ton  | -         | -  | 46.1  | 26.1  | -   | 0.2 | -   | -  | -  |
| 16 | 09-Jan-16 | No.  | 1         | -  | 24    | 22    | -   | -   | -   | -  | -  |
|    |           | ton  | 0.1       | -  | 38.9  | 28.6  | -   | -   | -   | -  | -  |
| 17 | 10-Jan-16 | No.  | 15        | -  | 20    | 21    | -   | -   | -   | -  | -  |
|    |           | ton  | 10.9      | -  | 39.2  | 37    | -   | -   | -   | -  | -  |
| 18 | 11-Jan-16 | No.  | 27        | -  | 54    | 53    | -   | -   | -   | -  | -  |
|    |           | ton  | 9.3       | -  | 84.5  | 71    | -   | -   | -   | -  | -  |
| 19 | 12-Jan-16 | No.  | -         | -  | 47    | 44    | 1   | -   | -   | -  | -  |
|    |           | ton  | -         | -  | 75    | 58.4  | 0.5 | -   | -   | -  | -  |
| 20 | 13-Jan-16 | No.  | 9         | -  | 63    | 63    | -   | 1   | -   | -  | -  |
|    |           | ton  | 7.6       | -  | 100.8 | 90.5  | -   | 0.2 | -   | -  | -  |
| 21 | 14-Jan-16 | No.  | 15        | -  | 94    | 92    | 1   | 1   | 1   | -  | -  |
|    |           | ton  | 9.2       | -  | 167.5 | 145.6 | 0.9 | 0.5 | 0.5 | -  | -  |

