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OPTIMIZING LOGISTIC CHAIN OF ANIMAL TRANSPORT AND MEAT DISTRIBUTION: STUDIES ON LIVESTOCK MARKETS AND ABATTOIRS IN ADDIS ABABA CITY

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of MASTERS OF SCIENCE IN CIVIL ENGINEERING/ROAD AND TRANSPORT ENGINEERING STREAM

By

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Master Degree

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Abstract

Ethiopia has the largest livestock population in Africa. Livestock production is an integral part of the country's agricultural production system and the livestock sector constitutes a significant share of the country's GDP. As one of the milestones for the overall livelihood in the country, livestock serves as a source of draught power for the rural farming population, supplies farm families with milk, meat, manure, serves as a source of cash income, and plays significantly in the social and cultural values of the society. Despite the importance of the livestock sector to the agricultural and national economy in the country, the sector is underdeveloped and underutilized. The challenges facing the transport and handling of slaughter animals was thought to be one of the obstacles to the livestock sector shadowing the role it can play in the national economy.

This study aimed at mapping out the animal supply chain from regions to the terminal markets in Addis Ababa and further to the Abattoirs, identifying and mapping the existing livestock market and Abattoirs in the city, mapping out the activities and processes at the abattoir, determining possible locations of the livestock markets and abattoirs in the city, and evaluating the existing meat distribution in the capital in addition to pointing out possible recommendation for efficient transport and handling of slaughter animals in the city and from different parts of the country to the city.

Slaughter animals in Addis Ababa are brought from different parts of the country passing different hierarchy of markets. Isuzu trucks, not designed for the purpose of transporting animals, are used for transporting the slaughter animals from various regions to the terminal market in Addis Ababa although animal trekking was also another mode of animal transport to the city especially for shorter journeys. Considerable problems in handling and treatment of animals during loading, transport, and unloading were observed and the process as a whole was not in line with the animal handling guidelines of the country due to various technical and institutional problems.

Addis Ababa Abattoir Enterprise(AAAE) was the biggest Abattoir in the city responsible to provide 85% of the city's meat demand (both in slaughtering and distributing meat) where the remaining 15% share of the meat consumption was covered by Kara-Alo Abattoir and Abattoirs

in Oromia regional state nearby the capital. The meat distribution process with respect to route choice, delivery order, vehicle scheduling and management, sanitation problems were inefficient in minimizing distribution costs, delivering quality and healthy meat to the customers, and on time delivery of the product to the customers. The result of route optimization using RouteLogiX Professional V 5.5 (5 Professional) showed that the distribution routes and delivery orders were not optimized and up to 41% savings in distribution distance with an average saving of 12.33% and up to 39.68% savings in distribution times with an average saving of 13.58% would be achieved if optimized routes were used.

The existing livestock market centers and Abattoirs in Addis Ababa were evaluated with respect to their location, standard and effect on the community nearby them. The result of location analysis showed that most of the market centers and Abattoirs are located at city centers with fewer standards than required affecting the health of the inhabitants negatively. Location factor rating technique was used as a tool to determine optimum positions of livestock market centers and Abattoirs at optimum locations that will resolve the existing challenges and contribute to the well being of the inhabitants as well.

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List of Acronyms

AAAE	Addis Ababa Abattoirs Enterprise
AATIDB	Addis Ababa Trade and Industry Development Bureau
GDP	Gross Domestic Product
MOARD	Ministry of Agriculture and Rural Development
ILRI	International Livestock Research Institute
GHG	Green House Gases
M	Meter
Kg	Kilogram
Sq mi	Square mile
KM	Kilo Meter
Sq km	Square Kilometer
CLM	Council of Logistic Management
SCM	Supply Chain Management
CSCMP	Council of Supply Chain Management Professionals
WB	World Bank
MDGs	Millennium Development Goals
ERA	Ethiopian Road Authority
EFTC	Ethiopian Freight Transport Corporation

NABC	Netherlands-African Business Council
FAO	Food and Agriculture Organization of the United Nations
EC	European Commission
UKFAWC	United Kingdom Farm Animal Welfare Council
MSL	Mean Sea Level
AU	African Union
UNECA	United Nations Economic Commissions for Africa
UN	United Nations
GPS	Global Positioning System
Min	Minute
ETB	Ethiopian Birr
E.C	Ethiopian Calendar

1. Introduction

1.1. Problem and background

Ethiopia has the largest livestock population in Africa. The contribution of the livestock sector to the national economy is thought to be significant. Ministry of Agriculture and Rural Development (MOARD, 2007) outlined that the livestock sector constitute 16% share in the national GDP, 27-30% share in the agricultural GDP, and 13% share in the country's export earnings. Besides, livestock are important sources of food (meat and milk), cash income, services (transport and traction) and manure (for soil fertility management and fuel) at individual small holder's level. However the sector has remained underdeveloped and underutilized due to technical, organizational, institutional, infrastructural, and policy constraints. ILRI (2007) reported that the contribution of the livestock sector to the Ethiopian Economy, at either the macro or micro level is below potential.

Transport and handling of slaughter animals need special attention so as to avoid animal stress during loading, transport, and unloading. Slaughter animals should be transported using specially designed livestock trucks in a manner that avoid injury and minimizes stress throughout the journey. Poor transportation can have serious effects on the wale fare of the animals and it can lead to a significant loss of meat quality and production (MOARD, 2008). However, slaughter animals were poorly handled during transport to the terminal markets in Addis Ababa, within the market centers and inside lairage. Trekking of slaughter animals to Addis Ababa from nearby market centers is common where trekking large groups of animals together, beating by sticks and ropes (which put the animals in stress) were the main observed problems.

Addis Ababa is the largest and capital city of Ethiopia, with a population of 3,384,569 according to the 2008 population census. Addis Ababa lies at an altitude of 2400 meters with an estimated area of 530.14 square kilometers (204.69 sq mi), an estimated density of 5,165.1 inhabitants per square kilometer (13,378 /sq mi) and is a chartered city.

The existing locations of livestock market centers and Abattoirs in Addis Ababa were thought to be contributory factors for traffic congestion, traffic accident, environmental pollution, and poor

health conditions of the inhabitants. As 80% (Geberemariam, 2011) of the motor vehicles in the country are driven in the city of Addis Ababa, the transport of slaughter animals within the city were observed to be an additional factor accelerating congestion in the city. With respect o road safety also, Addis Ababa is experiencing around 700 accidents per month which accounts for 60% of the accidents that occur in the country where crashes between vehicles and animals is one of the contributory causes (Berhanu, 2000). In addition, sanitation and hence health problems due to wastes from market centers and Abattoirs are very considerable at different places in the capital.

Most of the livestock market centers in Addis Ababa are located in the city centers and their capacity and standard is much less than the required ones. The capacity of the market centers are very limited that, on street marketing of animals is very common in the city which are also major problems in traffic congestion and road safety. In case of Abattoirs, AAAE is the only biggest Abattoirs responsible for slaughtering animals and distribution of meat to customers in the city. It is common to see poor handling of meat during loading and unloading by working personnel of the enterprise and the meat distribution process is also affected by the traffic congestion in the city especially during peak traffic hours. Beside the location of the Abattoir, route choice and choice of delivery order during meat distribution are additional factors for increased distribution costs and on time delivery of fresh products to the customers.

Therefore, it is thought that evaluating logistic chain of animal transport and meat distribution in the city and recommending possible solutions to solve the underlying problems will improve the whole animal supply chain in the city. Optimum location of livestock market centers and Abattoirs will play a significant role in reducing traffic congestion and traffic accidents. Location decisions considering land use, environmental protection, and proximity to customers will solve sanitation problems in the city, improve the health conditions of the inhabitants, and make the whole animal logistic chain in the city more efficient. Optimization of meat distribution routes will also reduce delay in delivery; minimize distribution costs (such as vehicle maintenance cost, fuel cost, and labor cost) there by contributing positively to the whole urban transport system.

1.2. Literature review

1.2.1. Definitions and concepts

The historic development of logistic concept is debatable among different scholars. It is believed that logistics as an activity was there in the ancient human civilization when an organized trade was started (Lambert et al., 1998). Other literatures link logistics origin with earlier military activities. According to Kuse et al. (2001) logistics was originally a military term used together with strategy and tactics where it came to be used as a business term as well in the latter half of the twentieth century. Tseng et al. (2005) also strengthen this idea stating that the term was initially a military activity concerned with getting soldiers and munitions to the battlefront in time for flight, but it is now seen as an integral part of the modern production process.

A series of definitions were then given for what logistics mean once the word had come to study. The Council of Logistics Management (CLM, 1991) defined logistics as 'part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics is also defined as "The management of the flow of goods or materials from point of origin to the point of consumption, even some times to the point of disposal" (Lambert 1998). The common modern definitions of logistics describes it as a process of moving and handling goods and materials, from the beginning to the end of the production, sale process and waste disposal, to satisfy customers and add business competitiveness.

As the definition of logistics is varying from context to context, the development of concepts behind logistics is becoming interesting to many scientists. According to Waters (2003), at the heart of an organization are operations that create and deliver products which are traditionally described as either goods or services. The products created by an organization are passed to its customers giving the cycle shown in figure 2.1 in which customers generating demands with operations using resources to make products to satisfy them. D.waters therefore believes that it is logistics which is responsible for moving materials along this cycle. "Logistics is the function

responsible for the flow of materials from the suppliers into an organization, through operations within the organization, and then out to customers" (Waters 2003).

***Materials**:* In the definitions above, it is outlined that logistics is mostly concerned with the movement of materials. It is therefore fundamental to put a definition for what a material exactly stands for in the context of logistics. "Materials are all things that an organization moves to create its products. These materials can be both tangible (such as raw materials) and intangible (such as information)" (Waters 2003).

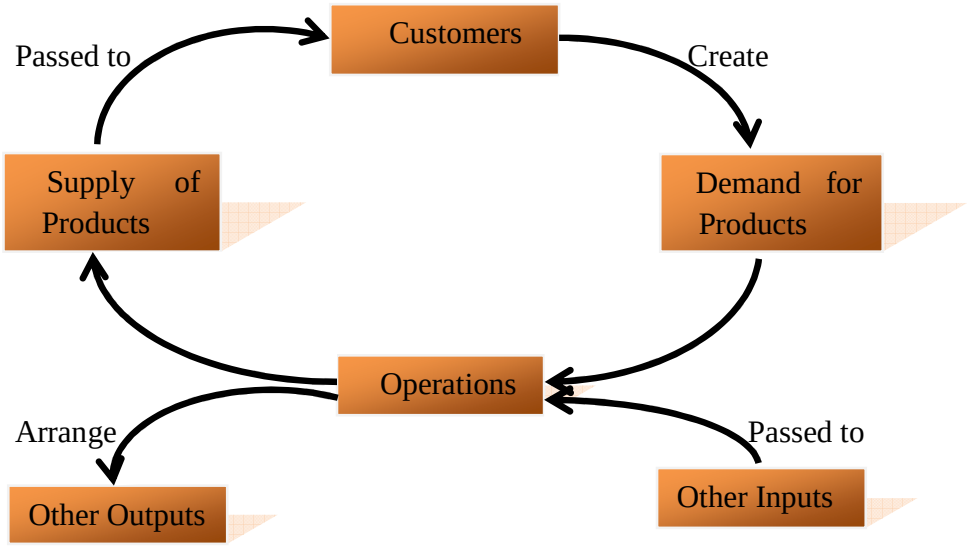

Figure 1.1. Cycle of supply and demand (Waters, 2003)

***Supply Chain and Value Chain**:* In the concept of logistics, there is a chain of activities and organizations through which the movement of materials is to pass. Different scholars use different terms to represent these chain of activities and organizations of which the common two are Supply chain and Value Chain. According to Waters (2003), supply chain consists of the series of activities and organizations that materials move through on their journey from initial suppliers to final customers. A broader term which integrates logistics across the whole supply

chain is a Supply Chain Management (SCM). “SCM is managing the flow of information, products, and services across the network of customers, enterprises, and suppliers” (Russell 2009).

The definition of SCM as per Council of Supply Chain Professionals (CSCMP, 2011) encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. It also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers as it integrates supply and demand management within and across companies.

A Value Chain mostly represents the integration of all value adding activities in terms of good quality, fair price, and fast and accurate delivery for the customers. “The *value chain* describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use” (Kaplinksy and Morris, 2000). Value chain analysis describes the activities within and around an organization, and relates them to an analysis of the competitive strength of the organization. Therefore, it evaluates which value each particular activity adds to the organizations products or services.

1.2.2. Transports as a global issue

Transport is the backbone of any country not only because it is a milestone for economic development but also because it is becoming a burning political agenda all over the globe. According to the report by World Bank (WB, 2008), putting in place a safe, clean, and affordable transport is the front prerequisite to achieve the Millennium Development Goals (MDGs). The current facts on the ground seem to highly support this idea. It is outlined on the same report that between 40 to 60 percent of the people in developing countries live more than 8 kilometer (KM) from a health care facility which is a big concern with regard to safe transport. With respect to road safety, an estimated 1.2 million people lose their lives and more than 50 million are injured per year due to road crashes where the poor are the more affected ones (WB, 2008).

In regard to clean transport, the contribution of transport to environmental pollution is considerably sensitive at present. In this line, 90 percent of the gases generated by motor vehicles are killing around 800,000 people each year and the transport sector is contributing for 15 percent of global greenhouse gas emissions (WB, 2008). The recommendations on alleviating the connection between economic growth and transport-generated greenhouse gases shows that changes in travel behavior, logistics decisions, technology choices, and transport modes can moderate the problem overtime.

Transport affordability is another question especially in developing countries as the physical supply of transport is not enough. Affordable transport is an input to trade and competitiveness as efficient and affordable freight transport and logistics services are critical for both domestic and international trade. In most countries, transport accounts for a quarter of all logistics costs, and the share may even be larger in developing economies (WB, 2008). At individual level, an estimate of 1 billion people (WB, 2008) in low-income countries lack access to an all-weather road. Therefore, affordable transport can not only enhance mobility but also increase inclusion and promote social, economic and political integration

In general, the five key ways through which the transport sector could contribute to the achievement of the MDGs are by (WB, 2008): -

- Facilitating economic growth and regional integration through international trade
- Making cities work better for their citizens, for the environment, and for economic growth
- Creating economic opportunity and growth in rural areas.
- Providing access to facilities that deliver health care and education
- Becoming safer and cleaner for users and the community

Transportation in logistics

Transportation constitutes one key component in logistics that moves raw material from source to factories and products from factories to consumers. It moves products that are geographically separated and provide added value to customers where it can contribute to the level of customer

service which is one corner stone in customer satisfaction. Lambert et al. (1998) states that transportation creates place utility and contribute to time utility both of which are important for successful marketing effort. By place utility it means that transportation adds value to products by physically moving them from where they are produced to where they are needed where as time utility is created by warehousing and storing products until they are needed. Transportation is also a factor in time utility as it determines how fast and how consistently a product moves from one point to another.

Of the total logistics cost, the share of transportation cost is also very significant as outlined on different literatures. According to TSENG et al. (2005), one-third of the total logistics cost is occupied by transportation and the performance of the whole logistics system is highly influenced by transportation systems. Lambert et al. (1998) also underlined that transportation is one of the largest logistics cost for many firms and may account for a significant portion of the selling price of some products. Based on these facts transportation is considered to be the key element in a logistic chain which joins different separated activities.

Another important factor in transportation is the mode to choose in transporting goods as the mode choice depends on various factors in practice mainly on the nature of the material to be moved, the volume and distance. The following are factors to be considered in choosing transport modes in logistics (Waters 2003):-

- Value of materials, as expensive items raise inventory costs and encourage faster modes.
- Importance, as even low-value items that would hold up operations needs fast, reliable transport.
- Transit times, as operations that have to respond quickly to changes cannot wait for critical supplies using slow transport.
- Reliability, with consistent delivery often being more important than transit time.
- Cost and flexibility to negotiate rates
- Reputation and stability of carrier
- Security, loss and damage
- Schedules and frequency of delivery

- Special facilities available.

In summary, the cheapest modes of transport are the least flexible (Waters 2003). Table 1.1 below shows a ranking for the cost, speed, flexibility and load limits of different modes of transport. The modes are ranked in order, with 1 being the best performance and 5 being the worst.

Table1.1. Ranking among different modes of transport in logistics

	Rail	Road	Water	Air	Pipeline
Cost	3	4	1	5	2
Speed	3	2	4	1	5
Flexibility	2	1	4	3	5
Volume/Weight limit	3	4	1	5	2
Accessibility	2	1	4	3	5

Source: Waters, 2003

1.2.2.1. Transport in Ethiopia

Ethiopia, as a land locked country, is mainly dependent on road transport for economic development and roads are also the country's backbone of infrastructure. Roads are currently the main infrastructure to support growth in agriculture and industry, to link ports and tourism areas, and to connect each administrative region to the rest of the country. They also furnish access to internal markets and social infrastructure such as schools and health centers.

According to Tadesse (2006), due to the fact that Ethiopia is landlocked, has varied geographical terrain, and scattered settlement pattern, road transport is the most important mode of transport in the country.

Besides movement within the country, road transport plays an important role to cater the international transport requirement with the neighboring countries where the major international traffic is primarily observed in the Addis Ababa- Djibouti corridor. Though road transport has such importance to the development of the country, the road network coverage is much lower than its importance and the density within the country is also low. Road Transport Network service in the country is insignificant in relation to the size of the population and geographical

area of the country. The distribution in the country is also uneven and therefore it could not contribute significantly to the efforts to balance the distribution of social services (Tadesse 2006).

Data obtained from Ethiopian Road Authority (ERA) shown in table 1.2and 1.3 also show that, the road coverage and road quality in Ethiopia needs an improvement to support the county's economic development.

Table 1.2. Length of classified road network in km

Road Class	Paved	Unpaved	Total
Federal Roads	4635	13905	18540
Regional Roads	-	15956	15956
Community Roads	-	2000	2000
Total	4635	31861	36496

Source: ERA, Network analysis (2004), cited in Tadesse (2006)

Table 1.3. Condition of road network in percent

Road Type	Good	Fair	Poor
Federal Roads	31	25	44
Regional Roads	28	35	37
Average	30	30	40

Source: ERA (2002), cited in Tadesse (2006)

1.2.2.2. Freight transport in Ethiopia

In developing countries, either due to economic problems or due to lack of technical capabilities to go for alternative modes of transport, road transport continues to be the prominent mode of transport. In Africa for instance, Road transport accounts for over 80% (Tadesse, 2006) of all freight and passenger movements which makes the sector most essential for the operation of the African trade. In Ethiopia, about 95% of the cargo movements are transported through road freight transport services (Tadesse, 2006).

Commercial road freight transport in Ethiopia is one of the sectors that suffer a lot in the past and is one that is still suffering due to many technical as well as economical problems. During the "Derg" regime (1974-1991), the sector was highly centralized where the Ethiopian Freight Transport Corporation (EFTC), a publicly owned commercial transport entity, was responsible for most of the services and managing private operators. All commercial freight transport operators were organized into zones (called "Ketenas") where five "Ketenas" were for dry cargo transport while one "Ketena' was for all bulk cargo transportation. EFTC then leads the "Ketenas", set tariff rates, collect five percent commission, allocate loads, organize payments, and overall owned the business where the role of the private operators were limited to operating and maintaining the vehicles. Due to these and other underlying reasons, road freight transport services was passed through unfavorable business environment that discouraged private investment in the sector resulting in the continuous depletion of the stock of commercial vehicles and shortage of spare parts(kifle et al. , 2000).

Proclamation number 14/1992 deregulated the transport sector in Ethiopia where the "Ketena" system was dismantled and EFTC was broken into four government enterprises which are Comet, Shebelle, Wayira and Gefersa. The four enterprises were allowed to operate independently with their own budget and management as well as the private sector were permitted for free entry and exist in the provision of freight transport services. Despite these policy changes and the improved operating environment created by the government, the road freight transport sector still suffers from inadequate supply and an aging fleet of vehicles with low carrying capacity and low utilization (kifle et al., 2000).

Some of the challenges facing the road freight transport sector in Ethiopia are (Aschenaki, 2004):

- A significant percent of the industry's fleet is old and poorly managed and this may hinder the efficiency and the export competitiveness
- Although domestic costs are somewhat competitive, it is difficult to say that the market has no barriers to entry or exist and is supported by sufficient information technology.
- Ethiopia's terrain is also an obstacle that needs an innovative way of thinking for other solutions beyond road construction.

- As custom tariff on trucks and spare parts are high, the majority of the freighters in Ethiopia are outdated.

1.2.3. Transport and handling of animals

Animals mean almost everything for us. We can work with them, eat their meat, use their skin as leather, produce energy or fertilizer from their waste, etc. Besides, animals are good friends of human being since before. However, it is a day in-day out fact that animals are poorly handled during transport especially in developing countries. When coming to slaughtered animals, the problem becomes a magnified one as the mishandling of this animals can affect the meat quality that may even harm human health. To mitigate this fact and improve humane treatment of animals, many researches are conducted by different scholars all over the world. Under this topic, different literatures on the effect of transport on animals, how animals has to be handled during transport and the way animals has to be treated in the whole logistic chain of animal transport with emphasis on slaughtered animals are assessed.

1.2.3.1. Overview of the livestock sector in Ethiopia

Ethiopia ranks first in Africa and tenth in the world with respect to livestock population (Gebremedhin, 2007). According to the report by Netherlands-African Business Council (NABC, 2010), The population of livestock in Ethiopia is believed to be one of the largest in the world and the largest in Africa with an estimated total number of 13433 million animals. Food and Agriculture Organization of the United Nations (FAO, 2004) also reported that Ethiopia has one of the largest livestock inventories in Africa with livestock ownership supporting and sustaining the livelihood of an estimated 80 percent of the rural poor. Livestock play an important role in the country both at individual household and national level. At individual householders' level, livestock serves as source of food (meat and milk), cash income, services (transport and traction) and manure (for soil fertility management and fuel). Moreover, livestock have social and cultural values among producers particularly pastoralists and they are store of wealth and hedge against inflation for the average rural farm household with limited investment alternatives (ILRI, 2007).

The contribution of the livestock sector to the national economy has also a significant weight even though the contribution of this sector to the national and agricultural GDP is not yet acceptably figured out. FAO (2004) estimated the contributions of livestock to total GDP at 18.84% and to the agricultural GDP at 44.54%. MoARD (2007) also reported that the livestock sector accounts for 16% of the national and 27–30% of the agricultural GDPs, and 13% of the country's export earnings. Depending on the above figures, it is a common consensus that livestock are among the milestones of the country's economy contributing a lot both to the national economy and to the livelihood of individual house holders.

The suitability of the environment for livestock production is also another advantage for Ethiopia. The country's vast grazing land area, if properly developed and managed, could contribute significantly to the alleviation of the feed shortage problem. Besides, the large human population the country owns and its proximity to potential export markets offer great opportunities for market-oriented development of the sector. With the improved management practices, the indigenous livestock breeds which have good meat quality can increase marketable surplus. The growing domestic demand as a result of increased urbanization, higher incomes due to economic growth, and rising population, offers significant incentive for increased market oriented livestock production. The increasing demand for meat and live animals in the international market especially in the Middle East also offers Ethiopia an opportunity to expand its export earnings (ILRI, 2007).

Even though Ethiopia owns a significantly large livestock population, the sector has remained underdeveloped and underutilized due to technical, organizational, institutional, infrastructural, and policy constraints. ILRI (2007) reported that the current levels of contributions for the livestock subsector in Ethiopia, at either the macro or micro level is below potential. Unlike the size of the livestock population, the level of foreign exchange earnings from livestock and livestock products is also much lower than expected. Traditional technologies, limited supply of inputs (feed, breeding stock, artificial insemination and water), poor or non-existent extension service, high disease prevalence, poor marketing infrastructure, lack of marketing support services and market information, limited credit services, absence of effective producers'

organizations at the grass root level, and natural resources degradation are among fundamental constraints underlying the undesirable outcome from the sub sector (ILRI, 2007).

Currently, there is a better recognition from the government side of the huge and yet untapped potential of the sector, accompanied by renewed efforts to develop and elevate its contributions to both the domestic and export markets. Various encouraging changes in approaches and methods to develop the sector are under progress. However, lack of adequate experience and knowledge, poor input supply system, inefficient input/output marketing system, limited support services and other technical and socio-economic considerations has limited the performance of the sector. The major technical constraints are shortage and fluctuation in quality and quantity of feed, poor genetic resource base for production traits, poor management practices, diseases, poor market infrastructure and institutional arrangements. Most inputs have been supplied by the government and there is a tendency to continue in the future too (ILRI, 2010).

1.2.3.2. Stress in animals

Although stress is a well known term, the definition for animal stress and the meaning of stress in this context varies from literature to literature. Borell (2001) defined stress as "A condition in an animal that results from the action of one or more stressors that may be of either external or internal origin." The stressor can be considered as harmful or not depending on the way an organism is able to cope with a threatening situation. Stress can also be described as a consequence of adverse effects of environment or management systems that causes changes in an animal's physiology or behaviour to avoid physiological malfunctioning, thus assisting the animal to cope with its environment (Fazio and Ferlazzo,2003). The adverse states in animals can be assessed through different ways such as by observing their behaviour, measuring physiological changes, and some haematochemical and haematological values.

Various scientific researchers have shown that warm-blooded animals (this includes livestock) feel pain and the emotion of fear. In particular mammals, including food animals of this group, are susceptible to feel fear and suffering from pain, and it is likely that they suffer pain in the same way as humans (FAO, 2001). The strong causes of stress in livestock which then can affect the quality of meat obtained are fear and pain. Pain is usually the effect of injury and suffering,

which also affects the quality and value of meat. well-organized, experienced and quiet handling of livestock, using recommended techniques and facilities, as well as taking measures to eliminate pain and accidental injury, will reduce stress , unnecessary discomfort in the animals and prevent quality deficiencies in meat and by-products(FAO, 2001).

1.2.3.3. Animal welfare

The concern of animal welfare and its influence on product quality are major considerations in many developed countries. In the developing countries, however, the welfare of animals receives low priority due to factors such as prevalence of food insecurity, traditional customs and beliefs, lack of knowledge in animal handling and sub standard handling facilities (Ndou, 2011). Road transport of slaughter animals is the cause for a variety of potential stressors such as heat, cold, poor air quality, vibration, motion of the lorry, and noise which can compromise the welfare and health of the animals and also decrease product quality and may even cause death (Ljungberg et al., 2006).

The welfare of an animal can be said to have been compromised if the animal cannot cope with its environment or copes with difficulty. The welfare of animals has a link with carcass and meat quality. Their response to environmental conditions, other animals, pathogens, and human handling have an effect on the carcass and meat quality (Adzitey, F, 2011). From the above literatures, the welfare of animals is directly related to the way they are handled and transported. During transport, animals are vulnerable to various conditions to which they cannot cope with and that can affect the welfare as well as the product quality. It is therefore necessary to develop effective logistics systems, taking into consideration, road and traffic conditions, climate, transport time and distance, and queuing at delivery (Ljungberg et al., 2006).

1.2.3.4. Handling of slaughter animals

Animals undergo several activities and processes that may reduce their product quality before slaughtering. These activities and processes take place on the farm, during transportation, marketing and at the slaughter plant itself. Unless we care for them, animals appreciably change their conditions within few days prior to slaughter which will adversely reduce their weight, affect the meat quality and subsequently reduce profit. According to Adzitey(2011), due to poor

pre-slaughter handling, animals are exposed to all kinds of stresses ranging from physical such as high ambient temperature, vibration and changes in acceleration, confinement, noise, and crowding; to psychological such as the breakdown of social groupings and mixing with unfamiliar animals, and unfamiliar or noxious smells.

What to consider in handling animals?

The following are key points to critically consider in handling slaughter animals and to increase the product quality (Adzitey, 2011):

a). The animal

As reported on different literatures, even if the degree varies with the animal type, almost all animals are believed to suffer from poor pre-slaughter handling. In this line, Adzitey(2011) reported that ruminants (sheep, cattle and goat) are less susceptible to stress compared to non ruminants (poultry and pigs) making poultry meat and pork more prone to meat quality defects compared to mutton or beef. Females and young animals are also more susceptible to stress compared to males and older animals. It is therefore very essential to treat animals according to their susceptibility rather than thinking them as one and the same during handling.

b) Farming

As animals are reared almost entirely on farms, the farming systems and feeding programme significantly contributes to meat quality. Arguello et al. (1999) has found that kids nursed by their dams has strong muscle with higher water holding capacity when compared to those fed on commercial milk replacer. Besides, nutrition also plays an important role in carcass and meat quality of animals. Sink and Caporaso (1977) also reported that certain foodstuffs (legumes and grains) can intensify flavor of sheep meat and whereas withdrawal of sheep from grazing before slaughter can reduce flavour.

c) Housing conditions

In many developing countries, the house used for cattle do not have roofs. The report by Moyo and Masika (2009) confirms that during the rainy season, the animals are exposed to excessive rain, especially at night and become susceptible to diseases, such as foot rot. Besides, cow dung during the rainy season creates muddy conditions which is uncomfortable for cattle to lie down in addition to creating conducive conditions for diseases (Ndou et al., 2011).

d) Transportation

Usually, animals are transported from farm on which they are reared to other locations for many reasons. This may include other places with better and less expensive feed, market centers, and slaughter plants. Great care should be taken while transporting slaughter animals especially during loading and unloading. According to Adzitey and Nurul (2011), both loading and unloading ought to be done in a gentle manner and under a quieter environmental condition. Transport also exposes animals to environmental stress such as heat, cold, humidity, noise and overcrowding. Driving conditions such as over speeding, sudden stops, rapid acceleration and long journey times without appropriate rest are also known to increase the spate of carcass and meat quality defects.

e) Marketing

Market is another place where animals are exposed to bad conditions. Unless sent directly to the abattoirs, animals are usually sold at the markets where they may be kept in groups and in open pens which may expose them directly to the sun or cold. Animals may also suffer from stresses such as noise, unfamiliar environment and social regrouping and they can also be starved or dehydrated if feed and water is withdrawn longer than recommended (Adzitey, 2011).

F) Feeding and watering

To prevent animals from starvation and dehydration that can lead them to depletion of muscle glycogen and reduction in weight, they must be provided with feed and water when necessary during transportation or marketing. According to the Council of Europe (1972), animals should be offered water and appropriate food at suitable intervals during transport and they should not be left more than 24 hours without being fed and watered. This period may, however, be extended if the journey to the destination where the animals are unloaded can be completed within a reasonable period. It is therefore essential to provide animals with the proper feed and water during transportation or marketing if the animals are going to be transported or kept in the lairage over a longer period than recommended.

g) Lairaging

Lairage is a place where animals are held temporarily prior to slaughter and it also serves as a collection point for different animals just before slaughter. Lairage is also very essential in providing animals with some amount of recovery from stress during transport. Adequate amount of suitable feed and water has to be given to the animals if they will be kept in the lairage longer than expected. Lairageing may be a major source of meat quality problems unless appropriate treatment is not made to protect the animals. Animals may suffer from different degree of bruising and injury as a result of fighting or overcrowding. Careless and improper handling of animals in the lairage such as the use of electrical goads, abstracting the movement of animals through race, beating and firm grip of the coat with the hand, exposure of animals to microbial contaminations will adversely have effect on the carcass and meat quality(Adzitey, 2011).

h) Stunning

Proper stunning is the end to pre-slaughter handling and once the animal is properly stunned, it is made unconscious and sensitivity to pain stops. The type of stunning equipment used can contribute to the quality of carcass that will be produced. The European Food Safety Authority (AFSA, 2004) recommends that, non -penetrating captive bolt, penetrating captive bolt, and electrical stunning methods have to be used to stun adult cattle and calves where as penetrating captive bolt and electrical stunning/killing are appropriate for stunning and killing of sheep. Therefore, the use of well trained personnel and maintained stunning equipments is so binding to avoid unnecessary stress and distress to animals and improve carcass and meat quality.

1.2.4. Road transport of slaughter animals

Transport of slaughter animals is a major activity in the whole meat supply chain and is also one that troubles the wellbeing of the animals and even may result in reduced product quality if not properly managed. FAO (2001) reported that transport of livestock is the most stressful and injurious stage in the chain of activities between farm and slaughterhouse and contributes significantly to poor animal welfare and loss of production. Poor transportation can seriously affect the welfare of the animals and can lead to significant loss of quality and production. Therefore, transport of slaughter animals has to be well planned and managed to mitigate the fore

mentioned problems and to improve product quality. The milestones in the transport of slaughter animals are type of vehicles to be used, appropriate planning of the journey, loading, stocking density, travel (or journey) management, and unloading(MORAD, 2008).

Transport stresses are unfavorable and crucial problem in the growing livestock industry worldwide. “Road transport stress or road sickness is the acquired stress condition of animals during their transportation by road in which the rules and regulations governing normal transport welfare are broken” (Minka & Ayo, 2010). Lack of adequate preparation before the journey, influence of hostile climatic factors and management-related problems during the process of transportation are considered to be the main cause of transport stresses. Different literatures reported that animals can be subjected to transport related stresses mainly due to various pre-transport, transport and post-transport causes.

1.2.4.1. Livestock trucks

Trucks used for the transport of slaughter animals should have adequate ventilation, non-slip floor with proper drainage and roofs to protect the animals from sun and rain. The surfaces of the sides should be smooth and there should be no protrusions or sharp edges (FAO, 2001). The guidelines regarding livestock vehicles by FAO which is also adapted by Ethiopia was summarized as under (FAO, 2001 and MORAD, 2008):

Ventilations: Transport vehicles should never be totally enclosed and they should be well-ventilated. Lack of ventilation will cause undue stress and even suffocation, particularly if the weather is hot. Poor ventilation may cause accumulation of exhaust fumes in road vehicles with subsequent poisoning. Free flow of air at floor level is important to facilitate removal of ammonia from the urine.

Floors: non-slip floors in all vehicles are necessary to reduce the risk of animals falling. A removable grid of cross slating made from wood or metal is suitable for this purpose. The uses of materials to create non-slip surfaces such as grass or sawdust are not suitable. Additional balance for the animals should be provided by partitioning the interior of the vehicle with either wood or metal poles or solid boards. Broken floors should be avoided to prevent leg and other injuries.

Vehicle floors should be level with off-loading platforms, otherwise animals will injure themselves climbing off or when manhandled in order to remove them.

Sides: The sides of vehicles should be high enough to prevent animals from jumping out and injuring themselves. The insides of the vehicle should be padded at hip level with, for example, old tyres to reduce bruising of animals. There should also be no gaps between the pads through which a leg might protrude and be broken. Narrow entry doors can lead to considerable bruising of hips.

Roofs: All vehicles must have a roof since animals can be exposed for hours in the hot sun. Wind blowing on wet animals being transported in cold weather causes a wind chill factor, where the body temperature is considerably reduced, resulting in severe stress or deaths.

1.2.4.2. Journey planning and management

Proper planning of journey before loading has a positive effect on the well being of the animal to be transported as illustrated in different literature. According to MORAD(2008), all issues regarding road choice, duration of the journey, vehicle design and maintenance, required documentation including animal health certificates, space requirement per animal, rest time and place, water and feed system, animal observation in route, control of diseases and emergency response procedures needs to be planned before transporting animals. Exposing animals to social groups before transport increases their adaptability to the situation thereby improving welfare during loading and transport.

Preparing animals for journey needs well consideration of the journey length, the species type, and the time of the day for the planned journey. Short and direct journeys without any stoppages are mostly recommended, by different guidelines on animal transport, where possible. The guideline by MORAD (2008) specifies a maximum of 36 hour journey period for cattle and sheep/goats in which offloading for feed and water after 24 hour is a must if the journey is to take longer than that. For longer journeys, where watering and feeding will be necessary on the vehicle, it is recommended to collect the animals involved two to three days before the transport as this will make the animals preparation easier and they can be accustomed to the feed that will be offered on route. In cases where this system is not practical to use, animals should be given

the same feed during transport that to which they have been accustomed (European Commission, EC, 2002). The time of the day for the journey is also another contributing factor for the wellbeing of the animal during transport. FAO (2001) guideline specifies that cooler mornings and evenings or even nights are advisable for transporting animals in vehicles as high environment temperature will raise the risk of heat stress and mortality during transportation.

Besides planning, journey management is a major concern that needs a due attention in transporting livestock. It includes all organizational aspects of transport such as route planning, travel times, driving quality, food and water supply and resting periods. These all are believed to affect animal welfare and proper management can lessen the problem as they all are influenced by human. For longer journey where feeding and watering is required on the vehicle, off-and-on loading for resting is not recommended as it increases the stress level and the risk of injury. Resting periods are potential risk for spreading disease and for activity such as fighting and mounting especially among unfamiliar male animals. For such type of transport, the standard of the vehicle has to include that resting, watering or feeding in vehicle is possible (EC, 2002).

1.2.4.3. Loading and unloading

Loading and unloading are the cause for most of the changes in body parameters of the transported animals (Minka and Ayo, 2010). The stress initiated at loading can last for the first few minutes of transport until the animal is accustomed to transport where by the stress response gradually disappears. Loading is the cause for a combination of several stressors that can largely affect the welfare of animals. The forced physical exercise as the animals climb steep ramps, especially when animals are moved into the vehicle, is one of the major stressor at loading stations. The novelty of being moved into unknown surroundings is another important psychological stress in addition to the stress caused by mixing with unfamiliar animals. For animals that are not habituated to human contact, loading can also be a cause for fear in animals. The pain from mishandling at loading and unloading stations such as beating or poking animals with a stick is another stressor against the wellbeing of the animals (EC, 2002).

For animals, especially for those reared predominantly under the traditional extensive management system, the sudden loading into a vehicle is an unusual exercise. The pressure

exerted by the ropes that are used to restrain animals can also be the potential source of stress during road transportation. The prolonged standing of animals at loading points while awaiting the vehicle or its departure is the other stress factor acting upon the animals just before transportation (Minka and Ayo, 2010). The genetic difference among animals is also an important factor to consider during handling at loading and unloading stations. The report by EC (2002) specifies that some species of pigs that carry the halothane gene are more susceptible to the stress of loading.

Loading and unloading ramps are another important aspect to consider during animal transportation. In most developing countries, there is a serious lack of good ramps for loading and unloading animals from trucks. Animals are forced to jump off large trucks as there are no ramps available. Methods to built economical ramps from locally available materials have to be encouraged in such areas. Ramps should have non-slip floors and appropriate slopes to be climbed by the animals. The slopes of the ramps to be used should consider the type of the animal to be transported as some species have more difficulties in negotiating steep ramps than others. Ramps having slopes of 20 degree or less are generally recommended for cattle and pigs where as sheep can easily move up and down steeper ramps (Grandin, 2008).

1.2.4.4. Space allowance

The amount of space provided for animals during transport is one of the most important factors compromising the welfare of the animals. The issue is sensitive particularly in developing countries because lower unit cost of transport can be achieved by lowering space allowances in addition to the problem with respect to vehicle shortage (Ndou et al., 2011). Most literatures treat space allowance in two components. Stocking density which is the floor area available to the animal to stand or lie in is the first and most important component of space allowance. The second component is the height of the compartment in which the animal is carried and is usually important with multi-decked road vehicles. Due to either practical constraints on the overall maximum height of the vehicles or financial reasons, the vertical distance between decks (deck height) is usually reduced there by reducing the volume of space above the animals head. This

reduction in deck height may adversely affect adequate ventilation which may result in suffocations of the inside compartment in which the animals are held (EC, 2002).

The most common form of defining stocking density is either m^2 floor area per animal of specific live weight (e.g. M^2/100kg) or live weight per m^2 floor area (kg/m^2). Defining stocking rates as m^2 per animal (m^2/animal) are not recommended by many scholars since such rates do not take in to account variation in animal weight. In addition to the live weight, several factors are needed to precisely quantify the minimum space allowance for animals during transportation. The dimensions of animals, behaviors of animals during real or simulated transport conditions, and indications on adverse effects of transport such as amount of bruising on the carcass also affect the minimum space allowance. According to EC (2002) report, linear measurements will be proportional to the cube root of W ($\sqrt[3]{W}$) for animals of the same shape where W is the body weight. The area of a surface of the animal is therefore proportional to the square of this linear measure $\left(\left(\sqrt[3]{W}\right)^2\right)$ which is algebraically equal to $W^{0.67}$. Based on this, a general exponential equation (eq. no. 1.1) was given by United Kingdom Farm Animal Welfare Council (UKFAWC) to determine the minimum acceptable area for all types of animals (UKFAWC 1991, cited in EC, 2002).

$$A = 0.021\ W^{0.67} \quad \text{…….. (Eq. 1.1)}$$

Where A is the minimum floor area required by the animal in m^2 and

W is the weight of the animal in kg.

The constant (0.021) is the ratio of body length to body width for the animal.

In addition to the minimum baseline space allowance given by equation 1.1, some allowances are recommended for some animals with special needs. According to Dickson and Stephenson (1979), horned sheep need 17% more space than the minimum value. An increase of floor space allowances by about 5 to 7 %(EC, 2002) for horned animals is also recommended.

The other important component of space allowance is the height of compartments within which animals are transported. The compartment height should allow the animal to freely stand, adequate temperature regulation, and effective ventilation to occur. For sheep, it is recommended

to have 15 cm space above the top of the head for vehicles with good forced ventilation systems and 30 cm for vehicles without forced ventilation systems (EC, 2002).