## 2.4 Modjo Control station

| No | Date      | Unit | Axle load |    |       |       |      |      |     |    |    |
|----|-----------|------|-----------|----|-------|-------|------|------|-----|----|----|
|    |           |      | F1        | F2 | R1    | R2    | R3   | R4   | R5  | R6 | R7 |
| 1  | 20-Oct-15 | No.  | 7         | -  | 334   | 326   | 24   | 12   | 6   | -  | -  |
|    |           | ton  | 1.4       | -  | 324.2 | 323.2 | 8.4  | 4.1  | 2.4 | -  | -  |
| 2  | 21-Oct-15 | No.  | 2         | -  | 307   | 285   | 17   | 10   | 1   | -  | -  |
|    |           | ton  | 1.3       | -  | 312.1 | 320.7 | 7    | 5.4  | 0.9 | -  | -  |
| 3  | 22-Oct-15 | No.  | 5         | -  | 381   | 373   | 26   | 21   | 7   | -  | -  |
|    |           | ton  | 1.5       | -  | 292.8 | 319.9 | 14.3 | 14.1 | 4.1 | -  | -  |
| 4  | 23-Oct-15 | No.  | 2         | -  | 381   | 355   | 29   | 14   | 6   | -  | -  |
|    |           | ton  | 0.2       | -  | 309.8 | 309.9 | 10.6 | 11.8 | 8.8 | -  | -  |
| 5  | 24-Oct-15 | No.  | -         | -  | 296   | 313   | 15   | 5    | 3   | -  | -  |
|    |           | ton  | -         | -  | 265.9 | 328.6 | 9.9  | 4.2  | 1.1 | -  | -  |
| 6  | 25-Oct-15 | No.  | 1         | -  | 186   | 195   | 12   | 8    | 1   | -  | -  |
|    |           | ton  | 0.1       | -  | 172.7 | 204.3 | 5.8  | 3.8  | 0.3 | -  | -  |
| 7  | 26-Oct-15 | No.  | 4         | -  | 361   | 353   | 11   | 6    | 2   | -  | -  |
|    |           | ton  | 0.8       | -  | 173.8 | 197.9 | 1.5  | 1.3  | 0.7 | -  | -  |
| 8  | 24-Aug-15 | No.  | 9         | -  | 247   | 237   | 18   | 7    | 2   | -  | -  |
|    |           | ton  | 2.2       | -  | 320.6 | 296.5 | 14.8 | 5.6  | 1.7 | -  | -  |
| 9  | 25-Aug-15 | No.  | 1         | -  | 199   | 192   | 20   | 7    | 4   | -  | -  |
|    |           | ton  | 1.1       | -  | 241.1 | 227.2 | 10.8 | 7.4  | 2.7 | -  | -  |
| 10 | 26-Aug-15 | No.  | 4         | -  | 243   | 237   | 15   | 6    | 4   | -  | -  |
|    |           | ton  | 2.1       | -  | 307.3 | 317.5 | 10.8 | 4.4  | 3.1 | -  | -  |
| 11 | 27-Aug-15 | No.  | 7         | -  | 219   | 217   | 26   | 12   | 5   | -  | -  |
|    |           | ton  | 3.5       | -  | 303.7 | 300.1 | 22   | 9.3  | 2.5 | -  | -  |
| 12 | 28-Aug-15 | No.  | 8         | -  | 270   | 256   | 32   | 6    | 4   | -  | -  |
|    |           | ton  | 5.2       | -  | 322.5 | 335.3 | 20.5 | 4.5  | 2.2 | -  | -  |
| 13 | 29-Aug-15 | No.  | 13        | -  | 204   | 203   | 19   | 10   | 1   | -  | -  |
|    |           | ton  | 5.8       | -  | 192.7 | 196.6 | 11.4 | 8.3  | 1.1 | -  | -  |
| 14 | 30-Aug-15 | No.  | 1         | -  | 42    | 41    | 10   | 2    | -   | -  | -  |
|    |           | ton  | 0.7       | -  | 56.4  | 53.1  | 8.6  | 0.3  | -   | -  | -  |
| 15 | 23-Sep-15 | No.  | 5         | -  | 332   | 328   | 24   | 8    | 3   | -  | -  |
|    |           | ton  | 1.1       | -  | 367.2 | 374.9 | 19.8 | 7.7  | 1.6 | -  | -  |
| 16 | 24-Sep-15 | No.  | 11        | -  | 267   | 259   | 14   | 6    | -   | -  | -  |
|    |           | ton  | 2.9       | -  | 375.7 | 373.8 | 9.1  | 1.8  | -   | -  | -  |
| 17 | 25-Sep-15 | No.  | 5         | -  | 286   | 288   | 28   | 16   | 6   | -  | -  |
|    |           | ton  | 1.0       | -  | 350   | 371.8 | 15.7 | 9.5  | 2.2 | -  | -  |
| 18 | 26-Sep-15 | No.  | 3         | -  | 422   | 411   | 46   | 14   | 6   | -  | -  |
|    |           | ton  | 5.0       | -  | 466.2 | 468.9 | 27   | 7.5  | 2.9 | -  | -  |
| 19 | 27-Sep-15 | No.  | 5         | -  | 155   | 152   | 14   | 3    | 2   | -  | -  |
|    |           | ton  | 2.1       | -  | 178.2 | 178.3 | 5.8  | 1.2  | 0.7 | -  | -  |
| 20 | 28-Sep-15 | No.  | -         | -  | 74    | 67    | 9    | 1    | -   | -  | -  |
|    |           | ton  | -         | -  | 71.7  | 75.2  | 4.5  | 0.6  | -   | -  | -  |
| 21 | 29-Sep-15 | No.  | 3         | -  | 378   | 367   | 22   | 9    | 7   | -  | -  |
|    |           | ton  | 0.9       | -  | 472   | 453   | 13.1 | 4.2  | 2.5 | -  | -  |