1.2.5. Facility locations in logistics

The problems of locating new logistic facilities or relocating existing ones are so critical which need in depth analysis of many governing factors. This is because of the fact that location decisions are both costly and irreversible in their nature. According to the report by Daskin et al. (2003), facility location decisions are the most critical and the most difficult among the decisions needed to realize an efficient supply chain as these decisions are often fixed and difficult to change even in the intermediate term. The report also underlines that inefficient location of logistic facilities will result in excess costs being incurred throughout their lifetime, no matter how well the production plans, transportation options, inventory management, and information sharing decisions are optimized in response to changing conditions.

Facility location problems are varied with main concern on certain specific objectives such as minimizing transportation cost, providing equitable service to customers, or capturing the largest market share. Arabani and Farahani (2011) explained that choosing where to site a distribution center in a supply chain, selecting a right location for placing a warehouse, and setting where to position a recreational facility are among the common application of facility location problems. They also defined location problems interms of two elements: the space element which is the planning area where facilities are located and the time element where establishing a new facility or modifying the existing one is indicated. The inter modality nature of most freight logistics is another factor making location decisions more critical and complex in the supply chain design. Kayikci (2010) reported that the location of an intermodal freight logistics centre should be selected carefully as they play an important role in achieving socio-economic and environmental sustainability by enhancing an optimal integration of different modes to provide an efficient and cost-effective use of the transport system through customer-oriented, door-to-door services while favouring competition among transport operators.

1.2.5.1. Location analysis techniques

There are three techniques used for making location decisions (Russell and Taylor, 2009): the location rating factor, the center-of-gravity technique and the load-distance technique. The location factor rating method mathematically evaluates location factors where as the center of gravity and the load-distance techniques are quantitative models that centrally locate a proposed facility among existing facilities.

In summary, location decisions are not one way steps but requires analysis of different steps as shown in Figure 1.3.

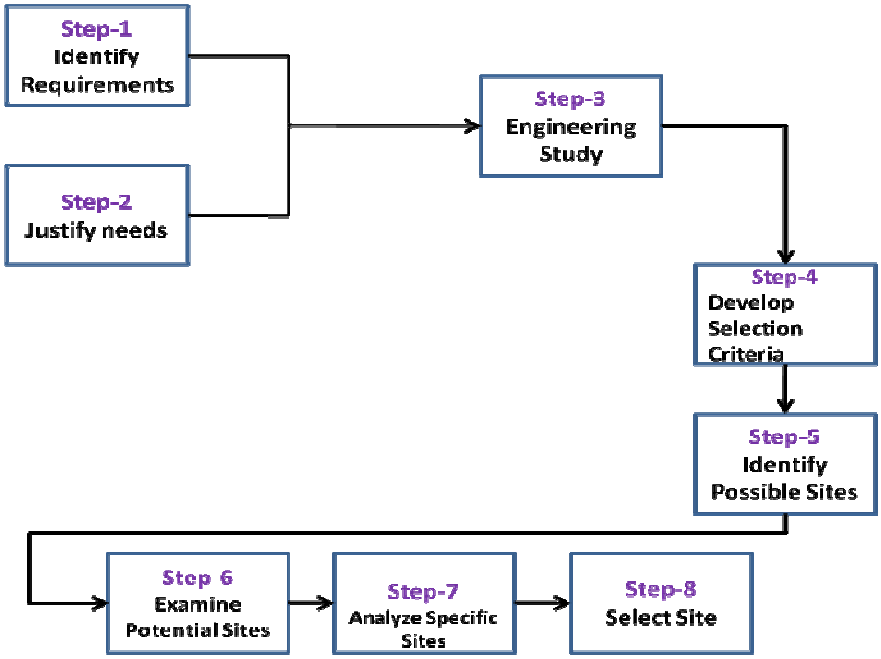

Figure1.2. Basic steps of location analysis (Nebyi, 2011)

1.2.6. Meat distribution in city areas

The increase in the activities of delivering and collecting goods, logistics activities, in towns and city centers are becoming a challenge for urban inhabitants. Traffic congestion, air pollution, noise and increased logistic costs, and hence the price of products are more critical concerns due to the rapid increase in freight vehicles in urban and metropolitan areas (Russo and Comi, 2010). In addition, the increase in the risk of traffic accidents mainly due to combination of different

types of vehicles on the road is significant. According to Ljungberg and Gebresenbet (2005), traffic induced environmental problems are increasing worldwide despite the efforts made to improve the situation both locally and globally. Specifically, they outlined the case of Uppsala city in Sweden where the issue of climate change, pollution and congestion in the city centers are gaining more attention due to the restriction of traffic and good distribution by pedestrian areas and one-way streets in the city centers.

The situation in Addis Ababa is so similar to other cities around the world with regard to economic, environmental and social impact of urban freight transport. Over the past 10 years, the population of Addis Ababa has increased by nearly 20 percent (Nebyi, 2011) due to major rural exodus to the capital. This development coupled with little infrastructure, weak transport management and poor city logistics experience has strained the city's infrastructure to breaking point.

Meat distribution in cities suffered from congestion and other problems related to urban transportation. On-time delivery of fresh products, choice of specially designed vehicles for meat transport, and other sanitation issues related to packing and transport of meat are of great concern especially in developing countries. Frimpong et.al. (2012), reported that none of the butchers, those responsible for transporting meat from Kumasi Abattoir in Ghana to their meat shops, used an approved meat vans. The same study also outlined that only limited butchers were able to sell fresh meat products in a day as most of them used refrigeration to preserve the left-over meat.

With respect to delay in meat distribution, the use of centralized and large-scale abattoirs in cities was thought to be a major factor for the problem. According to Gebresenbet et.al.(2011), **e**stablishing small-scale abattoir rather than large-scale and centralized abattoir were found to be necessary with respect to minimizing distribution delays which have a direct impact on meat quality, reducing greenhouse gas (GHG) emissions generated by transporting vehicles, and increasing the acceptance of locally produced meat by the consumers**.**

2. Objectives

The main objective of this research is to study the animal supply chain from regional markets to livestock market in Addis Ababa city and the meat supply chain from Abattoirs to customers in Addis Ababa city in order to develop recommendations and possible options to improve the management of these supply chains.

The specific objectives of this research are to:

i. map out the animal supply chain from different regions to Addis Ababa livestock market and further to abattoirs.
ii. identify and map the existing animal markets and abattoirs in Addis Ababa city
iii. map out the activities and process at the abattoir and lairage (inventory).
iv. determine/suggest possible location of the livestock markets and abattoirs in Addis Ababa.
v. evaluate the existing meat distribution from the Addis Ababa Abattoir to the customers
vi. optimize the meat distribution routes in Addis Ababa

Significance and impact of the study

The outcome of this study will directly or indirectly support the progress in the development of the livestock subsector in the country in general and improve the value chain of animal transport, abattoirs operation, and meat distribution in Addis Ababa in particular. Livestock transport in Addis Ababa has many consequent problems including effect on congestion, traffic accidents, environmental pollution and poor health conditions of the community. This study has a significant effect on pointing out solutions on these problems. Summarized consequences of this research results are as bulleted under.

- The result of this research can help the government to establish or modify rules and regulations on transport and handling of animals for the efficient and effective logistic chain of meat and animal transport in the country.

- Stakeholders (line ministries and government offices, animal transporters, meat and live animal exporters, traders, butchers and others involved in livestock subsector) can use the results of this research to improve animal handling and product quality.

- The recommendations of this research will point out the optimum locations of livestock markets and the Abattoirs in Addis Ababa. The administration of the Addis Ababa Abattoirs can also use the results to improve the meat distribution process and the activities in the lairage.
- The result from this study will improve congestion, sanitation problems, minimize traffic accidents, and in general play a significant role for efficient urban transport system in Addis Ababa city.
- The important application of this study is developing knowledge in the logistic area in general and in the area of livestock transport in specific. In this regard, it can benefit researchers and other scientific communities as a reference for teaching and further research in the area.

3. Materials and Methods

3.1. Description of the study area

The study was conducted mainly in Addis Ababa city although interview based information was gathered regarding the regions from which the animals are transported. Addis Ababa, located at 9°1'48"N and 38°44'24", is the federal capital of Ethiopia and a chartered city having three layers of Government; city Government at the top, 10 sub city administrations in the middle and 116 woreda administrations at the bottom. The average altitude of the city is 2400m above Mean Sea Level (MSL). Being founded by Emperor Menelik II and Empress Taitu in November 1887, Addis Ababa is currently the seat of the African Union (AU), the United Nations Economic Commissions for Africa (UNECA) and many other continental and international organizations.

According to the 2008 population census, Addis Ababa has a total population of 3,384,569; all of the population being urban inhabitants. The city lies at an average altitude of 2400m, has an estimated area of 530.14 square kilometers (204.69 sq mi) and an estimated density of 5,165.1 inhabitants per square kilometer or 13,378 /sq mi (Nebyi, 2011). With an unemployment rate of 31.4 %(UN-HABITAT, 2008), Addis Ababa is one of the oldest and largest cities in Africa facing the greatest development challenges where insufficient and poor housing conditions, improper public transportation, significant sanitation problem, and unemployment are becoming the major concerns.

Addis Ababa is one of the fast growing cities in Africa due to high rate of rural urban migration which nearly accounts for 40% of the growth coupled with rapid natural population growth (UN-HABITAT, 2008). This fact makes the city to suffer from critical life challenges especially from high rate of unemployment, housing shortage and environmental deterioration even though the capital has a comparative and geographic advantage interms of social and economic infrastructures compared with other urban centers in the country.

3.2. Methods of data collection

Both primary and secondary data were collected for the study. According to J.Hox and R. Boeije (2005), primary data are data collected for the first time and for the specific research problem at hand using procedures that fit the research problem best where as secondary data are those which have already been collected and analyzed by someone else and are made available for reuse by the general research community. Primary data were collected from key actors/stakeholders who are involved in rearing, loading and unloading, transporting, brokering, and trading of animals, managing livestock markets and abattoirs, and managing animals at market centers and inside lairage. In addition; direct observation and registration on the field, video filming and photography were used to collect the primary data needed. Data bases and documentations from Addis Ababa Abattoirs Enterprise (AAAE) and Addis Ababa Trade and Industry Development Bureau (AATIDB) were the main sources of secondary data for this study. These collected data were analyzed and summarized in the way to address the stated objectives of the research.

3.2.1. Primary data collection

Various primary data necessary to meet the specified objectives were collected on animal transport, loading and unloading, vehicle type and stocking density, animal handling during transport, at market centers and inside lairage, activities inside abattoirs and meat distribution in Addis Ababa. The methods used to collect the primary data include personal interviews, direct observations, field measurements, taking photos, and video filming. Driver interview at the terminal markets in Addis Ababa using Semi structured interview questionnaire (Appendix A) was made to collect data about the origin of the animals, the loading condition, the type of road and driving situation, feeding and watering during the journey, the journey start time, the arrival time at the terminal market, the time at which unloading takes place, and any challenge they faced during loading, journey and unloading.

On field registration of the unloading time, the type of the unloading platform, the type and floor area of vehicles used, the type of vehicle floor on which the animals stand, and the height of vehicle sides, was made. Data on animal welfare and behavioral alteration at unloading

stations, market centers, on the way from market centers to abattoirs and inside lairage of abattoirs was collected through direct observation, taking photographs and video filming. Registration of main activities in abattoirs starting from lairage to loading of meat for distribution and direct observation of the abattoirs main processes including sanitation requirements was undertaken at AAAE.

In depth interview was carried out with different personnel and stake holders who have a major role in the whole animal logistic chain. These include farmers, brokers, drivers, traders, and livestock market managers, officials from AAAE and Addis Ababa Trade and Industry Development Bureau (AATIDB). Farmers in Addis Ababa livestock markets were asked about the origin from where they brought their animals, mode of transport to Addis Ababa, and feeding and watering at the source, during transport, and in the markets. Brokers were interviewed about the role they play in the whole chain and the payment they get per animals.

Interview of drivers were about their driving conditions including their speed, the road condition they faced, rest given for the animals during transport, care and inspection of animals in the journey and their understanding of animal handling and transport. Traders were asked about the region or market from which they brought the animals, regional prices of the animals, mode of transporting the animals to Addis Ababa, whether transportation is done by themselves or other transport enterprises, main actors and challenges in the whole chain, and whether they have attended any course on animal handling and humane treatment. Officials from AAAE were interviewed about source market from where they brought the animals, whether they involve in transporting animals, the main activities in the enterprise and its role in the whole logistic chain, and about their by product and waste management systems. AATIDB officials were asked regarding animal transport in the city centers, control on illegal slaughtering, on street marketing of animals in the city centers, main actors in the whole animal logistic chain, suitability and sufficiency of existing market centers and Abattoirs.

Route optimization data for meat distribution was collected by registering the location (latitude and longitude) of delivery points using handheld GPS (GARMIN *etrex* GPS). In addition to location data, quantity of meat delivered per trip and total quantity per week for each delivery point customer code, delivery time, route length, and meat quantity in the vehicle was

registered using prepared data collection format(Appendix B) for eleven main distribution routes of AAAE. For location analysis, the locations (latitude and longitude) of existing livestock market centers and abattoirs were registered with similar GPS. In this regard, locations registration of six market centers and three abattoirs were made.

3.2.2. Secondary Data Collection

Data base on annual and monthly slaughtered quantity for different animals was collected from AAAE. The total number of meat distribution routes for AAAE and their customers in Addis Ababa was also collected before tracking each route with GPS. Service charge for slaughtering different animals such as cattle, sheep and goats, and pigs as modified on 1st of August 2011 was collected from AAAE. The main transaction costs along the whole animal supply chain were obtained from AATIDB. The other data collected from AATIDB includes main livestock market centers in Addis Ababa, the sub cities where they are located, area and their holding capacity, the type of animals they contain, their regional animal source, their weekly market days and the average supply on the market days.

3.3. Data analysis

3.3.1. Analysis of animal supply chain

Both quantitative and qualitative methods of data analysis were used to fully describe the animal supply chain. In quantitative data analysis, the information obtained during data collection from the participants is expressed in numerical forms where as the information obtained is not expressed in numerical forms in the case of qualitative methods of analysis (Psychology press Ltd, 2004). Parameters like travel distance, loading density, loading and unloading time, and queuing time during unloading were analyzed quantitatively. The qualitative parameters included were regional sources of animals, road condition, journey time, type of vehicle used for transporting animals, feeding and watering in the journey, and humane treatment of the animals during loading, transport, unloading, in the markets, inside the lairage and during stunning.

Data that were collected through key informant interviews, personal observations, and secondary document analysis were analyzed using system of thematic analysis. In thematic analyses, more focus is on identifying and describing both implicit and explicit ideas within the data, that is, themes which is beyond counting explicit words or phrases. Codes are then typically developed to represent the identified themes and applied or linked to raw data as summary markers for later analysis. Value chain mapping was done for the whole animal supply chain starting from source to slaughter house.

In the quantitative analysis, simple descriptive statistics such as simple measures of central tendency: mean, standard deviation, frequency, percentages, minimum, and maximum of the quantitative variables were used. Microsoft Excel 2007 software was employed to analyze the data. The analyzed data were presented using tables, graphs and charts.

3.3.2. Facility location analysis

Location analysis for livestock market centers and Abattoirs in Addis Ababa was done based on different theoretical and practical considerations. Registration of existing market centers and Abattoirs in the city was the first task before deciding on their location. The locations (Latitude and Longitude) of the existing market centers and Abattoirs were registered using handheld GPS (GARMIN *etrex* GPS). The existing locations were then plotted on digital map of Addis Ababa to evaluate whether the current locations can satisfy the basic requirements of market centers and Abattoirs locations.

There are three techniques used for making location decisions (Russell and Taylor, 2009):-

- the location rating factor
- the center-of-gravity technique and
- the load-distance technique.

The center-of-gravity and load-distance techniques are quantitative methods used to determine the location of facilities based on transport weight and distance and they are not usually sufficient for making an actual location decisions, but they do provide means for helping in the location analysis decision process.

The location factor rating method however is a system for weighting the importance of different factors in the location decision, scoring the individual factors, and then developing an overall location score that enables a comparison of different location sites. This method is therefore used to determine the possible locations of the existing market centers and Abattoirs in the capital. In this method, each factor that is important in the location decisions were identified and weighted from 0 to 1.00 to prioritize the factor and reflect its importance. A subjective score (usually between 0 and 100) was assigned to each factor based on its attractiveness compared with other locations, and the weighted scores were summed. In general the following procedures were followed to determine the possible locations for the market centers and Abattoirs:-

- First Relevant factors have been listed
- Importance weight to each factor were assigned between 0 and 1
- For each factor, scale was developed between 1 and 100
- Each location was scored using factor scale
- Scores were multiplied by weights for each factor & totaled
- Locations with large total score were selected

The new market centers and Abattoirs location were then plotted on map of Addis Ababa (Figure 4.22).

3.3.3. Analysis of meat production and distribution.

The evaluation on meat production and distribution was mainly done in AAAE as it is the biggest enterprise which can deliver meat to most of the customers in Addis Ababa. A site visit was made to AAAE to accurately map out the activities in the abattoir including its capacity. Activity registration and mapping was done starting from animal intake point in the factory to unloading in the delivery point for the customers. Environmental protection, health and sanitation requirements, and other institutional capacities on meat production and distribution were also evaluated based on the visit and interview with the concerned officials of the enterprise.

Secondary document analysis was made to obtain data base on monthly and annual meat production and distribution of the enterprise. Analysis on annual meat production was done to estimate the capacity of the enterprise and evaluate the growth in meat consumption in the capital using a twenty year data. Seasonal variation in production and distribution was also analysed to see the peak season in meat production and consumption.

Evaluation of meat distribution in Addis Ababa including customer number and location, delivery time, route choice, vehicle utilization, and sanitation requirements were done based on primary data obtained through interview, personal observation and on field registration. Registration of delivery points (customers) was made by traveling with the drivers during distribution and the total customer in each delivery route was obtained from AAAE. Route optimisation was made for eleven selected routes using RouteLogiX Professional V 5.5 (5 Professional) route optimisation software. RouteLogix could be used to obtimise the route choice between call points as well as the visit order for call points with respect to time, distance or cost (Ljungberg et al., 2006). In this study however, optimisations were made with respect to time and distance only where time and distance before optimasation were compared with time and distance after optimisation.

3.3.4. Demand and supply forecast

Future demand and supply of meat distribution in Addis Ababa was analyzed using time-series forecasting technique. ”A time series is a time-oriented or chronological sequence of observations on a variable of interest”(Montgomery et.al., 2008). As they provide information on future demands, forecasts are a basic input in the decision processes of operations management.

Time series extrapolation presupposes that some features of the past demand time pattern will remain the same. The demand pattern is then projected in to future. This method assumes that what has occurred in the past will continue in the future. Historic data of meat distribution from AAAE to its customers are used to develop forecasting models.

Time series method includes the moving average, exponential smoothening and linear trend line. A moving average forecast uses a number of the most recent actual data values in generating a forecast. In this method, as each new actual value becomes available, the forecast is updated by adding the newest value and dropping the oldest and then recomputing the average. Consequently, the forecast "moves" by reflecting only the most recent values. Exponential smoothing is a weighted averaging method based on previous forecast plus a percentage of the forecast error. Each new forecast is based on the previous forecast plus a percentage of the difference between that forecast and the actual value of the series at that point.

Linear trend line is the other type of time series forecasting method which differs from linear regression forecasting method in that it explains when demand displays an obvious trend over time and relates demand to time. The method relates a dependent variable of demand and one independent variable of time in the form of a linear equation and was used in meat demand forecasting in this study.

Seasonal adjustment of trend line demand forecasting is required when the demand pattern shows a seasonal trend. There are several methods for reflecting seasonal patterns in a time series forecast. A seasonal factor is a numerical value that is used to multiply the normal forecast to get a seasonally adjusted forecast. It represents the extent of seasonal influence for the particular segment of the year. One method for developing a demand for seasonal factors is to divide the demand for seasonal period by total annual demand. The resulting factor (index) indicates how much the average of the demand of the seasonal period tends to be below or above the mean of total annual demand. Hence, to get an accurate estimate for the seasonal index, computing of the average of each period of the cycle and dividing each by the overall average is important. The formula for computing seasonal factors is(Bitew, 2011):

$$S_i = D_i / D \quad \text{(Eq. 3.1)}$$

Where S_i=seasonal index for i^{th} period

D_i=average demand for i^{th} period,

D= average of total annual demand.

i= the i^{th} seasonal period of the cycle

Deseasonalized process (Seasonal Adjustment) is then important in removing recurrent and periodic variations over a short time frame. The deseasonalized data was then obtained by dividing each time frame observation by the corresponding seasonal index. Hence, incorporating seasonality in a forecast is useful when the time series has both trend and seasonal components. A simple way to forecast using a seasonal adjustment is to use a seasonal factor in combination with an appropriate underlying trend of total value of cycles. The seasonal factor (index) is then multiplied by the annual forecasted demand to yield adjusted forecasts for each season.

Seasonal index of meat distribution using time series method was based on a quarterly and monthly data of 3 years which was obtained from AAAE data base.

4. Results

4.1. Transporting animals to Addis Ababa

4.1.1. Regional sources of animals

Slaughter animals, found in livestock market centers of Addis Ababa, were transported from different parts of the country to the city. The main entrances for the animals in order of their share were Gojam Gate, Ambo Gate, Dessie Gate, Akaki Gate, and Jimma Gate. Field survey during the study and data obtained from AATIDB showed that, 27% of the slaughter animals in Addis Ababa were said to enter through Gojam Gate from different places found in North Shoa. Through the Ambo Gate, mainly from Wellega, Ginchi, Guder, and Kata, 26% of the animals were estimated to enter the city. The Dessie Gate, where Dessie, Debrebrhan, and Sheno were thought to be the main sources, was believed to be an entrance for 23% of the slaughter animals in the capital. Harar, Adama, Awash, and Arsi were estimated to be the sources for 18% of the slaughter animals entering through Akaki Gate. The other 6% of the animals in the city were assumed to enter through Jimma Gate where Jimma and Walayita areas were thought to be the main sources. The proportions of animals entering through each gate are shown in Figure 4.1 below.

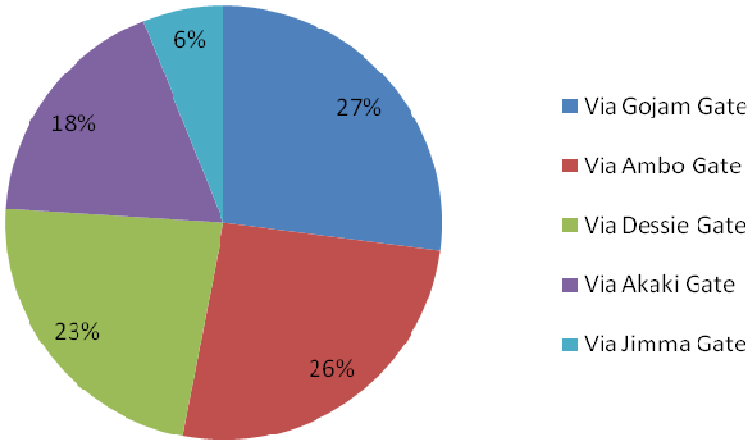

Figure 4.1. Proportions of animals entering to Addis Ababa via each Gate

According to animal traders, the regional sources of the animals are both from pastoralist and agro-pastoralist zones of Ethiopia. Animals were brought to the local markets by individual owners (farmers, pastorals, or anybody who fatten animals in his/her house), local traders, cooperatives, and brokers. In some pastoralist zones (especially those which are nomadic), animals were collected from the pastorals by the brokers and then brought to the local markets. The mode of transporting animals to the local markets was trekking. Animals, from the local markets, were then transported to Addis Ababa.

4.1.2. Loading animals at local markets

Drivers' interview indicated that loading at local markets was done by stopping the vehicle under elevated ground (with height approximately equal to the vehicle's floor level) and pulling the animals to the vehicles. Rope tightens on their kend or neck was used to pull the animals to the vehicles. There were no formally prepared loading platform at most local livestock markets as indicated by drivers and animal traders. The estimated total loading time (including preparation and time for tying the animals on vehicles) varied between 15-75 min, with an average value of 26.96min for smaller Isuzu model and 49.38min for FSR model. Figure 4.2. shows the frequency distribution for the total loading time per vehicle at different local markets based on the data from the drivers' interview.

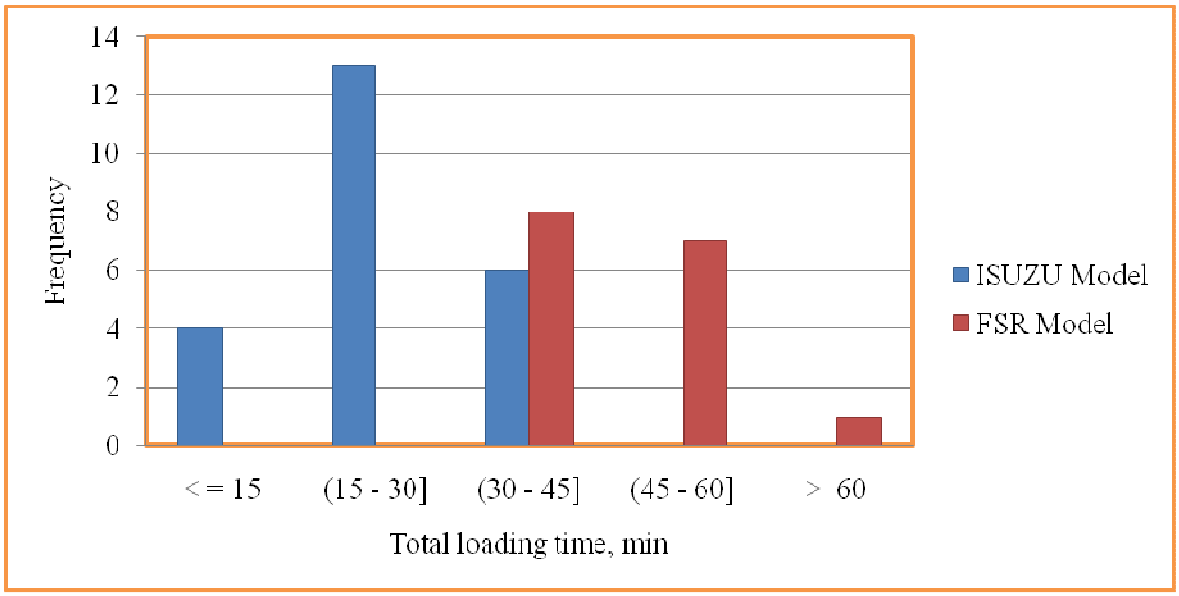

Figure 4.2. Distribution of total loading time at local markets

4.1.3. Animal transport to Addis Ababa

4.1.3.1. Animal trekking

For shorter distances (up to 100km as estimated by traders), animals were transported to Addis Ababa by trekking. Animals from markets within 100km radius from the capital were trekked to the city. During trekking, it was observed that animals were transported in mass (for example 40 - 50 bulls in one group trekked by 5 persons) along the main highways to Addis Ababa. Interrupting with pedestrian and vehicle traffic, beating the animals by very strong stick ("Dula") and especially made rope ("Jiraf" in its native name) were observed as the main problems during these periods. Mounting to one another, refusing to walk, and vocalization were among the common behaviors shown by the animals. Typical example in trekking of animals from Hamus gebeya livestock markets (located 75km from Addis Ababa along Addis Ababa – Dessie highway) was shown in Figure 4.3.

Figure 4.3. Animal trekking to Addis Ababa livestock markets.

4.1.3.2. Road transport of animals

Road transport was the most common mode of transporting slaughter animals from local markets to the livestock markets in Addis Ababa. Data collected from kera livestock markets indicated that slaughter animals were transported from different regions of Ethiopia to Addis Ababa by vehicles. The total travelled distance varied from short journey of 150km to long journey of 550km with an average value of 311km (Figure 4.4.). It was indicated that there was no watering and feeding during the journeys and almost all journeys were during the night times. The road types specified were asphalt roads, gravel roads, and earth roads. Analysis of the collected data showed that the average distance transported on asphalt, gravel, and earth roads respectively were 254.17, 49.58, and 7.29 km. The percent share of each road type, respectively, were 81.72%, 15.94%, and 2.34% for asphalt, gravel, and earth road as depicted in Figure 4.5.

Vehicles used to transport the slaughter animals were Isuzu models of two types; the smaller Isuzu having an average floor area of $8m^2$ and larger Isuzu (FSR) with an average floor area of $13.2m^2$. It was observed that animals were tied on the vehicles with ropes and animals were not allowed to lie down until they were unloaded at Addis Ababa Livestock markets (Figure 4.6). Some grasses or powdered timber was sprinkled on the vehicle floor to prevent the animals from slipping. Analysis of space allowance during transport indicated that the average loading densities for the smaller and larger (FSR) Isuzu models, respectively, were 0.8 and 0.88. The average results for loading capacity, floor area, and speed while transporting animals for both vehicle models were indicated in Table 4.1.

According to the drivers and traders, traffic accident, thieves during night journey, and bad road conditions were main problems in transporting the animals from the local markets to Addis Ababa. Traffic accidents were said to occur mostly due to sleeping of the drivers during night journeys.

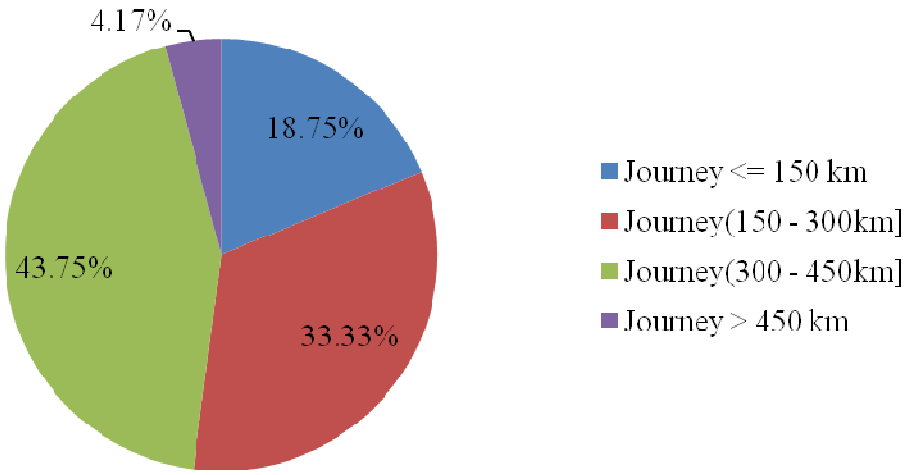

Figure 4.4. Proportions of journey length travelled by slaughter animals

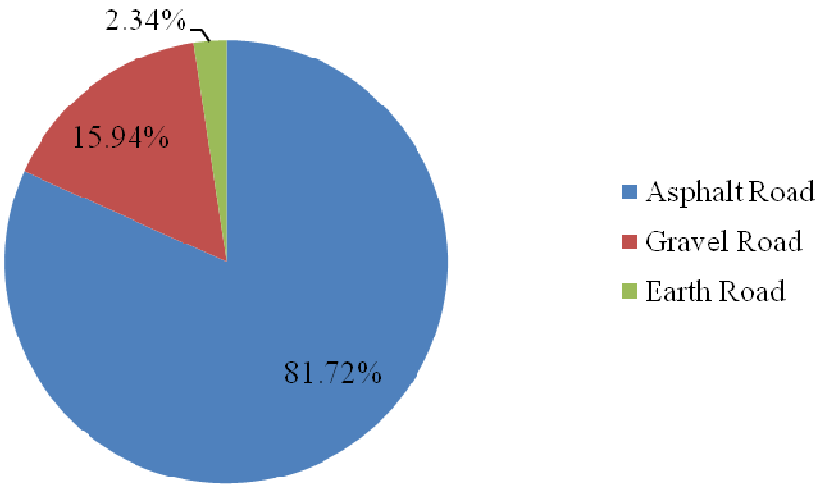

figure 4.5. Proportion of road type faced in transporting animals from local markets to Addis Ababa

Figure 4.6. Transport of animals from local markets to Addis Ababa livestock markets.

Table 4.1. Space allowance and speed of vehicles during animal transport

Vehicle Type	Observed No	Average:			
		No of animals per vehicle	Floor area(m^2)	Loading density(m^2/head)	Travel speed(km/hr)
Isuzu	30	10	8	0.8	45
FSR	18	15	13.2	0.88	46.68

4.1.3.3. Unloading at Addis Ababa livestock markets

Slaughter animals transported from different regions of the country were unloaded in Addis Ababa for selling or slaughtering. Interview of traders and drivers indicated that unloading is mostly done at livestock markets but can also be at any convenient place for selling or slaughtering the animals. It was observed in Kera livestock market that unloading was done using unloading platform made of concrete. After opening the rear side of the vehicles, animals were guided to walk out of the vehicles through the unloading platform. It was also observed that some unloading was done by letting the animals to jump from the vehicle floor without using unloading platform. The unloading situation was shown in Figure 4.7.

Registrations of unloading time at Kera livestock market showed that, the total unloading time (including untighing the animals and vehicle preparation) varied from 5 to 30 minutes with an average of 14.61min for smaller Isuzu and 17.2min for FSR Models (Figure 4.8).

Figure 4.7. Unloading situation in Kera livestock market, Addis Ababa

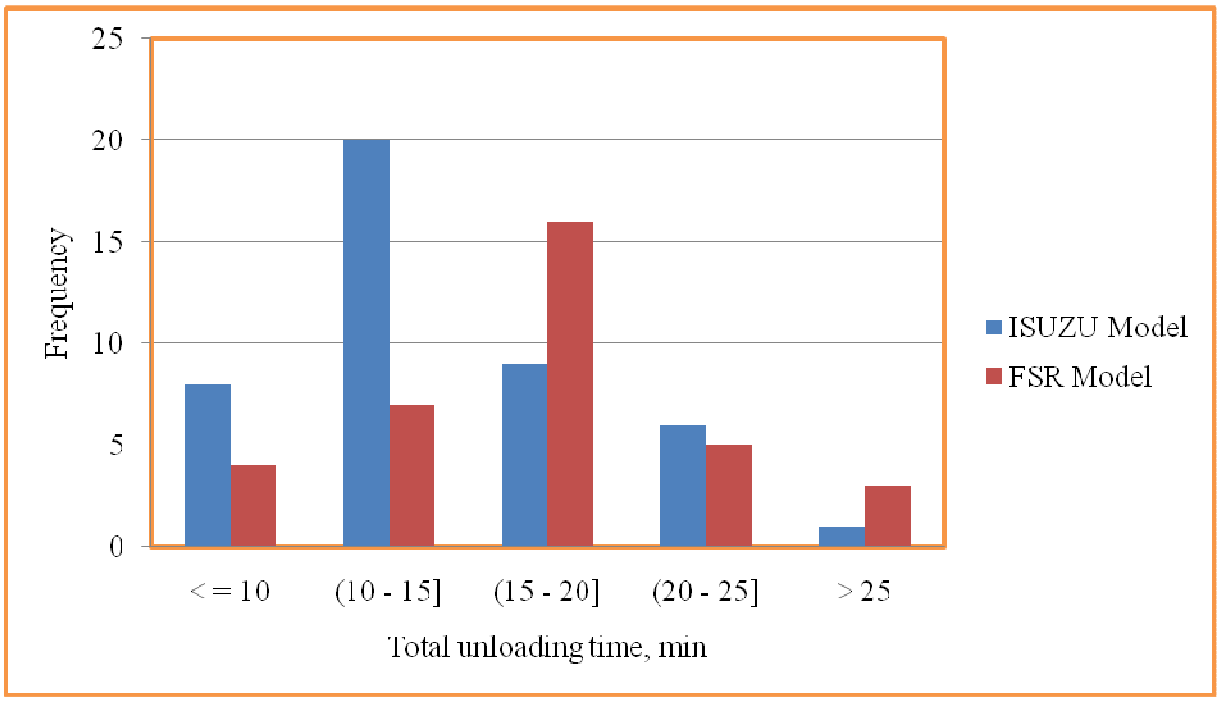

Figure 4.8. Total unloading time at Kera livestock markets

4.2. Animal stay in markets and transport to Abattoirs

Animals unloaded at livestock markets or any other selling places in Addis Ababa were kept in the marketing places until selling. Interview of animal traders showed that animals could stay up to 15 days (even more if they are not sold) in the market centers. The animal traders had to pay 10ETB per animal per five day as market fee. It was observed that animals were provided with water and food during staying in the markets. There were no animal staying shelters in all visited markets and animals were allowed to stay in an open air in rain and sun. The photographs in Figure 4.9 show animal staying for selling in Kera and Shola livestock markets.

Once sold, animals were transported to Abattoirs for slaughtering service. It was not believed that all sold animals were transported to Abattoirs for slaughtering. Discussions with officials of AAAE and AATIDB showed that a significant number of animals were slaughtered illegally outside Abattoirs especially at the time of public holidays. Transport to the Abattoirs could be through trekking (for market centers near by the Abattoirs) or by vehicles (for market centers far away from the Abattoirs). The transport service was given by individuals, cooperatives or the Abattoirs themselves. Some animals from distant market centers in Addis Ababa were transported to AAAE by the enterprise itself. The enterprise had six vehicles used for transporting live animals from different market centers in Addis Ababa to the lairage of AAAE.

Figure 4.9. Animals waiting for selling in markets centers; Kera market (left) and Shola market (right), Addis Ababa

4.3. Unloading queues at livestock market centers

Slaughter animals transported from different regions were unloaded at market centers (for majority of the animals) or any other animal staying and selling places in Addis Ababa. Field observation and interview with animal transporters showed that there were no unloading queues in most livestock market centers and other animal unloading places except at Kera market. Vehicles arrived at Kera markets during the night time had to wait up to morning (06:00) for unloading as the markets were closed during the night times. Data collected from drivers showed that (Figure 4.10.) unloading queues at kera market centers varied from 2 hours (120 minutes) to 7 hours (420 minutes) with an average value of 4.12 hours (247.19 minutes). Traders and drivers complained that unloading queue at Kera market was the top serious problems in transport of slaughter animals from local markets to Addis Ababa. Field observation of the Kera market also confirmed that loaded vehicles were forced to wait for longer waiting lines for unloading the animals (Figure 4.11).

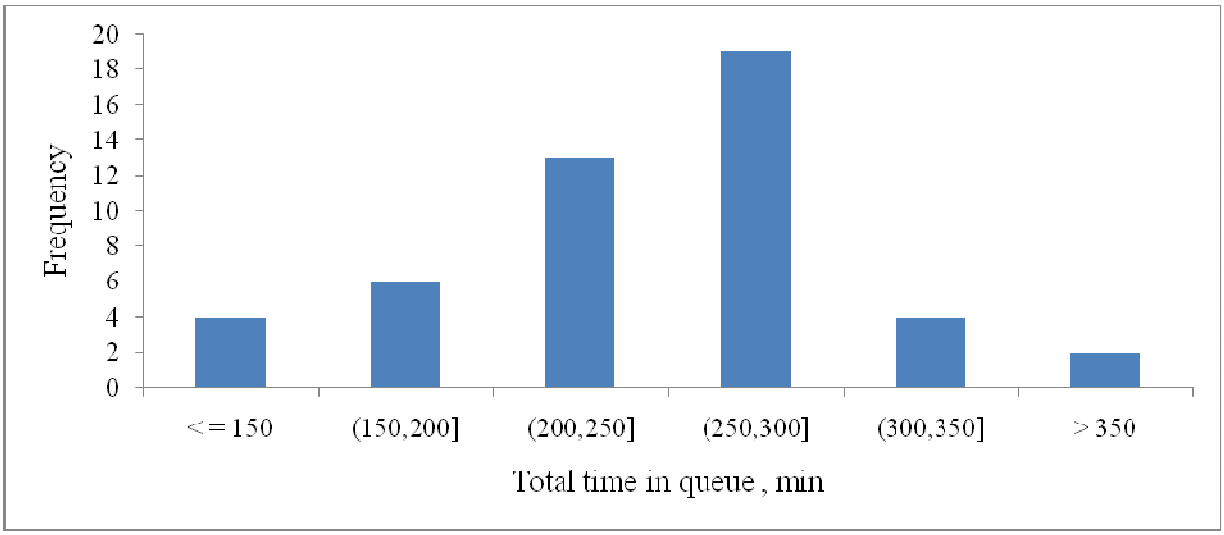

Figure 4.10. Total duration of queuing time during unloading at Kera livestock markets, Addis Ababa (48 observations, mean value 247.19 min).

Figure 4.11. Vehicles waiting lines for unloading at Kera livestock markets, Addis Ababa

4.4. Activity Chain in Addis Ababa Abattoirs Enterprise

Slaughter animals from different markets in Addis Ababa were brought to the Abattoirs either by vehicles or through trekking. Service charge was paid by the customers and the animals were put in the lairage after transferring the customer code to the animals. The service charges were revised timely depending on the market inflations and were varied depending on the type and size of the animals (Table 4.2). The lairage was divided into different partitions where animals were put in each partition according to their route of meat distribution and their time sequence of arrival at the Abattoirs. Anti-mortem inspections, including pregnancy test, were done for the animals where suspected animals which did not fulfill slaughtering criteria of the abattoirs were separated from the normal ones.