## 2.5 Awash Control station

| No | Date      | Unit | Axle load |     |       |       |       |      |       | R6   | R7  |
|----|-----------|------|-----------|-----|-------|-------|-------|------|-------|------|-----|
|    |           |      | F1        | F2  | R1    | R2    | R3    | R4   | R5    |      |     |
| 1  | 10-Jul-15 | No.  | 5         | -   | 192   | 176   | 111   | 70   | 57    | -    | -   |
|    |           | ton  | 7.7       | -   | 325.6 | 284.3 | 126.9 | 70.9 | 78.5  | -    | -   |
| 2  | 11-Jul-15 | No.  | 1         | -   | 174   | 154   | 62    | 73   | 46    | -    | -   |
|    |           | ton  | 3.1       | -   | 210.9 | 153   | 61.1  | 41.7 | 50.4  | -    | -   |
| 3  | 12-Jul-15 | No.  | 5         | -   | 165   | 146   | 55    | 74   | 42    | -    | -   |
|    |           | ton  | 1.3       | -   | 230.4 | 181.1 | 48.8  | 34.7 | 33.9  | -    | -   |
| 4  | 13-Jul-15 | No.  | 3         | -   | 184   | 159   | 75    | 72   | 55    | -    | -   |
|    |           | ton  | 2.5       | -   | 238.7 | 186.2 | 75.1  | 38.7 | 63.7  | -    | -   |
| 5  | 14-Jul-15 | No.  | 5         | -   | 218   | 202   | 92    | 110  | 75    | -    | -   |
|    |           | ton  | 2.9       | -   | 351.7 | 273.6 | 117.3 | 54.5 | 92.2  | -    | -   |
| 6  | 15-Jul-15 | No.  | 15        | -   | 294   | 274   | 108   | 95   | 91    | 1    | -   |
|    |           | ton  | 13.2      | -   | 411.5 | 337.1 | 128.1 | 52.9 | 107.4 | 2.0  | -   |
| 7  | 16-Jul-15 | No.  | 2         | -   | 176   | 159   | 90    | 73   | 58    | 8    | -   |
|    |           | ton  | 1.9       | -   | 250.7 | 201.9 | 100.9 | 39.7 | 87.8  | 16.6 | -   |
| 8  | 23-Nov-15 | No.  | 8         | -   | 297   | 258   | 90    | 46   | 80    | 26   | 1   |
|    |           | ton  | 3.1       | -   | 579.3 | 443   | 66.5  | 25.8 | 124.3 | 48.4 | 0.9 |
| 9  | 24-Nov-15 | No.  | 3         | 1   | 295   | 267   | 93    | 27   | 44    | 12   | -   |
|    |           | ton  | 0.7       | 3.7 | 557.7 | 467.1 | 56    | 18.6 | 64.8  | 26.4 | -   |
| 10 | 25-Nov-15 | No.  | 1         | -   | 89    | 82    | 29    | 12   | 22    | 9    | -   |
|    |           | ton  | 0.1       | -   | 132   | 114.7 | 31    | 4.8  | 23.7  | 18.5 | -   |
| 11 | 26-Nov-15 | No.  | 2         | -   | 313   | 280   | 104   | 35   | 68    | 11   | -   |
|    |           | ton  | 0.9       | -   | 628.7 | 495.9 | 85.2  | 34.7 | 91.1  | 25.5 | -   |
| 12 | 27-Nov-15 | No.  | 5         | -   | 202   | 171   | 41    | 15   | 38    | 4    | -   |
|    |           | ton  | 1.7       | -   | 408.2 | 303.3 | 30.6  | 10.8 | 52.4  | 9.9  | -   |
| 13 | 28-Nov-15 | No.  | 2         | 1   | 104   | 94    | 21    | 4    | 15    | 2    | 1   |
|    |           | ton  | 0.3       | 0.5 | 148.9 | 130.3 | 12.9  | 1.5  | 16.4  | 3.2  | 1.7 |
| 14 | 29-Nov-15 | No.  | 3         | 1   | 319   | 287   | 87    | 29   | 54    | 14   | -   |
|    |           | ton  | 1         | 0.6 | 644.6 | 509.1 | 73.6  | 20.2 | 95.8  | 26.8 | -   |
| 15 | 12-Oct-15 | No.  | 1         | -   | 152   | 143   | 36    | 20   | 21    | -    | -   |
|    |           | ton  | 0.4       | -   | 303.8 | 264.6 | 25.9  | 17.6 | 27.1  | -    | -   |
| 16 | 13-Oct-15 | No.  | 2         | -   | 106   | 92    | 22    | 34   | 21    | 1    | -   |
|    |           | ton  | 1         | -   | 179.2 | 130.2 | 17.1  | 8.6  | 28    | 1.2  | -   |
| 17 | 14-Oct-15 | No.  | 15        | -   | 258   | 233   | 104   | 44   | 56    | 9    | -   |
|    |           | ton  | 11.1      | -   | 496.5 | 405.3 | 80.4  | 33.3 | 79    | 13.2 | -   |
| 18 | 15-Oct-15 | No.  | 8         | -   | 250   | 233   | 69    | 29   | 36    | 1    | -   |
|    |           | ton  | 4.6       | -   | 429.3 | 372.9 | 54.5  | 20.5 | 55    | 1.3  | -   |
| 19 | 16-Oct-15 | No.  | 4         | -   | 240   | 216   | 73    | 41   | 57    | 2    | -   |
|    |           | ton  | 2         | -   | 405   | 334.9 | 52.3  | 27.8 | 87.8  | 1.7  | -   |
| 20 | 17-Oct-15 | No.  | 12        | -   | 328   | 283   | 88    | 34   | 53    | 5    | -   |
|    |           | ton  | 7.9       | -   | 517.1 | 424.5 | 65.3  | 21.9 | 59.8  | 7.5  | -   |
| 21 | 18-Oct-15 | No.  | 18        | -   | 398   | 356   | 132   | 82   | 130   | 2    | -   |
|    |           | ton  | 7.5       | -   | 758.6 | 597.5 | 118.8 | 62.1 | 226.4 | 6.2  | -   |