Table 4.2. Customers service charge of AAAE (includes slaughtering and transporting service, revised 2011/12)

Type and size of animal	Service charge per animal, ETB
Cattle, big	230
Cattle, medium	185
Calves, big	90
Calves	64
Sheep or goat	30
Sheep or goat, big	50
Pigs	110

Normal animals, ready for slaughtering, were brought from the lairage to the stunning area where animals were made unconscious before slaughtering. Stunning was made by penetrating a knife like metal tool into the skull of the animals. Slaughtering activities were then started immediately after stunning using machines and various skilled personnel where different operations were done in sequence and/or parallel until the meat is ready for loading as shown in Figure 4.12. Observations of slaughtering activities in AAAE and data obtained from the enterprise showed that the total average time spent (lead time) to slaughter one cattle (from stunning until the meat is ready for loading) was 15 minutes.

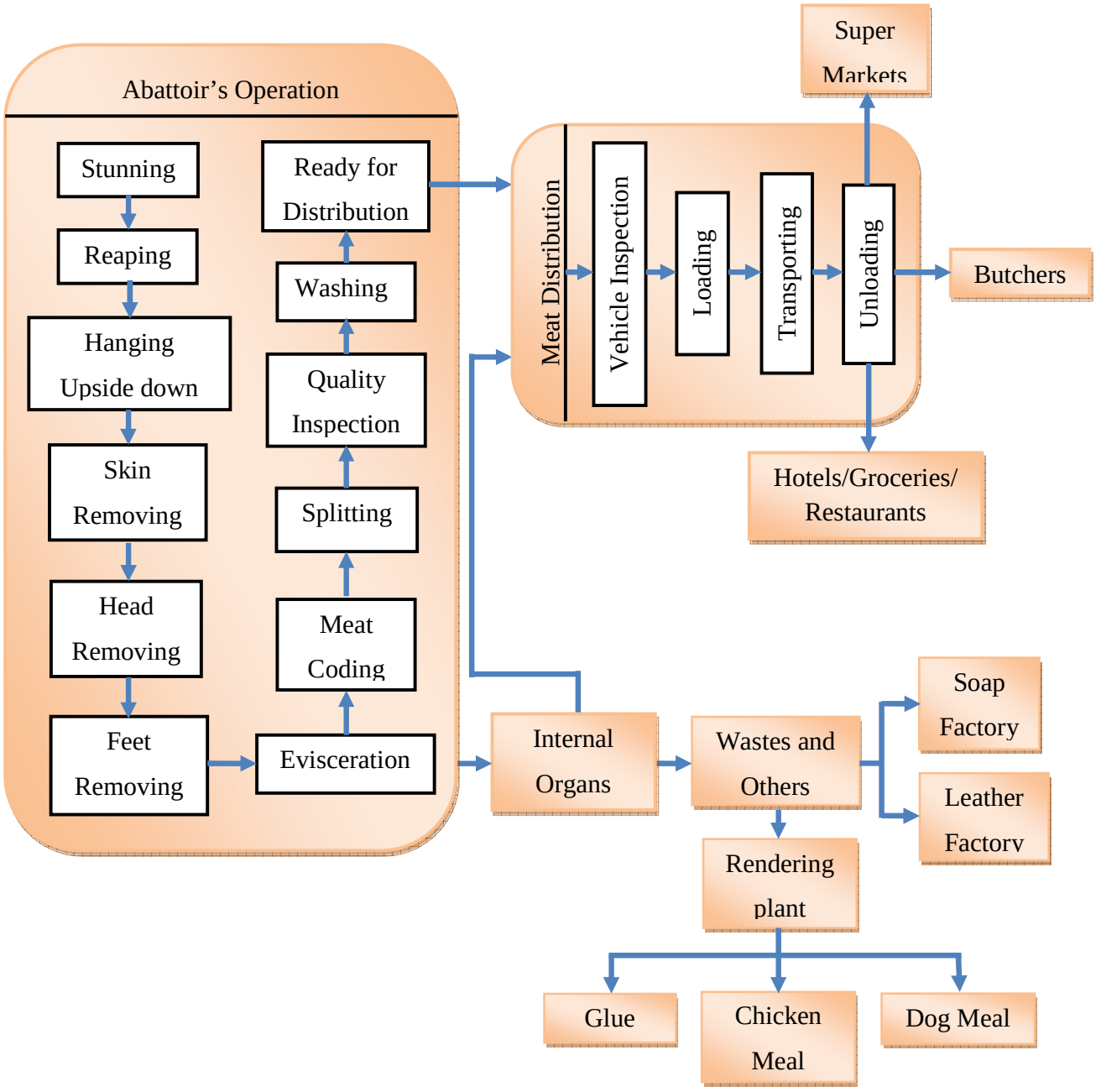

Figure 4.12. Activity chains of abattoir's operations and meat Distribution

4.5. Summary for the whole meat value chain

The whole meat value chain beginning from the local household level in the regions to the meat consuming customers in Addis Ababa was as shown below in Figure 4.13.

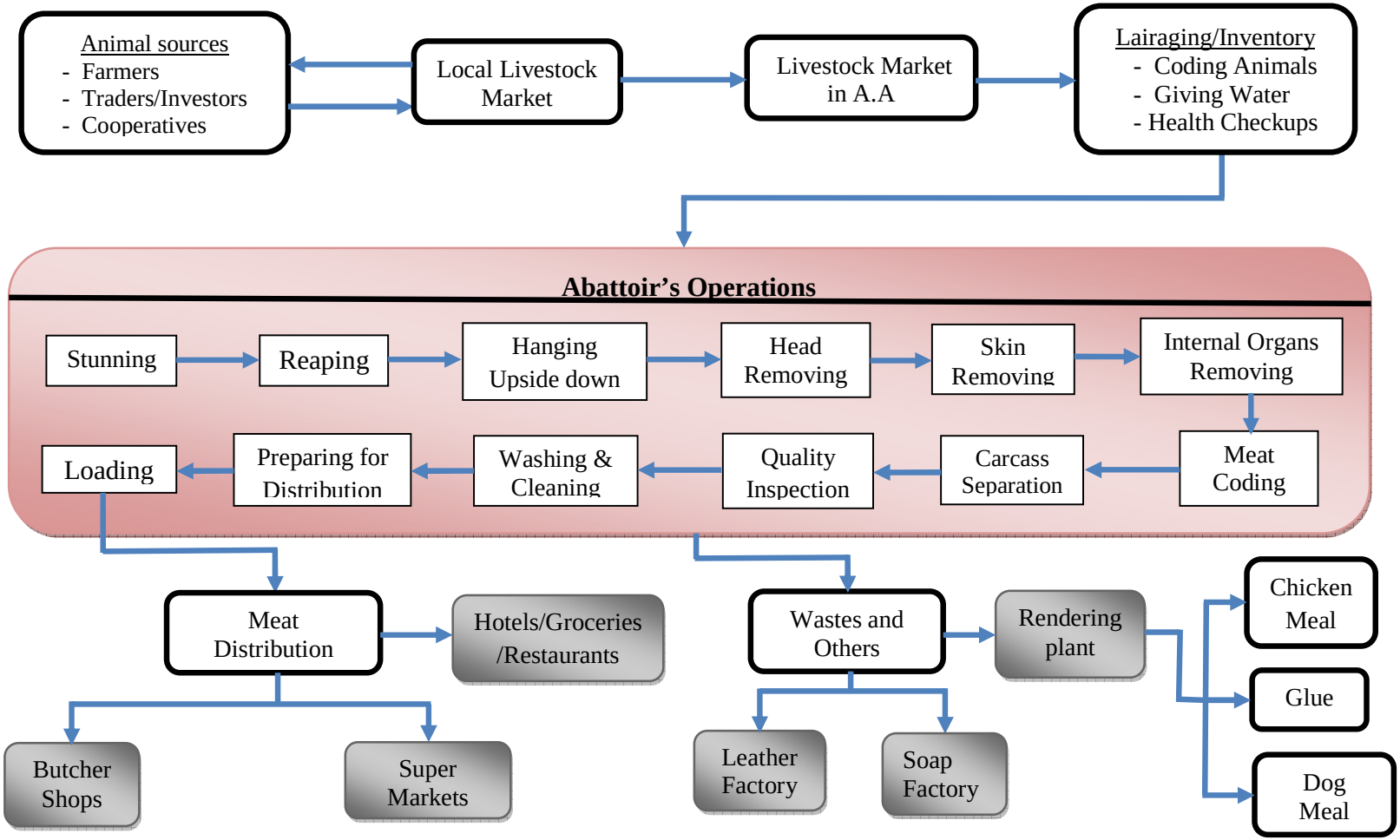

Figure 4.13. Summary of the whole meat value chain

4.6. Meat distribution in Addis Ababa city

4.6.1. Meat sources for Addis Ababa customers

AAAE, founded in 1956 as a Share company and became a governmental organization in 1984, is the biggest abattoir in Addis Ababa serving almost all parts of the city in slaughtering and meat distribution services. According to data obtained from AATIDB, 85% of the total meat consumption in Addis Ababa was covered by AAAE where the remaining 15% was from Kara-Alo Abattoir, Abattoirs from nearby oromia cities and illegal slaughtering. AAAE has its main factory in Kera and its branch in Akaki Kaliti. The enterprise has a total capacity of slaughtering 2000 cattle, 1000 sheep and goats, 100 pigs, and 10 camels per 8 hours. There were four Christian slaughtering rooms (three for cattle and one for sheep and goat), two Muslim slaughtering rooms (one for cattle and one for sheep and goat), and one pig slaughtering room in the main factory found in Kera. The enterprise has 35 vehicles for transporting meat to the customers and 6 vehicles for transporting live animals from different nearby markets to the abattoirs.

AAAE has a total of 1473 customers in different parts of the city where each customer has its own unique identity code through which the meat is delivered to their gate. The identity code, which contains customer and area code, will be transferred from the live animals to the meat during slaughtering. Meat loading was done considering the identity code where meat of the same area code will be loaded together for the ease of transporting in the same route. Most meat distributions were done in night starting from 8:00pm (in the evening) although some distributions were done earlier than 8:00pm.

4.6.2. Historic Meat Consumption in Addis Ababa

The historic meat consumption in Addis Ababa city had shown a significant increase over the last two decades. According to the data obtained from AAAE, the enterprise had slaughtered and distributed a total of 138155 animals in 1984 E.C where the number increased to 322858 animals in 2003 E.C (full data in Appendix C). The increase in the number of slaughtered animals which is directly related to the meat consumption in the city for the last twenty years is shown in Figure 4.14.

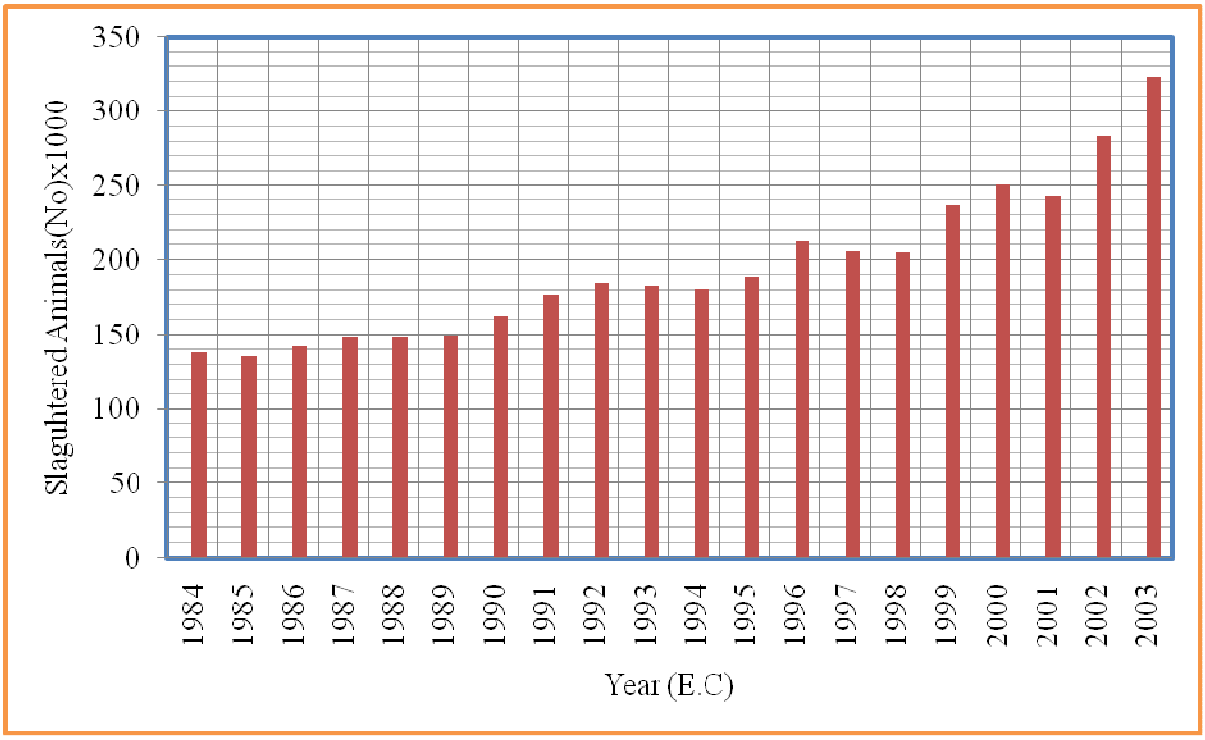

Figure 4.14. Amount of slaughtered animals in Addis Ababa city between 1984 to 2003 E.C

4.6.3. Meat demand forecasting

Before projecting the annual meat consumption for Addis Ababa, it is important to see the time series plot of the data for analyzing features like trend, seasonality, discontinuities and outliers. Hence, the plot of monthly slaughtered and distributed animals for the year 2008/09 – 2010/11 against the months of the years is shown in Figure 4.15. The plot indicated seasonal fluctuations for the three years. To estimate the demand for meat consumption for each forecasting year, seasonal index of each month was developed based on the three year demand where these indexes were multiplied by the yearly forecasted value to determine the monthly forecasted amount. The analysis of the seasonal indexes of twelve months using the formula presented in chapter three(methodology part) were presented in Table 4.3.

A seasonal index for a particular month shows the share for that month out of the annual overall average. A seasonal index of 1.00 for a particular month indicates that the expected value of that month is 1/12 of the overall average. A seasonal index of 1.5 indicates that the expected value for that month is 50% greater than 1/12 of the overall average. Similarly, the seasonal index of

0.621 indicated that the seasonal value for that month was about 38% less than 1/12 of the overall average. Seasonal index calculated in Table 4.3 can be explained in similar way. Hence, seasonal index for the months of September, October, January, May, July and August showed that the meat consumption in these months have higher contribution for seasonal variations.

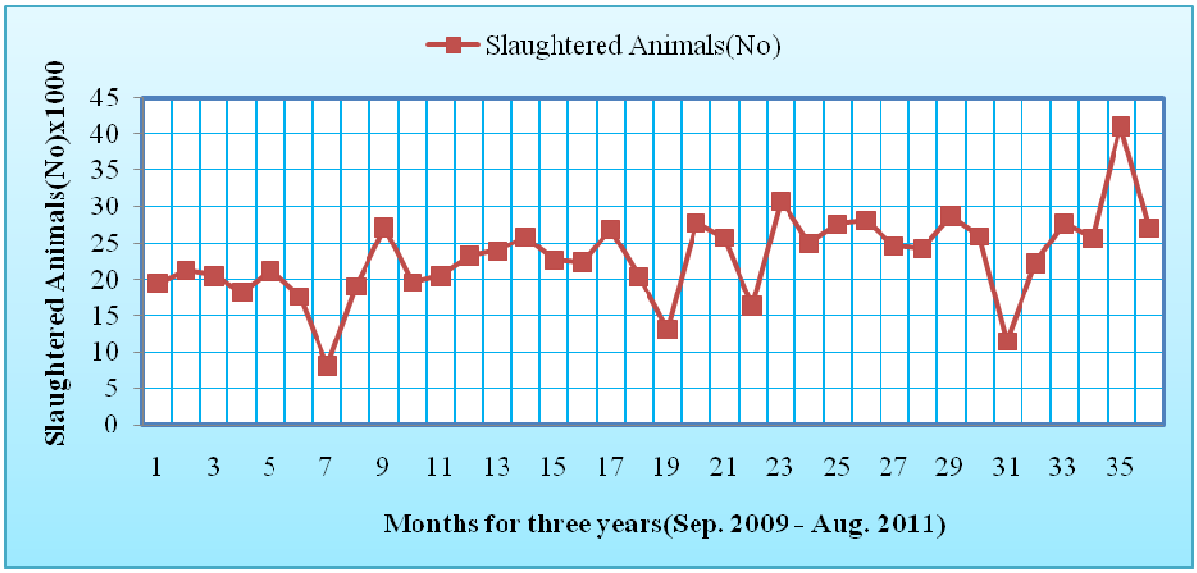

Figure 4.15. Monthly slaughtered and distributed animals in Addis Ababa from 2008/09 – 2010/11

Table 4.3. Seasonal Index Analysis of slaughtered and distributed animals in Addis Ababa from 2008/09 – 2010/11.

Month	2008/09	2009/10	2010/11	Monthly Mean	Seasonal Index
September	19375	23887	27553	23605	1.024
October	21202	25760	28053	25005	1.085
November	20478	22622	24548	22549.33	0.979
December	18194	22312	24181	21562.33	0.936
January	21145	26897	28643	25561.67	1.109
February	17634	20337	25883	21284.67	0.9234
March	8033	13048	11392	10824.33	0.470
April	18997	27713	22188	22966	0.997
May	27121	25702	27702	26841.67	1.165
June	19516	16338	25607	20487	0.889
July	20461	30779	41099	30779.67	1.336
August	23187	24927	27057	25057	1.087
				23043.6389	12.000

After analyzing the seasonal index, trend line was fitted for 20 years historical meat consumption in Addis Ababa for forecasting subsequent years demand and the best fit trend line was selected from the scatter plot based on coefficient of determination or coefficient of correlation (R^2) values obtained from EXCEL model. The result of the trend was shown in Figure 4.16.

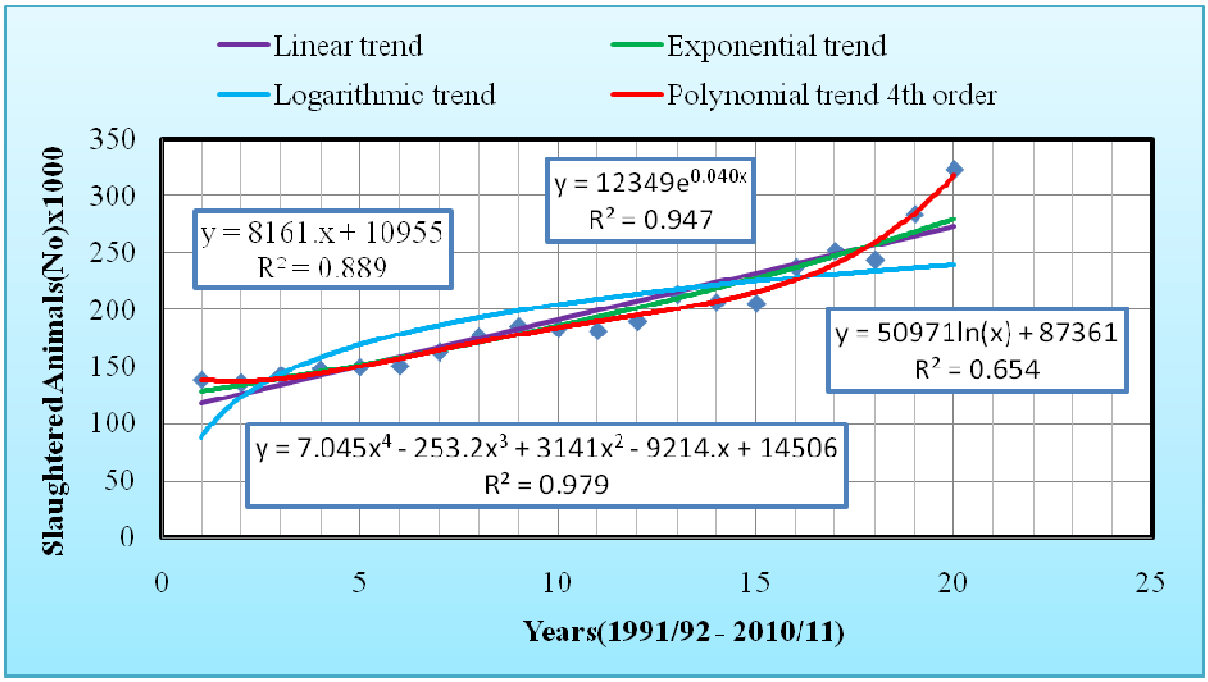

Figure 4.16. Twenty years annual meat consumption trend line fit from scatter plot.