### ANNEX 3: DATA COLLECTION FORMAT

#### 3.1 Axle load data collection template

| WEIGHBRIDGE DATA TEMPLATE  |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|----------------------------|-------------------|---------|------|--------|-------------|-----------|--------------------|---------------------------|----|----|----|----|----|----|
| Weighbridge Station: _____ |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
| I.N                        | Vehicle Plate No. |         | Date | Origin | Destination | Commodity | Axle Configuration | Actual Axle load (Quinta) |    |    |    |    |    |    |
|                            | Truck             | Trailer |      |        |             |           |                    | F1                        | F2 | R1 | R2 | R3 | R4 | R5 |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |
|                            |                   |         |      |        |             |           |                    |                           |    |    |    |    |    |    |

#### 3.2 Time data collection format

| WEIGHBRIDGE DATA TEMPLATE  |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |
|----------------------------|-------------------|---------|------|--------|-------------|--------------------|---------------------------|---------------------------|-----------------------------|----------------------------|------------------------|
| Weighbridge Station: _____ |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |
| I.N                        | Vehicle Plate No. |         | Date | Origin | Destination | Axle Configuration | Arrival Time (Hr:Min:Sec) | Service Time (Hr:Min:Sec) | Departure time (Hr:Min:Sec) | Time in Queue (Hr:Min:Sec) | Idle Time (Hr:Min:Sec) |
|                            | Truck             | Trailer |      |        |             |                    |                           |                           |                             |                            |                        |
|                            |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |
|                            |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |
|                            |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |
|                            |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |
|                            |                   |         |      |        |             |                    |                           |                           |                             |                            |                        |

## ANNEX 4: QUESTIONNAIRES

### 4.1 For control station Employees

**Ethiopian Roads Authority /ERA/  
Vehicle Weight and Size Control Station  
A survey for control station Employees**

This is a questionnaire prepared as part of a Civil Engineering master's degree program thesis in Road and Transport Engineering at Addis Ababa University in collaboration with Ethiopian Roads Authority.

Instruction: Please place "X" in the applicable boxes and provide explanations where it is required or needed.

1. Name of Vehicle weigh station: \_\_\_\_\_
2. Your employment position: \_\_\_\_\_
3. Age:  
18-25  26-50  18-25  >50
4. Gender  
Female  Male
5. Please indicate your highest level of education  
Primary school  Secondary school  Certificate   
Diploma  Bachelor's  Master's  Doctorate
6. If completed a certificate, diploma, or a degree, please indicate your area of study?  
\_\_\_\_\_
7. Please indicate your years of experience in this field of study?  
<10  10-20  20-30  >30
8. Please indicate the number of employees at your Vehicle weight and size station.  
10  15  20  30  Other \_\_\_\_\_
9. Please indicate the number of employment positions at your vehicle weight and size station and specify the number of employees under each position.  
\_\_\_\_\_  
\_\_\_\_\_
10. In your opinion, do you have enough employees at your vehicle weight and size station?  
Yes  No
11. If you indicated there are not enough employees at your vehicle weight and size station, please specify which positions you would like to see filled and how many employees?  
\_\_\_\_\_  
\_\_\_\_\_
12. At the weight and size station, do you have facilities and utilities needed to do your job?  
Example: Computers, traffic control devices, vehicles, electricity, water, restroom, lounge, etc.  
Yes  No
13. If the answer is "no" to number 12, what are some of the things your workplace is missing?  
\_\_\_\_\_  
\_\_\_\_\_
14. At your weigh station, do you have every equipment you need to do your job?  
Yes  No
15. If the answer is "no" to number 14, what are some of the equipment you are missing?  
\_\_\_\_\_  
\_\_\_\_\_
16. How often does the weighbridge get serviced?  
Daily  Weekly  Monthly  Yearly   
Other \_\_\_\_\_
17. How often does the weighbridge get checked for accuracy?  
Daily  Weekly  Monthly  Yearly   
Other \_\_\_\_\_