To choose the best trend model of the time series forecasting, a scatter plot was done and different trend options was fitted for comparing the trend options and selecting the right trend line for the data based on $\mathbf{R^2}$ values. Hence, by constructing the scatter diagram and plotting of trend lines, it was observed that polynomial trend of 4^{th} order provide a better fit which provided a higher $\mathbf{R^2}$ value **(=0.979)** than the other trend option models as summarized in Table 4.4.
Subsequently, the estimated forecasted meat consumption in Addis Ababa city was determined based on the equation of the polynomial trend line given in Table 4.4. The monthly meat consumption in the city for the forecasted year, were then determined using the seasonal index of each month given in Table 4.3.

Table 4.4. Summary of predicting models of time series data using Excel-2007

Trend model options	Equations	R^2
Linear Trend	$y = 8161x + 10955$	0.889
Polynomial Trend	$y = 7.045x^4 – 253.2x^3 + 3141x^2 – 9214x + 14506$	0.979
Logarithmic trend	$y = 50971\ln(x) + 87361$	0.654
Exponential trend	$y = 12349e^{0.040x}$	0.947

Where y = the annual number of slaughtered and distributed animals (annual meat consumption)

x = the target year (period 1, 2, 3 - - - - -20)

Based on the polynomial trend model given in Table 4.4 above, the results of the annual forecasted number of slaughtered animals (annual meat consumption in Addis Ababa) for five years were predicted as shown in Table 4.5 below.

Table 4.5. Forecasted number of slaughtered animals and distributed animals from 2011/12-2015/16

Year	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
Period	21	22	23	24	25
Forecasted	231426	286301	354968	439711	542984

Note: periods for X-value (21, 22, 23, 24, and 25) were used in polynomial trend formula in Table 4.5.

Monthly estimate of the yearly forecasted number of slaughtered and distributed animals in Table 4.5 can be adjusted using the seasonal adjustment factor or index calculated in Appendix-E. If the quarterly demand forecasting was required, quarterly adjustment factor could be applied based on quarterly indexes given in Appendix-E.

4.6.4. Route optimisation for meat distribution

Route optimization was done for meat distributed from AAAE. AAAE has eleven main meat distributing routes to reach its customers in different parts of the city where the start of all routes were in Kera, the location of the main Abattoir. The routes were named according to the area name in which the customers were located. The locations (latitude and longitude) of sampled meat delivery point (or customer) on each route were recorded using handheld GPS (GARMIN *etrex* GPS). These data were then inserted into RouteLogiX Professional V 5.5 (5 Professional) route optimisation software to map the existing meat distribution routes.

RouteLogiX Professional is responsible for optimizing distribution routes in logistics for optimum savings both in distance and time. The software selects the best route to connect two or more points among different alternative routes using road network with different description as a data base. For optimizing meat distribution routes in Addis Ababa, the road network of the city containing road type, road class, and surface condition was used as a data base. The software then selects the best routes for a given existing meat distribution from all alternative routes based on the data base. The best route also contains the best visiting/delivery order of the customers for the optimum savings.

4.6.4.1. Un-optimised meat distribution routes

Before optimizing the meat distribution routes, the actual delivery routes (un-optimised routes) were mapped using RouteLogiX Professional V 5.5 (5 Professional) route optimisation software. The un-optimised routes for Tekleymanot and Lideta distribution routes, both having 24 delivery points, were as shown in Figures 4.17 and 4.18 respectively. Similar mappings of other distribution routes were given in Appendix-H.

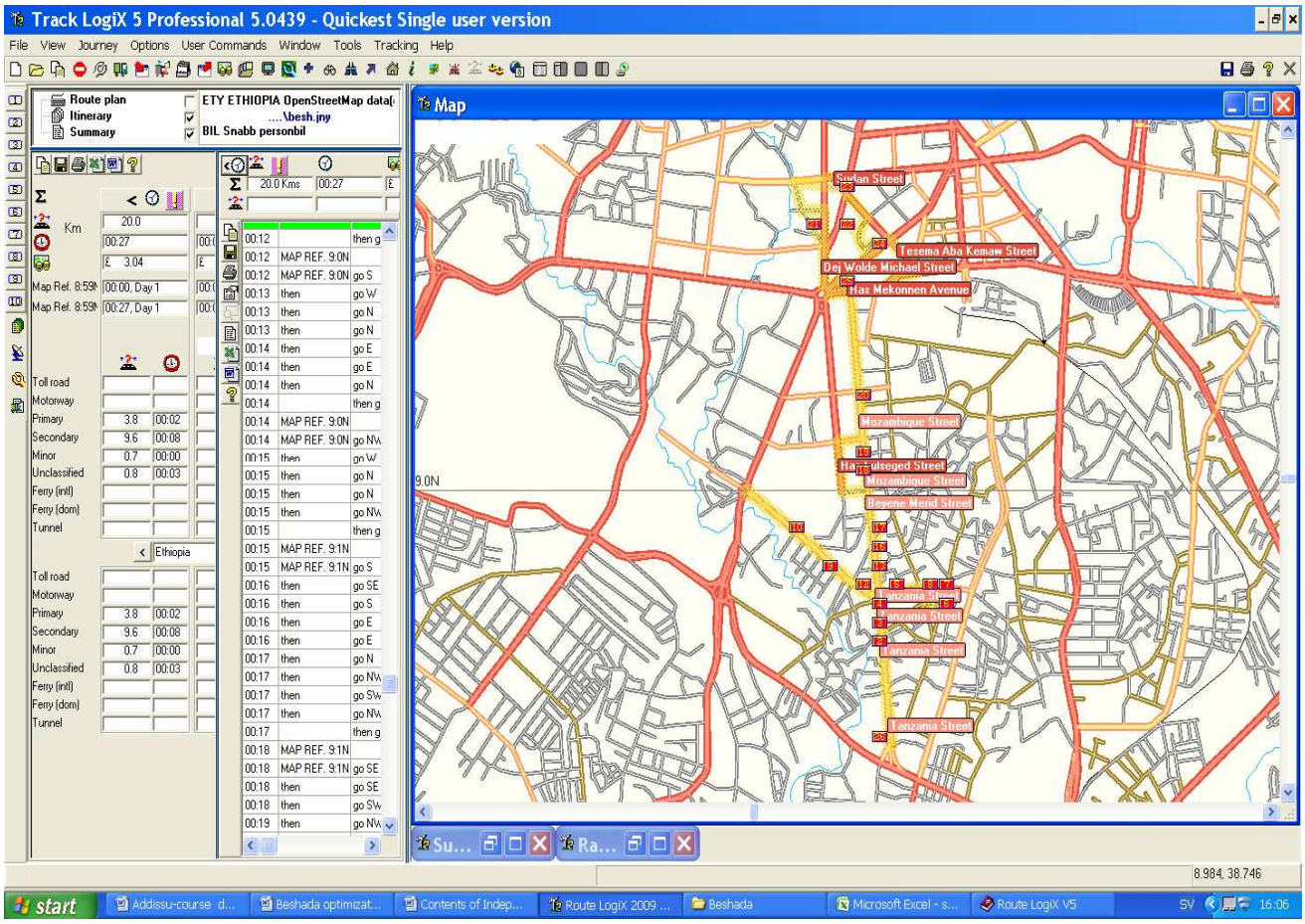

Figure 4.17. Un-optimised Tekleymanot meat distribution route: [24 meat delivery points, 20km distance covered, 27minutes required]

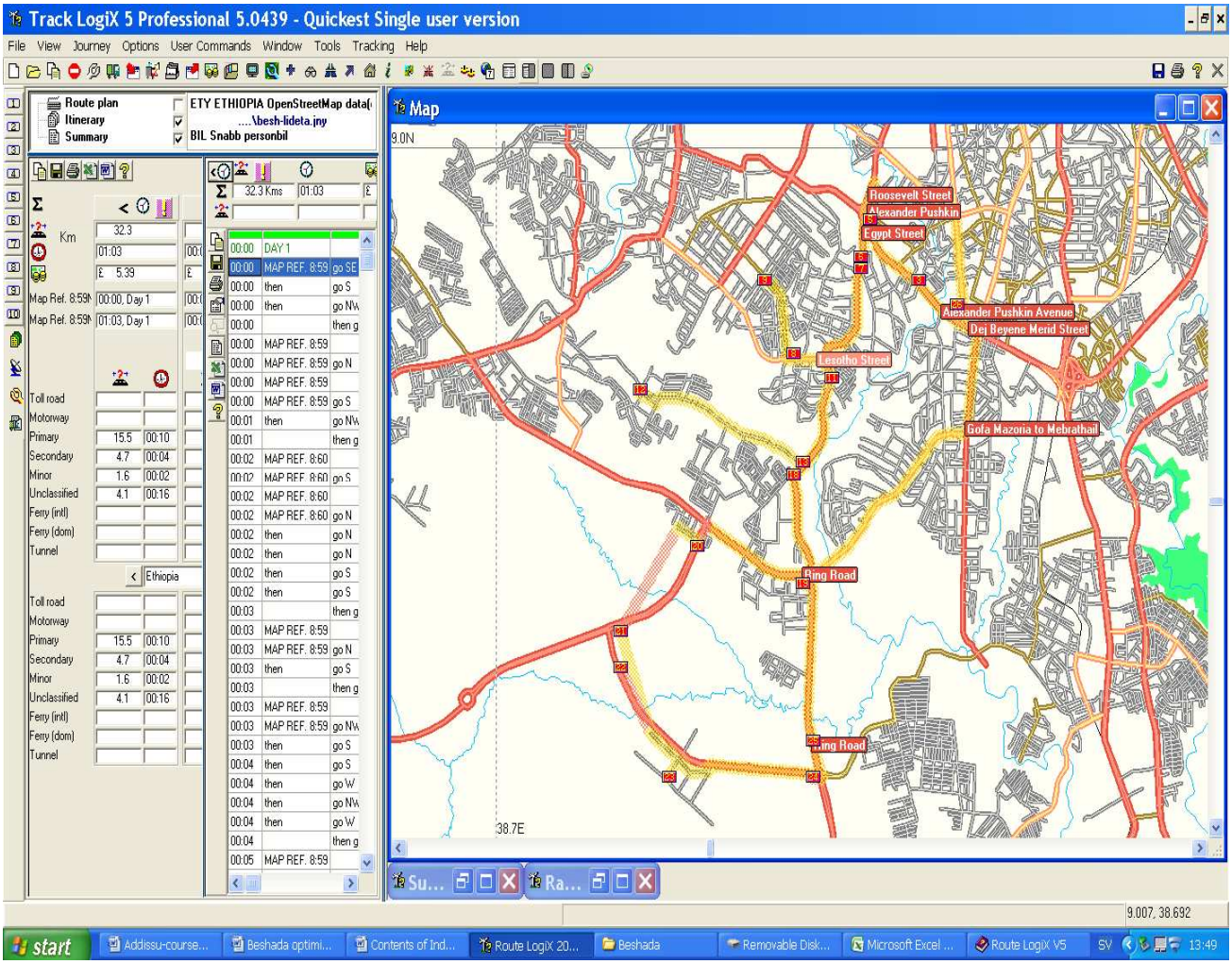

Figure 4.18. Un-optimised Lideta meat distribution route: [24 meat delivery points, 32.3km distance covered, 63minutes required]

4.6.4.2. Optimised meat distribution routes

After mapping the actual meat distribution routes, RouteLogiX Professional V 5.5 (5 Professional) route optimisation software was used to optimize the distribution routes. The optimized routes for Tekleymanot and Lideta distribution routes, both having 24 delivery points, were as shown in Figures 4.19 and 4.20 respectively. Similar results for other optimised distribution routes were given in Appendix-H.

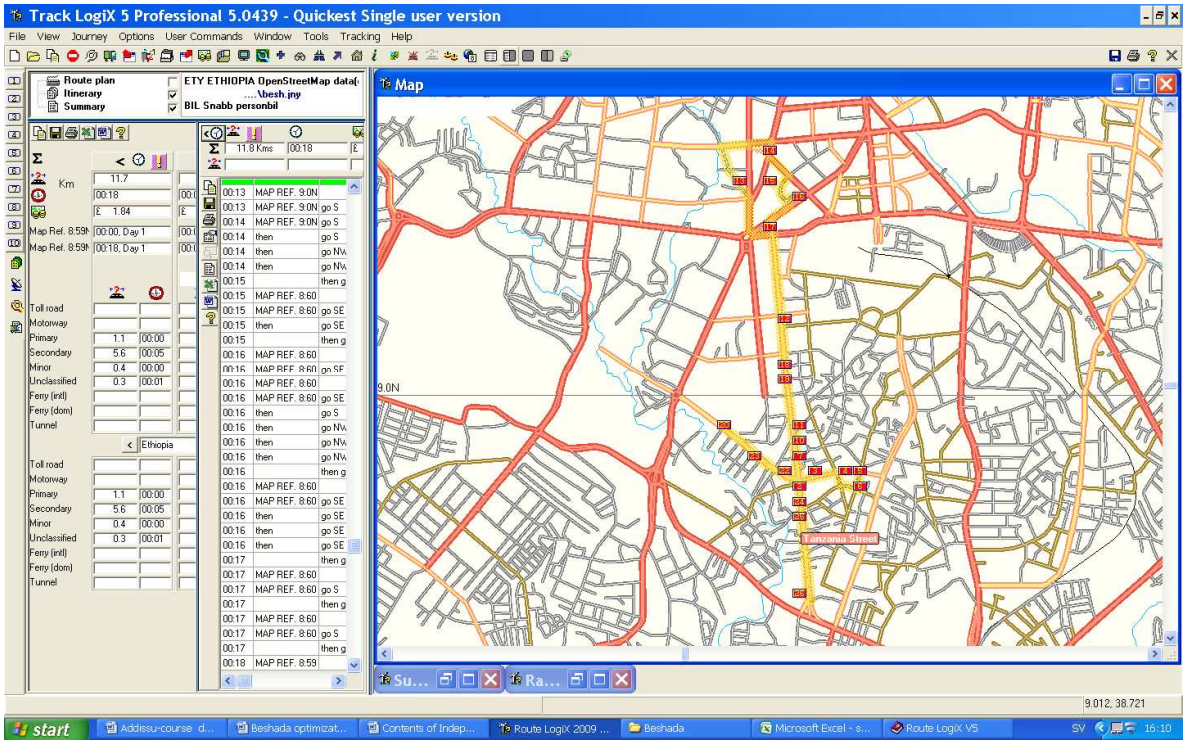

Figure 4.19. Optimised Tekleymanot meat distribution route: [24 meat delivery points, 11.8km distance covered (41% saved), 18minutes required (33.33% saved)]

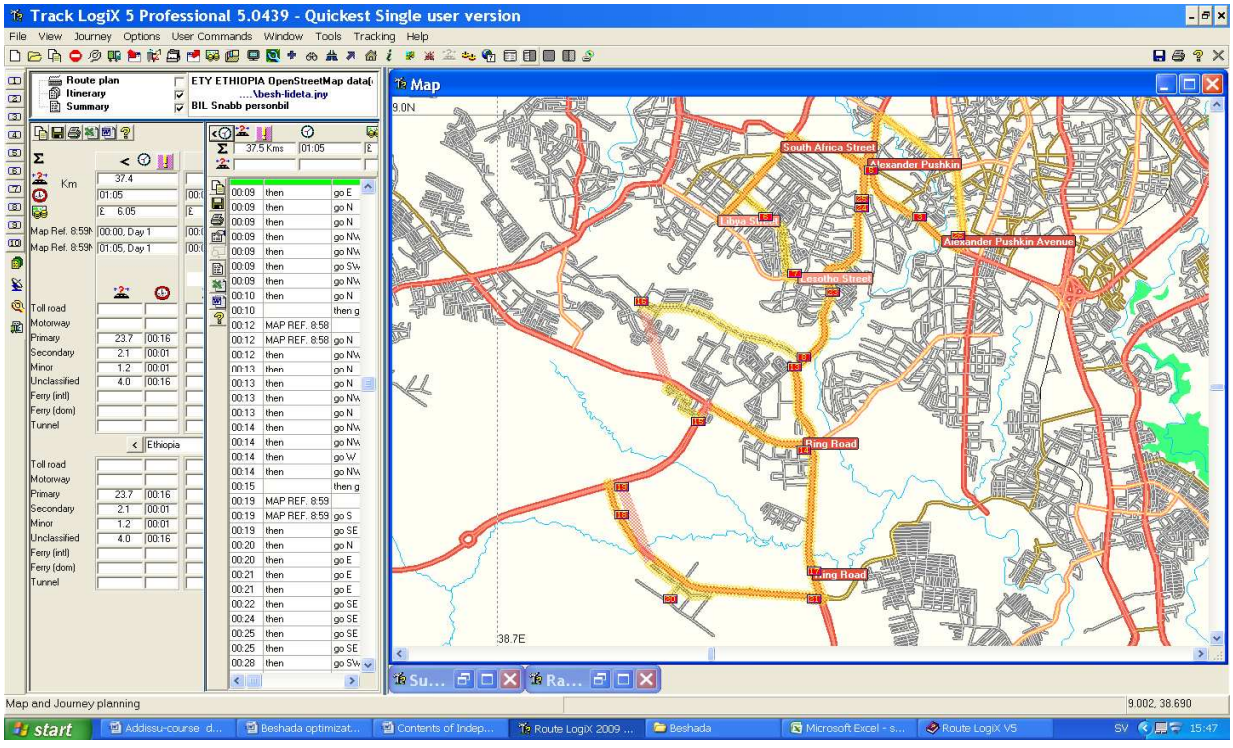

Figure 4.20. Optimised Lideta meat distribution route: [24 meat delivery points, 24.1km distance covered (25.39% saved), 38minutes required (39.68% saved)]

4.6.4.3. Summary of route optimisation

The result of route optimisation using RouteLogiX Professional V 5.5 (5 Professional) route optimisation software showed that there were a considerable savings in distance and time. Out of the eleven routes analysed, tekleymanot route had the largest savings in distance (41% saving) and Lideta route had the largest saving in time (39.68% saving). The result of the route optimisation also showed that there was an average of 12.33% saving in distance and an average of 13.58% saving in time for each distribution route. The optimized results for all the optimized distribution routes (given in Appendix I) were as summarized in Table 4.6.

Table 4.6. Summary of route optimisation for all meat distribution routes

Route Name	No of delivery points	Distance before Opti. (km)	Time before opti.	Distance after Opti (km)	Time after opti.	Distance saved (%)	Time Saved (%)
Saris	23	14.8	00:21	12.3	00:19	10.81	9.52
Meshaleka	21	24.2	00:38	21.6	00:32	10.74	15.79
Fetewrary	25	20.6	00:24	20.6	00:24	0.00	0.00
Arat Kilo	20	33.7	00:34	32.7	00:32	2.97	5.88
Lideta	24	32.3	01:03	24.1	00:38	25.39	39.68
Addis Ketema	29	22.3	00:29	21.5	00:29	0.36	0.00
Bole	18	29.5	00:34	25.2	00:30	14.58	11.77
Kolfe	19	25.3	00:31	22.4	00:27	11.46	12.90
Teklaymanot	24	20.0	00:27	11.8	00:18	41.00	33.33
Kebena	13	17.4	00:15	16.0	00:13	8.05	13.33
Arada	12	19.4	00:14	17.4	00:13	10.31	7.14
Total	228	259.50	05:30	225.60	04:35	135.67	149.34
Mean	20.73	23.59	00:30	20.51	00:25	12.33	13.58

4.7. Facility location analysis

4.7.1. Existing locations of market centers and abattoirs

According to the data obtained from AATIDB, there were six legally known livestock market centers and three Abattoirs located in different parts of the city. The observations during site visit in Addis Ababa however showed that, animal marketing were common on many streets and open places in the city especially during the holidays. Table 4.7 below summarizes the distribution of existing legal livestock market centers in Addis Ababa with their capacities. AAAE in Kera (main branch), AAAE in Akaki (Akaki branch), and Kara-Alo Abattoirs found in Kara were the three Abattoirs in Addis Ababa. Figure 4.21 below shows the mapping of existing livestock market centers and Abattoirs in the city.