18. How often does the weighbridge get calibrated?

Daily  Weekly  Monthly  Yearly

Other \_\_\_\_\_

19. Has the weighbridge been out of commission for any reason?

Yes  No

20. If the answer is "yes" to number 19, what other instruments were used to weigh vehicles instead?

21. What is the drivers' level of knowledge about the weight and size station, and what it does in terms of controlling vehicle weight?

Low  Medium  High

22. Do drivers of these vehicles take alternative routes to escape weight and size stations?

Yes  No

23. If the answer is "yes" to number 22, what measures do you take to prevent this and/or catch them?

24. What is the drivers' level of knowledge about the difference between gross vehicle weight and axle load?

Low  Medium  High

25. Please indicate fines and other consequences for vehicles found to be over the legal weight limit?

26. In your opinion, are fine amounts appropriate for vehicles over the legal weight limit?

Yes  No

27. How long do these drivers take to unload some of their weight until they reach the legal limit?

One Day  One Week  One month

Other: \_\_\_\_\_

28. Aside from getting drivers to unload some of their load until reaching legal weight limit, what else is done?

29. Do slightly overloaded vehicles get allowances? For example, how many more tons are allowed if the front axle is already above 8 tons, and the rear is 10 tons?

<5 tons  5-10 tons  10-15 tons  >15 tons

30. What is the procedure in place to implement fines on overloaded vehicles?

31. Does the vehicle weight and size station have a storage room for unloaded materials from drivers'?

Yes  No

32. On average how many vehicles go through this station every day?

<50  50-100  100-500  >500

33. Generally, how do you categorize the availability facilities of the station?

V.poor  Poor  Good  V.Good

34. Do you have additional comments?

*Thank you for your kind cooperation!!!*

## 4.2 For heavy vehicle owners and drivers

### **Ethiopian Road Authority /ERA/ Vehicle Weight and size Station**

#### **A survey for heavy vehicle owners and drivers**

This is a questionnaire prepared as part of a Civil Engineering master's degree program thesis in Road and Transport Engineering at Addis Ababa University in conjunction with Ethiopian Road Transport Authority.

Instruction: Please place "X" in the applicable boxes and provide explanations where it is required.

1. Name of company: \_\_\_\_\_
2. Employment position: \_\_\_\_\_
3. Age:  
18-25  26-50  18-25  >50
4. Gender  
Female  Male
5. Job experience:  
<10  10-20  20-30  >30
6. Do you know about Ethiopian Vehicle weight stations?  
Yes  No
7. Have you had your vehicle weighed at this vehicle weigh stations before?  
Yes  No
8. If you answer "yes" to question number 7, how often?  
Daily  Weekly  Monthly  Yearly
9. Which weigh stations have you been to most?  
Modjo  Awash  Sululta  Alemgena   
Sendafa  Holeta  All  Other: \_\_\_\_\_
10. What do you transport?  
Crops  Construction material  Machine  All
11. Have you been fined for loading over the legal limits?  
Yes  No
12. If you answered "yes" to number 11, how much was the fine?  
\_\_\_\_\_
13. If you answered "yes" to number 11, was the process to pay the fine clear and straightforward?  
Yes  No   
Other: \_\_\_\_\_
14. Have you ever been instructed to unload some of the overload after being fined?  
Yes  No
15. If you answered "yes" to number 14, how long did it take for you to get your unloaded material?  
Within a day  within a week  within a month  year   
other: \_\_\_\_\_
16. On average, how long does it take to go through a vehicle weigh station in your experience?  
<1 min  1-5 min  5-10 min  year   
other: \_\_\_\_\_
17. Do you know the difference between gross vehicle weight and axle load?  
Yes  No
18. What is your opinion on how the vehicle weighs station operates?  
V.poor  poor  good  v.good   
Additional opinion: \_\_\_\_\_
19. Do you have additional comment on question number 18?  
\_\_\_\_\_
20. Have you ever been forced to give money to employees at the weight and size station so that you would not have to unload or penalised?  
Yes  No
21. Have you wasted time sitting around the station unduly waiting for the staff to do their jobs? Please provide an explanation?  
\_\_\_\_\_
22. Do you have additional comments?  
\_\_\_\_\_