Table 4.7. Summaries of existing livestock markets in Addis Ababa city

Market Name/place	**Area(m^2)**	**Type of Animals**	**Average Supply in Market Days**	**Existing Location**	
				X:	**Y:**
Akaki Kaliti Market	10000	Cattle, Sheep, Goat	500	475242	981357
Kera Market	20500	Cattle	2000-3000	472168	993172
Kara Alo Market	8000	Cattle	3000-4000	484614	999292
Shegole Market	4300	Cattle	Up to 500	469903	1002333
Shola Market	4500	Sheep and Goat	Up to 5000	477602	997579
Addisu Gebeya Market	4500	Sheep and Goat	-	470262	1001966

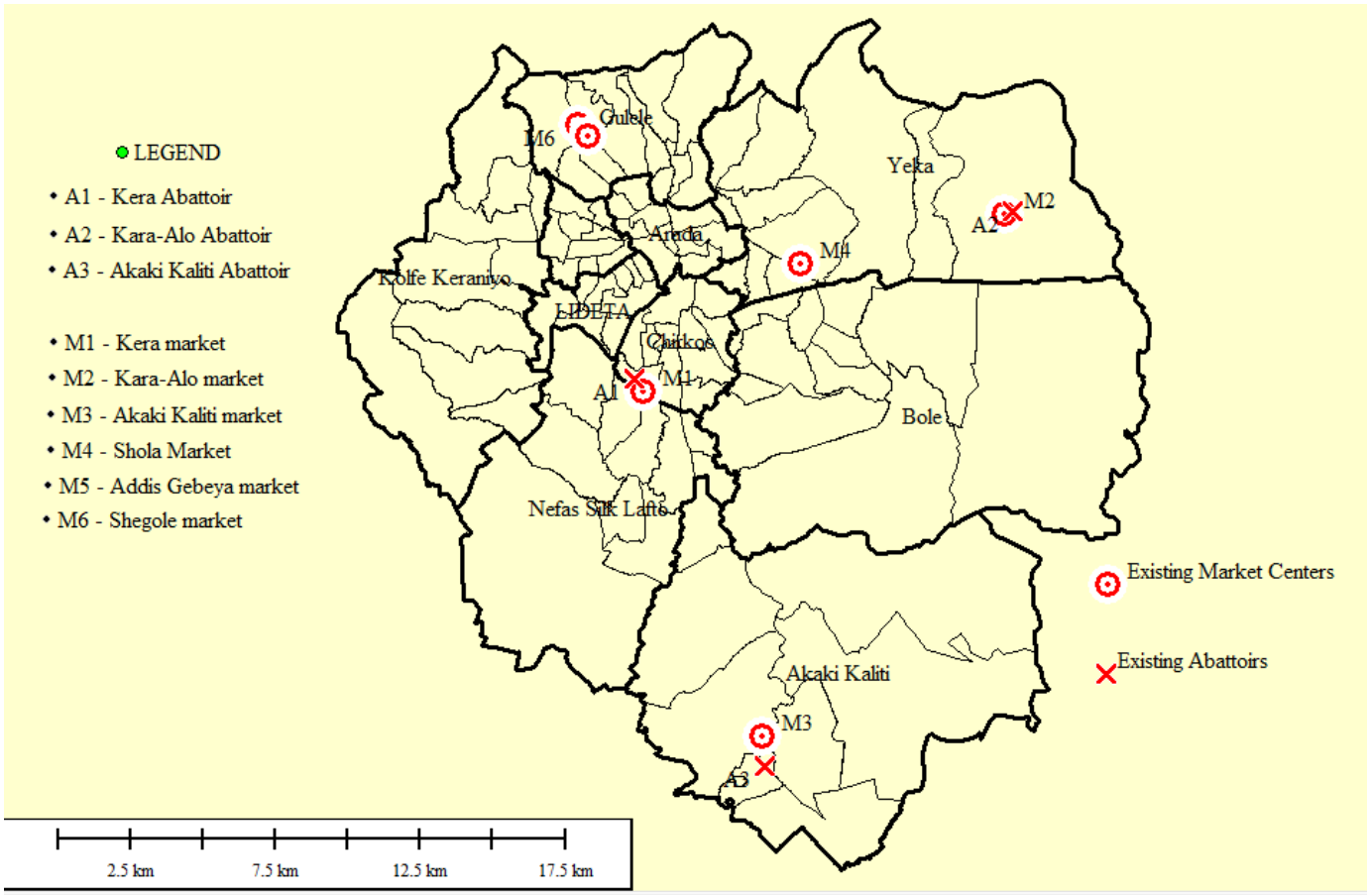

Figure 4.21. Locations of existing livestock market centers and abattoirs

4.7.2. Optimized locations of market centers and abattoirs

Location factor rating techniques was used as a tool to determine the optimum location of market centers and Abattoirs. Effect on environment, land use, proximity to customers, effect on traffic, labour availability, and proximity to suppliers were selected as location factors based on their significance in determining location decisions. The specific situation of Addis Ababa, the nature of livestock markets and Abattoirs were also considered in selecting the location factors. Three potential sites were selected for locating each market center and Abattoir based on these factors. The weights to the rating factors were assigned based on their importance in determining the locations. Each of the sites was evaluated with all rating factors where rating scores (0 to 100) were assigned to each site based on its importance for the respective location factor. The site with highest score on a specific rating factor is the best site for the specified factor where the sites with highest overall weighted average score was selected as the best site.

With the help of the collected digitized land use, road network, and centrality maps, the optimum locations of livestock market centers and Abattoirs at each gate of Addis Ababa were determined using factor rating method. The coordinates for optimum locations of market centers and Abattoirs were as shown in table 4.8 and the map showing their distribution is given in Figure 4.22. The full analyses of factor rating method were given in Appendix-J.

Table 4.8. Coordinates for optimized locations of livestock market centers and abattoirs in Addis Ababa city.

Gate Name	Coordinates of the best Site selected			
	Livestock Market Centers		Abattoirs	
	X	Y	X	Y
Dessie Gate	485727.90	999964.09	485723.94	999730.73
Gojam Gate	471100.10	1003127.99	471259.20	1002914.20
Ambo Gate	466053.28	1002715.83	466205.37	1002671.37
Jimma Gate	463883.47	990809.59	463920.89	990562.86
Akaki Gate	477685.38	978830.59	477887.24	978654.93

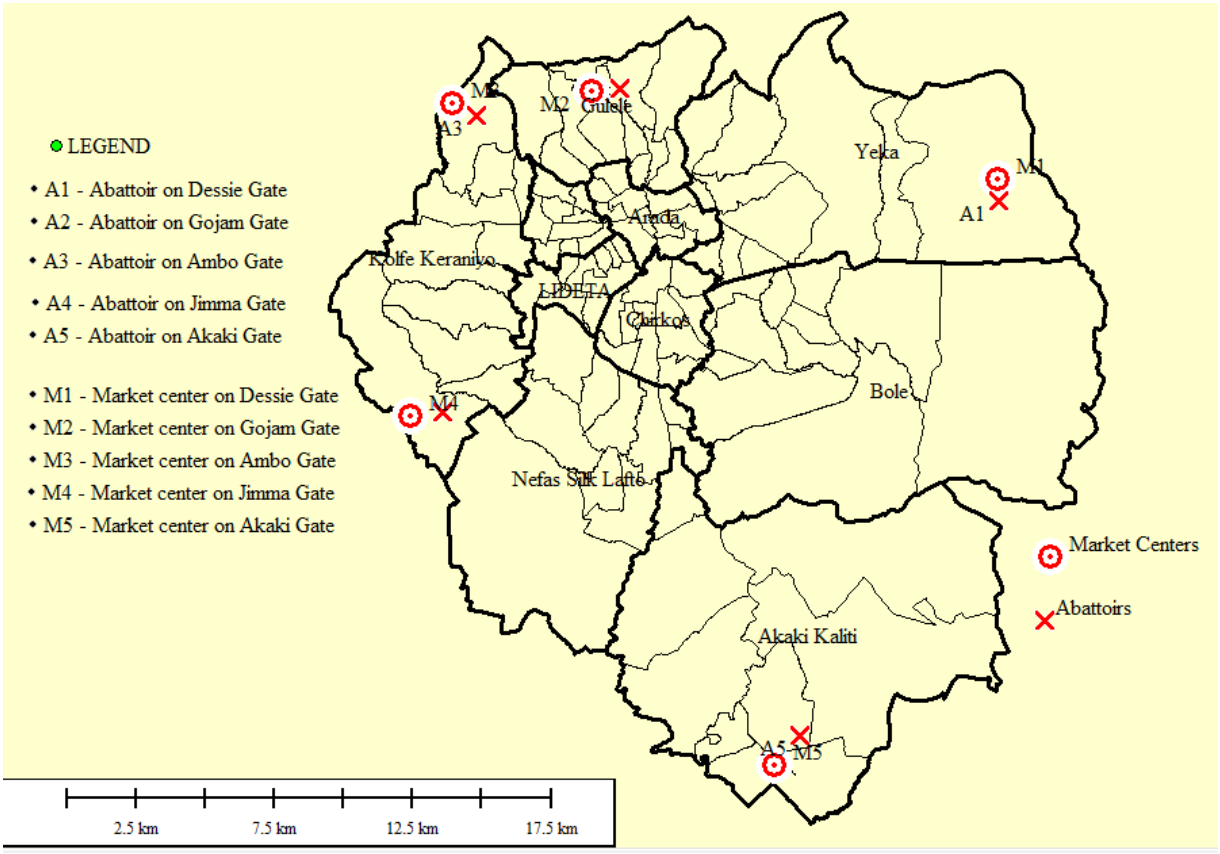

Figure 4.22. Mapping of optimized livestock market centers and abattoirs locations in Addis Ababa city

5. Discussion

5.1. Transport and Handling of Slaughter Animals

Slaughter animals were transported to the capital, Addis Ababa, from different regions of Ethiopia. The whole logistic chain of animal transport starts from the household level where animals were transported to the local markets by individual owners (farmers, pastoral, or anybody who rear animals in his/her house), local traders, cooperatives, and brokers. Animal sold in the local markets were passed to the next secondary markets by local traders and those which are not sold were returned to their home for the next market day. Slaughter animals generally pass through different market hierarchies before reaching the terminal market in Addis Ababa. Conventionally, livestock markets in Ethiopia are categorized into primary markets, secondary markets, and terminal markets based on the number of animals that attended the market per market day and the number of market participants in the market (ILRI, 2008).

Mode of transporting the animals were generally trekking in the case of transporting to the primary and secondary markets where as transport of the slaughter animals to the terminal markets in Addis Ababa were almost done using trucks especially for longer journeys in addition to trekking the animals from the markets near by the capital. In this line, a study conducted by ILRI in 2007 also confirmed that livestock were transported mainly by trekking at woreda levels.

Trekking of slaughter animals to the terminal markets in Addis Ababa is very common where many animals were put in one group and trekked along main highways for a journey length of approximately 100kms without any rest. However, the maximum recommended distance for trekking without rest was 30kms for cattle and 24kms for sheep/goats in case of one day journey. For journeys more than one day, the recommended distance was 24kms (for both cattle and sheep/goats) in the first day and 22kms for cattle, 16kms for sheep/goats in subsequent days (MOARD, 2008).

As the trekking were generally in the night times, it was common to see car accidents killing the animals as the animals were trekked along the motor traffic lane. The problem of traffic

congestion, interference with pedestrian traffic, and poor sanitation in the city of Addis Ababa due to animal trekking to the market places and Abattoirs were more critical.

The first main reason for the above mentioned pronounced problems was that most of the livestock market centers in Addis Ababa were located at city centers. The other reason was that there were no sufficient Abattoirs in the city as AAAE (the only biggest Abattoir) and Kara-Alo Abattoir (limited capacity) were the only Abattoirs where AAAE was located in the city center too. It is therefore not only necessary but also becoming mandatory to relocate the existing market centers and Abattoirs at optimum sites so that these problems will be reduced in a meaningful manner.

In case of transporting trucks, it is recommended that slaughter animals has to be transported using especially designed livestock truck in a manner that avoids injury and minimizes stress throughout the journey(MOARD, 2008). In this study however, the transporting trucks were Isuzu trucks designed for the purpose of transporting dry cargos. The manners of loading, transporting, and unloading were also more stressful which may even result in a significant loss of meat quality and production. The observed space allowance in floor area per animal during transporting cattle were 0.8 for Isuzu trucks (small models) and 0.88 for FSR(larger models). The recommended required floor area however is 1.0 – 1.4m^2 per animal for cattle (MOARD, 2008). This, therefore, may result in poor transportation of the slaughter animals affecting product quality too. Moreover, animals were not provided food and water during the journey until they were unloaded at the terminal markets in Addis Ababa.

During unloading, unloading ramps made of concrete were used although unloading without the use of ramps was also there in some ways. Unloading queues were very common in the terminal livestock markets due to limited number of unloading ramps and limited opening hours of the markets. Most livestock markets have one or two unloading ramps and the opening hrs of the markets were between mornings 12:00 to evening 12:00. Most of the trucks however arrive during the night times where they stopped in queues until morning and unloading of the trucks in the front queue lines.

The problem of queuing is more critical in Kera livestock market (which is the biggest livestock market in the city where most of the traders sell their animals) where loaded animals where

loaded animals were stayed in queues for more than four hours (on average) waiting for unloading. Hence, increasing the number of unloading ramps at each market centers and increasing the working hours of the market center (for 24 hours if possible) will automatically resolve this challenge.

Slaughter animals need proper treatment and handling in market centers, during transport to Abattoirs, and inside lairage so as to reduce stress and increase product quality. Biting the animals with sticks and ropes were however common to see during these periods. Aggressive behaviors of animals such as mounting one another, vocalization and fighting were also very common. To avoid these behaviors and protect the animals from restlessness, animals shouldn't be put in groups immediately after unloading. Mixing of the animals with other groups should be done gradually so that the animals will cope with their environment and becomes less aggressive in the mean time.

In the case of Abattoirs operations, for AAAE, the slaughtering processes were both manual and machine based. The process was well structured starting from animal intake point at the stunning box until the carcass was ready for distribution. Every job had its own technicians (personnel) and the work flow was observed to be good. Personal hygiene of the workers, however, was quite poor and it was not attractive to see the carcass while it was carried by the workers. The enterprise needs to upgrade its factory so that the manual based jobs will be done using machines which can improve its capacity and resolve the sanitation problems as well.

5.2. Evaluation of Meat Distribution in Addis Ababa

AAAE was responsible to distribute 85% of the total meat consumption in Addis Ababa as the enterprise was the only biggest Abattoir for fulfilling the meat demand of the city. In addition to AAAE, Kara-Alo Abattoir and Abattoirs in Oromia regional state nearby Addis Ababa were responsible to cover for 15% of the meat demand. AAAE has 35 vehicles specially designed for transporting meat to the gate of 1473 customers through 16 predefined distribution routes. The loading and unloading of meat were done using labors and the hygiene issues during these times were very poor. The dressings of the workers were poor interms of neatness and these needs to be improved to avoid the product from contamination.

The distribution time of the enterprise were mostly in the night times although some distributions may start early in the evening during the peak traffic hours. There were a lot of traffic congestion for distributions in peak traffic hours and this would result in a delay of transporting vehicles where it needs proper scheduling of delivery times. The historic meat consumption of Addis Ababa shows that the demand of the city had grown highly over the last two decades. The meat demand of the city had grown by more than 130% in 2010/11 when compared with the consumption in 1991/92. In addition, the time series forecasting result had shown that the meat consumption in the past two decades had grown polynomially showing that the city needs additional abattoirs to meet the growing demand.

The choice of the distribution routes is very essential for optimum use of distribution expenses (fuel cost, vehicle maintenance cost, and labour cost) and on time delivery of the product to the customers. The route optimization result for eleven main distribution routes showed that there were up to 41% savings in distribution distances and up to 39.68% savings in distribution times. This shows that a considerable amount of savings (both in distance and time) would be there if an optimized distribution routes were used.

5.3. Location Optimization for Livestock Market Centers and Abattoirs

Optimum location of facilities has a significant effect on minimizing transport cost and increasing overall profitability. Business facilities or plants had to be located in the right place at the right time to assure the firm's profitability and longtime survival (S. Russel, 2009). The existing market centers and Abattoirs found in Addis Ababa were located in city centers which results in a problem of traffic congestion, traffic accidents, poor sanitation and health condition of inhabitants. These facts showed that the market centers and Abattoirs need to be relocated at an optimum site so as to reduce the consequent problems.

The number of existing Abattoir in Addis Ababa is not enough to fulfill the increasing meat demand of the city. This was believed to be one of the main factors for illegal slaughtering of animals out of Abattoirs. The meat distribution process of AAAE has its own effect on traffic, meat quality and on time delivery of the product to the whole customers.

The existing market centers were very limited in area of holding animals and are located in city centers. The standard of the markets were very low as they do not have roofing's to protect sun and rains, have no sealed surfaces to protect mud during rainy seasons, and do not have rooms to keep animals until they were sold. It is common to see animal marketing on streets and big highways in the city interfering with motor traffic and causing poor sanitation on the street and in the city centers.

To overcome the abovementioned problems, increasing the number of market centers and Abattoirs and relocating them at an optimum location is very vital. The existing locations of market centers and Abattoirs were analysed and appraised based on different points of importance and an optimum location were selected using factor rating method as a tool and considering other important criteria. To fulfill the increasing demand for meat in Addis Ababa, five Abattoirs and market centers were proposed at each gate of the city considering land use and sanitation problems in the city.

It was believed that transporting meat to the city centers is better than locating the Abattoir at city centers and transporting animals to the Abattoirs. However, building market centers and Abattoirs at the proposed sites alone will not solve the existing problem by itself. Proper rules and legislations have to be established and enforced to protect on street marketing of animals and illegal slaughtering out of Abattoirs. The five market centers and Abattoirs to be built at the proposed sites needs to fulfill all facilities needed and they need to be at the required standard so as to resolve the existing underlying problems of the city.

6. Conclusion

The following conclusions can be drawn from the study on logistic chain of animal transport and meat distribution in Addis Ababa city:

- There were no specifically designed vehicles used for transporting slaughter animals as Isuzu trucks designed for transporting dry cargo were used to transport the animals from different regions of the country to Addis Ababa.
- Animal trekking from markets near by the city was very stress full for animals and a great challenge on traffic activities of the city.
- Handling and treatment of the slaughter animals during loading, transport, and unloading were poor and against the animal handling guidelines set by the country.
- Transport of slaughter animals were generally characterized by lack of specially designed animal transporting vehicles, lack of rest for longer journeys, absence of food and water during journeys, poor road condition, and high loading densities.
- Unloading queues at terminal markets in Addis Ababa were significantly large especially at Kera livestock market (the biggest livestock market in Addis Ababa).
- The slaughtering process in AAAE suffered greatly from lack of personal hygiene of working labors especially those responsible for loading and unloading of meat.
- The meat consumption in the city was found to increase significantly in the last two decades and also found to increase in the future.
- Route choice and order of delivery during meat distribution of AAAE needs to be revised for optimum savings both in distance and time.
- The number of Abattoirs found in the city was found to be very limited when compared with the increasing meat demand of the capital.
- The majority of existing market centers and Abattoirs were located at city centers leading to problems of traffic congestions and accidents, poor sanitation and health conditions of the nearby communities.

7. Recommendation

Based on the analysis result and conclusions, the following recommendations are made for the study:

- The government should develop a standard legislation on treatment and handling of animals during loading, transport, and unloading besides enforcing the existing animal handling guidelines.
- Road network and road construction needs to be improved especially at kebele and woreda levels so as to minimize long trekking of animals to reach secondary and terminal markets.
- Specially designed animal transporting vehicles should be used for transporting slaughter animals so as to reduce transporting stress and provide food and water during the journey.
- Awareness regarding the concept of animals handling and transport should be created for all stakeholders involved.
- Terminal market centers in Addis Ababa should open a relatively longer working time in a day (for 24 hours per day if possible) and they should have enough number of unloading ramps to minimize unloading queues.
- The city administration of Addis Ababa should protect against illegal slaughtering out of Abattoirs and on street marketing of livestock and should put and/or enforce legal punishments for doing so.
- During trekking of slaughter animals, putting large number of animals in one group, trekking for longer journey without rest, trekking the animals along motor traffic lanes, beating the animals with sticks and ropes should be avoided and proper training and awareness on animal handling and treatment should be given for all personnel involved in these process.
- More number of modern Abattoirs should be built at the proposed sites in Addis Ababa to meet the increasing demand of meat consumption in the city.

- AAAE should improve its whole process in a modern way giving attention on upgrading manual slaughtering operations to machine based and improving hygiene while distributing meat in the city.
- The government should set and enforce legislations on meat transport and create awareness to the concerned stakeholders as well.
- Route choice and delivery order in meat distribution should be optimized so as to minimize distribution cost and on time delivery of the product to the customer.
- The existing livestock market centers in Addis Ababa should be relocated at the proposed sites and their standard should also be improved so as to avoid the existing problems in addition to maintain the welfare of the animals and the health condition of the nearby community.

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APPENDIXES

APPENDIX -A QUESTIONERS FOR ANIMAL TRANSPORTERS

1. Origin of the animals _____
2. Total travel distance to the terminal market in km_____
3. Types of road you faced_____
4. Types of vehicle_____; Floor area_____; No of Animals it carries _____
5. Transport charge per animals_____
6. Any food and water on the journey? _____
7. Start time from source(origin) market_____
8. Arrival time at the terminal market_____
9. Unloading time at the terminal market_____; Time in queuing(9-8)_____
10. Any problem you mention regarding animal transport?