*Thank you for your kind cooperation!!!*

### 4.3 For Consultants and professionals

#### Ethiopian Roads Authority Vehicle Weight and Size Control Station Questionnaire For Consultants and professionals

This questionnaire is prepared for Master's degree final thesis in Road and Transport Engineering stream under AAiT which is sponsored by Ethiopian Roads Authority. The thesis is all about the evaluation of axle load control system and management performance and comes up with a recommendation to the most effective and efficient axle load controlling system.

**Instruction;** Please mark **X** in a box for the choice questions and give brief explanation for the questions in need of explanation. (Genuine Answers are very much appreciated as it is for educational purpose)

1. Organization: \_\_\_\_\_
2. Occupation: \_\_\_\_\_
3. Age:
  - 18-25  26-50  >50
4. Gender:
  - Female  Male
5. Educational qualification:
  - Primary school  Secondary school  Certificate
  - Diploma  Bachelor Degree  Master's Degree  Doctorate Degree
6. Field of Study: \_\_\_\_\_
7. Work experience in road related projects:
  - <10  10-20  20-30  >30
8. How many road design projects have you done/involved in?
  - <5  5-15  15-30  >30
9. For the design projects you involved in, did you need axle load data?
  - Yes  No
10. If you say 'Yes' for the above question, how many of the design projects require axle load data?
  - <5  5-15  15-30  >30
11. From where would you collect your axle load data?
  - From ERA  You will collect by your self  Both
  - If there is additional explanation (Please) \_\_\_\_\_
12. If you use data collected from ERA, do you have a method of checking the realness of the data?
  - Yes  No  I don't have to check
  - If there is additional explanation. \_\_\_\_\_
13. If you use data collected from ERA, what do you say about quickness of response?
  - Delayed than expected  Quick  On time
14. How do you see ERA's axle load controlling system? (if you collect data from ERA for design)
  - Poor  Good  V.Good  Excellent

15. Have you ever considered any safety factor for 'Special vehicle weight and size Permits' during your design?

Yes  No

If there is additional explanation \_\_\_\_\_

16. Do you believe that roads design life is compatible with the load they are carrying?

Yes  No

17. If you say 'No' for the above question, would you please give explanation?  
\_\_\_\_\_

18. How do you see the extent of overloading in Ethiopia?

Very low  Low  High  Very high

19. From your experience, which one of the following causes do you think to take the leading role in road deterioration?

Environmental Impacts  Traffic Overloading  Both

If there is additional explanation \_\_\_\_\_

20. Do you think that axle load data is available for all ERA's road network?

Yes  No

21. If you say 'No' for the above question, would you please give your professional opinion?  
\_\_\_\_\_

22. What do you think about ERA's vehicle weight and size regulation of ERA?  
\_\_\_\_\_

23. Do you believe that Vehicle weight and size control stations are at the right location?

Yes  No

24. If you say 'No' for the above question, would you please give your professional opinion on the approach you will follow to determine the optimum location?  
\_\_\_\_\_

25. Do you believe that ERA's Vehicle weight and size control stations are doing things right?

Yes  No

26. If you say 'No' would you please comment on it  
\_\_\_\_\_

27. Do you believe that the axel load data somehow can be manipulated?

Yes  No

28. If you say 'Yes' for the above question, would you give your professional opinion how to overcome the problem?  
\_\_\_\_\_

29. Do you think that drivers/owners have the need of setting vehicle weight and size regulation?

Yes  No

30. If there is additional explanation \_\_\_\_\_

31. If you have any additional explanations which you believe it to be additional input for the thesis you are very welcomed to forward  
\_\_\_\_\_

***Thank you for your kind cooperation!!!***

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## ANNEX 5: SAMPLE PICTURES OF VEHICLE WEIGHT AND SIZE CONTROL STATIONS