APPENDIX -B DATA COLLECTION FORM FOR MEAT DISTRIBUTION IN ADDIS ABABA

Date: _____ Time:_____ Car Plate No: _____

Route Name: Distribution days per week:

Total Quantity of meat in the Vehicle at origin (in no): _____ Km at origin_____ Km at end (Last customer)_____

Customer Code	Waypoint(X,Y,Z)	Meat Quantity per trip	Distribution Days	Total Quantity per week	No of no service months per year	Remark

APPENDIX-C HISTORIC MEAT CONSUMPTION IN ADDIS ABABA CITY

year	Slaguhtered Animals(No)
1984	138155
1985	135609
1986	142254
1987	147873
1988	149343
1989	150289
1990	162671
1991	176342
1992	185050
1993	183192
1994	181244
1995	189616
1996	213279
1997	206121
1998	205229
1999	237164
2000	251578
2001	243476
2002	283754
2003	322858

APPENDIX -D REGIONAL SOURCES OF ANIMALS IN MAIN LIVESTOCK MARKET CENTERS FOUND IN ADDIS ABABA

Market Name/place	**Type of Animals**	**Regional Sources of Animals**		**Market Days**	**Average Supply in Market Days**
		Supply region/Place	**Share (%)**		
Akaki Kaliti Market	Cattle, Sheep, Goat	Kara Alo Market, Farmers around Kera and nearby it.	-	Tuesday and Saturday	500
Kera Market	Cattle	North Shoa	40	Wednesday and Friday	2000-3000
		Harar	30		
		Wallega	10		
		Adama	10		
		Others	10		
Kara Alo Market	Cattle	Dessie	40	Wednesday and Friday	3000-4000
		North Shoa	30		
		Jimma	10		
		Wallega	10		
		Others	10		
Shegole Market	Cattle	North Shoa	40	Monday, Wednesday and Friday	Up to 500
		Harar	30		
		Wallega	20		
		Others	10		
Shola Market	Sheep and Goat	Dessie	60	Monday, Wednesday and Friday	Up to 5000
		North Shoa	20		
		Walayita	10		
		Others	10		
Addisu Gebeya Market	Sheep and Goat	Ginchi	75	Monday, Wednesday and Friday	-
		Sallale	5		
		Guder	5		
		Kata	5		
		Arsi	5		
		Sheno	5		

APPENDIX -E SAMPLE MARKETING EXPENSE FOR LIVE ANIMAL

Expense Type	Expense amount per animal	Remark
Buying expenses		
Transport and Hotel	40	400 ETB per trip
Broker	50	
Loading	20	
Transport	250	
Kela payment	25	Average 5 kela, 5ETB/kela/animal
Unloading	20	
Other expenses(wood, cable, grass)	5	
Subtotal 1	410	
Selling expenses		
For market usage	10	Until selling the animal
Food	160	10 average staying days with 16ETB per day
Water	20	2ETB per day for 10 days
For keeper in markets	150	15ETB per day for 10 days
Broker	50	
Subtotal 2	390	
Grand total	800	

APPENDIX -F SEASONAL INDEX RESULTS OF MONTHLY AND QUARTERLY NUMBER OF SLAUGHTERED ANIMALS

Month	2008/09	2009/10	2010/11	Monthly Mean	Seasonal Index
September	19375	23887	27553	23605	1.024
October	21202	25760	28053	25005	1.085
November	20478	22622	24548	22549.33	0.979
December	18194	22312	24181	21562.33	0.936
January	21145	26897	28643	25561.67	1.109
February	17634	20337	25883	21284.67	0.9234
March	8033	13048	11392	10824.33	0.470
April	18997	27713	22188	22966	0.997
May	27121	25702	27702	26841.67	1.165
June	19516	16338	25607	20487	0.889
July	20461	30779	41099	30779.67	1.336
August	23187	24927	27057	25057	1.087
				23043.6389	12.000

Quarter	Period			Mean of Quarters	Seasonal index
	2008/09	2009/10	2010/11		
Quarter 1	20351.67	24089.67	26718.00	23719.78	1.029
Quarter 2	18991.00	23182.00	26235.67	22802.89	0.990
Quarter 3	18050.33	22154.33	20427.33	20210.66	0.877
Quarter 4	21054.67	24014.67	31254.33	25441.22	1.104
Total	78447.67	93440.67	104635.3	92174.56	4.000

Key: Quarter 1 includes September, October, and November

Quarter 2 includes December, January, and February

Quarter 3 includes March, April, and May

Quarter 4 includes June, July, and August

APPENDIX -G KERA CUSTOMER NUMBER AND THEIR DISTRIBUTION (UP TO SEPTEMBER 2011)

S.No	Route	Total
1	Addis Ketema	80
2	kolfe	75
3	Lideta	183
4	Arada	77
5	Fetewrary	49
6	Kechene	29
7	Arat Kilo	68
8	Teklahymanot	72
9	Meshalekya	68
10	Kebena	112
11	Bole	126
12	Saris	174
13	Musilim	230
14	Europe	77
15	Gemet	23
16	Akaki Kaliti	30
	Total	1473

APPENDIX -H LOCATION OF SAMPLED CUSTOMERS FOR ROUTE OPTIMIZATION

sampled customer distribution

S.No	Route	surveyed	Total	percent
1	Addis Ketema	29	80	36.25
2	kolfe	19	75	25.33
3	Lideta	24	183	13.11
4	Arada	12	77	15.58
5	Fetewrary	25	49	51.02
6	Arat Kilo	20	68	29.41
7	Teklahymanot	24	72	33.33
8	Meshalekya	21	68	30.88
9	Kebena	13	112	11.61
10	Bole	18	126	14.29
11	Saris	12	174	6.90
Total		217	1084	20.02

Kebena Route Detail

Customer Code	way point	x	y
N9	402	474735.28	996556.2
K49	428	474752.56	996709.7
N87	432	474757.95	996747.1
N36	449	474773.82	996838.8
K12	480	474590.8	997155.2
K2	480	474590.8	997155.2
N112	491	474723.02	996808.1
N94	497	474864.71	996705
N93	497	474864.71	996705
N45	497	474864.71	996705
N140	504	475066.65	996709
N95	509	475418.21	996810.8
K4	510	474970.85	996677.2

Lideta Route Detail

Customer Code	Waypoint	X	Y
H65	230	471859	993625
H49	230	471859	993625
H119	234	471328	994203
J100	234	471328	994203
L40	242	471225	993917
L95	244	471196	993792
H55	255	470392	992931
H93	264	470113	993684
L86	287	470851	992753
L37	287	470851	992753
L57	306	468715	992671
H46	307	470498	991976
47	310	470407	991893
L19	310	470407	991893
L49	311	470433	991825
L85	311	470433	991825
L77	311	470433	991825
J45	316	470536	990850
J46	325	469338	991266
H101	331	468500	990454
H120	334	468419	990096
J88	339	468975	989073
H137	345	470605	989149
H131	349	470643	989453

Saris Route Detail

Customer Code	Waypoint	X	Y
Y27	11	472447	993210
805	12	472596	993155
S4	15	472500	992955
821	15	472500	992955
S61	15	472500	992955
S2	16	472486	992851
602	18	472328	992822
883	18	472328	992822
877	20	472465	992674
Y55	21	472451	992609
S39	22	472437	992481
855	23	472426	992379
S84	25	472367	472367
Y5	26	472170	992255
Y44	29	471661	991761
S62	29	471661	991761
Y95	31	471392	991617
S70	34	471646	991722
S33	35	471693	991777
Y78	35	471693	991777
Y88	37	471852	991957
S96	42	472397	992111
Y52	44	472508	992251

A/Ketema Route Detail

Customer Code	Waypoint	X	Y	Z
A34	265	471739	996269	2356
A51	272	471230	995981	2340
A11	275	470994	996092	2354
26	275	470994	996092	2354
88	275	470994	996092	2354
A80	275	470994	996092	2354
A2	287	470620	995918	2346
A99	287	470620	995918	2346
76	287	470620	995918	2346
A1	288	470634	996024	2352
37	288	470634	996024	2352
48	292	470826	996414	2364
A5	293	470837	996493	2366
75	300	471013	997322	2399
A4	304	470674	996980	2394
87	305	470710	997038	2397
36	308	470467	997125	2401
58	309	470550	996903	2391
A20	311	470344	996667	2371
63	315	470703	997165	2404
91	316	470708	997265	2412
31	317	470712	997290	2414
45	319	470721	997543	2427
A9	320	470713	997622	2434
50	322	470673	997910	2447
100	324	470741	998094	2445
15	325	470635	998153	2453
4	329	470090	998026	2417
56	339	469800	997016	2360

Fetewrary Route Detail

Customer Code	Waypoint	X	Y
W3	379	471956	998547
F13	382	471306	998617
F35	382	471306	998617
W21	383	471281	998800
W9	385	471105	999387
W11	388	470905	999019
F64	390	470775	998837
W19	390	470775	998837
W17	391	470776	998759
F33	394	470526	998861
W12	395	470584	998510
W36	396	470415	998603
F3	3396	470415	998603
W15	396	470415	998603
W52	397	470296	998606
F4	397	470296	998606
W92	402	470110	999316
F12	406	469813	998623
W88	407	469632	998760
W35	407	469632	998760
W78	410	469654	998266
W79	410	469654	998266
F92	411	469602	998096
F45	413	469263	997569
W39	413	469263	997569

Arada Route Detail

Customer Code	Waypoint	X	Y
299	389	472576	999166
D29	389	472576	999166
282	393	472625	999289
261	403	472848	998754
260	403	472848	998754
277	403	472848	998754
247	403	472848	998754
D5	408	472836	999139
225	411	472951	999482
D42	413	472890	999404
243	414	472844	999395
D39	421	473158	999265

Kolfe Route Detail

Customer Code	Waypoint	X	Y
O93	54	468509	999507
O77	54	468509	999507
O80	57	468377	999599
127	70	468837	998983
117	74	468751	998664
O48	77	468522	998579
110	80	468262	998562
105	82	468032	998552
O100	83	467923	998549
124	84	467914	998515
O70	84	467914	998515
O69	85	468025	998539
193	86	468189	998550
O23	87	468300	998558
O18	88	468346	998559
113	89	468410	998563
190	90	468474	998566
O80	91	468503	998569
152	92	468603	998568

Arat Kilo Route Detail

Customer Code	Waypoint	X	Y
R60	184	475167	1000989
Q68	185	475189	1001015
Q86	186	475218	1001046
Q26	187	475241	1001077
R38	187	475241	1001077
Q8	189	475462	1001160
Q75	190	475554	1001121
Q66	198	476847	1001786
Q67	208	475076	1001173
AR7	209	475037	1001303
Q71	215	474889	1002056
Q36	225	473887	1000770
R25	226	473879	1000679
Q73	227	473518	1000536
Q34	229	473499	1000719
Q54	232	473578	1001153
R11	237	473770	1001753
R95	238	473781	1001853
R98	240	473829	1001961
R59	247	473654	1002713

Teklhaymanot Route Detail

Customer Code	Waypoint	X	Y
T42	5	472321	993994
404	8	472309	994123
402	11	472331	994249
T7	13	472381	994263
790	24	472712	994200
T23	30	472759	994350
479	33	472570	994306
423	47	471959	994448
T4	53	471695	994649
422	67	472125	994311
T6	70	472210	994257
417	76	472278	994380
496	80	472264	994496
478	80	472264	994496
498	83	472255	994585
411	85	472243	994695
T10	88	472206	994946
435	90	472193	995116
494	94	472161	995454
499	108	471874	996363
409	112	472030	996437
T12	114	472064	996590
T48	119	472305	996290
416	122	472091	996097

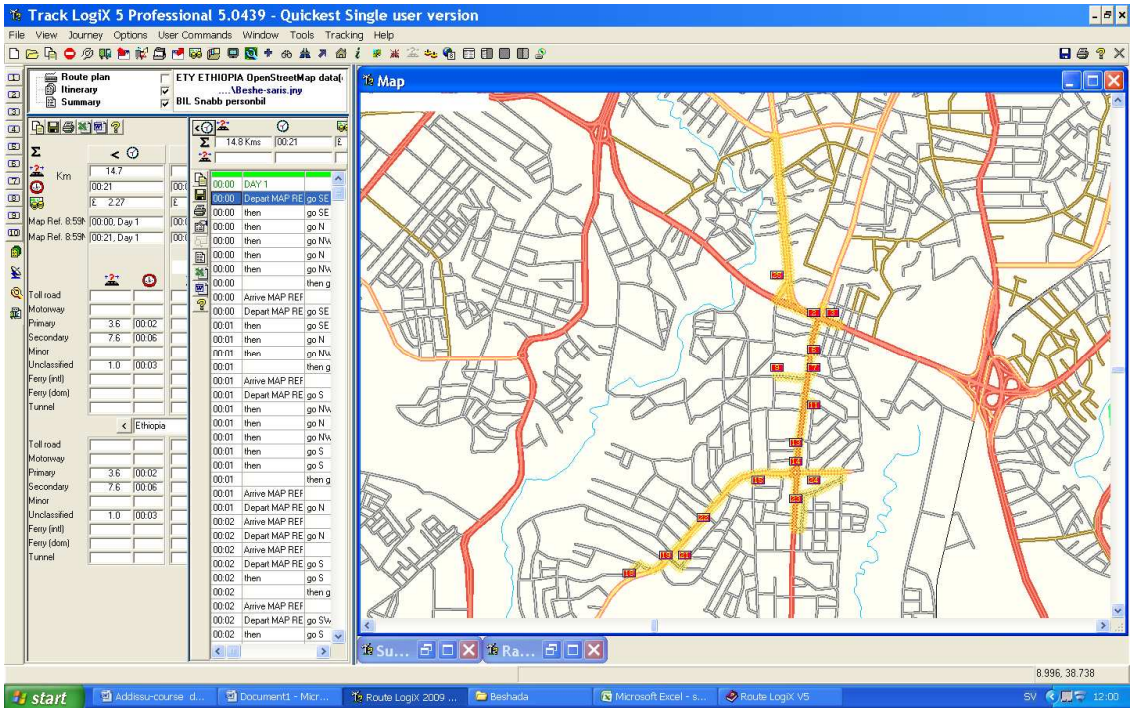
Bole Route Detail

Customer Code	Waypoint	X	Y	Z
616	126	473980	995839	2357
B25	129	474106	995693	2358
754	132	474259	995477	2357
B86	135	474312	995146	2355
B79	143	474351	994413	2345
717	151	474400	994887	2351
755	154	474461	995200	2351
B64	154	474461	995200	2351
B43	159	474839	995360	2353
B34	165	474634	995578	2350
701	179	474906	993923	2333
711	191	475987	993727	2315
732	202	475152	992844	2317
666	202	475152	992844	2317
601	202	475152	992844	2317
B96	205	475222	992713	2324
B30	216	477010	994148	2352
764	223	475967	995150	2348

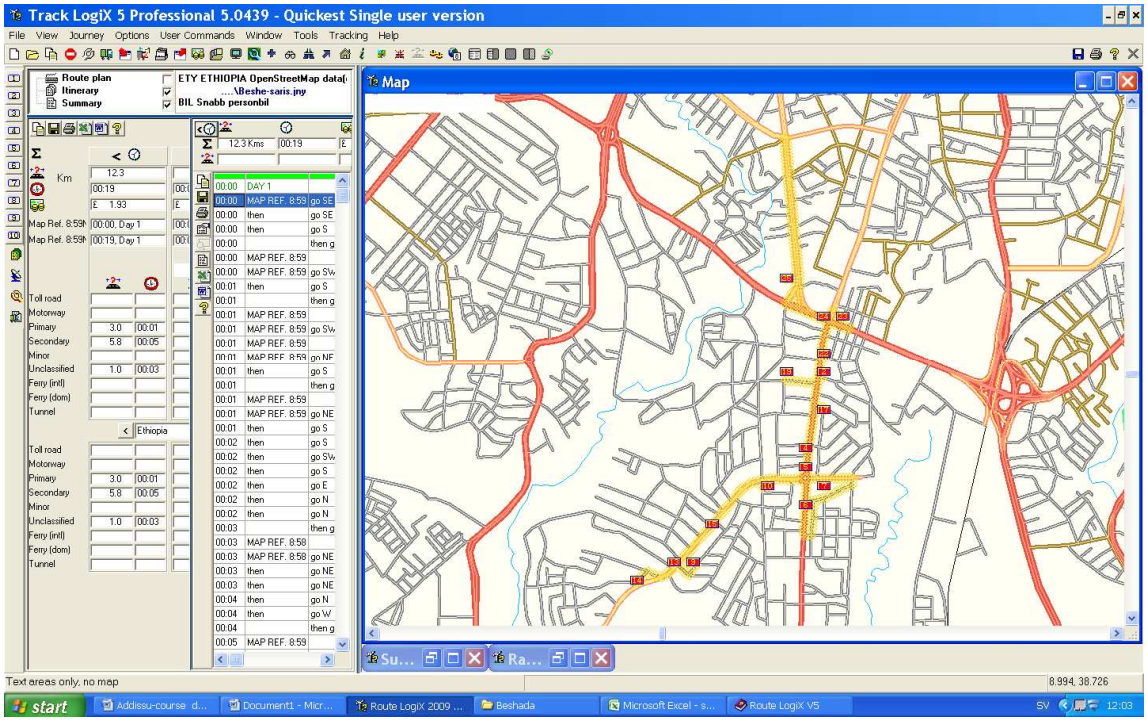
Meshaleka Route Detail

Customer Code	Waypoint	X	Y	Z
E66	64	473677	992571	2302
E18	69	473526	993173	2308
E585	83	473234	993061	2303
E82	84	473179	993076	2289
E17	91	473576	993133	2313
E89	92	473675	993094	2310
544	96	474002	993250	2316
503	101	474160	993530	2323
568	104	474253	993993	2336
E84	104	474253	993993	2336
525	113	473432	993728	2309
540	115	473474	993882	2319
531	116	473522	994031	2312
E69	118	473428	994418	2323
E83	119	473386	994593	2332
E55	120	473396	994656	2332
595	121	473394	994692	2337
E32	122	473397	994769	2341
554	124	473408	995076	2350
543	125	473416	995142	2351
594	126	473410	995277	2352

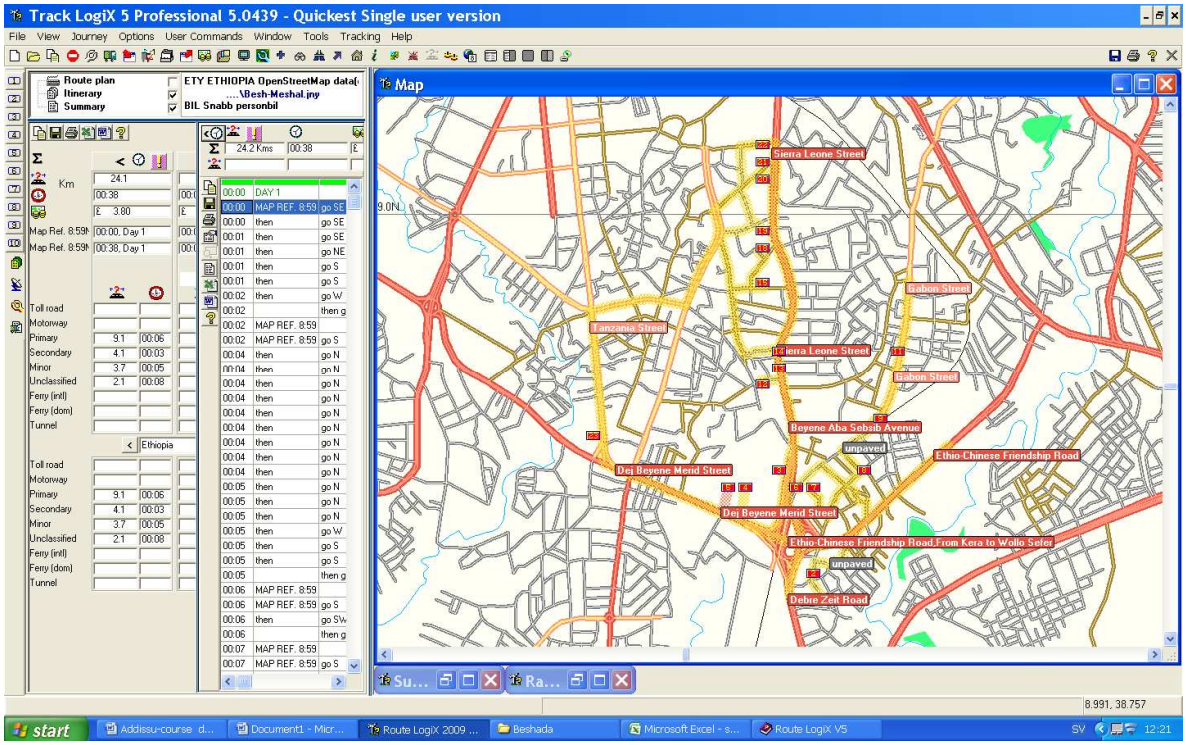
APPENDIX -I ROUTE OPTIMIZATION RESULT FOR MEAT DISTRIBUTION IN ADDIS ABABA



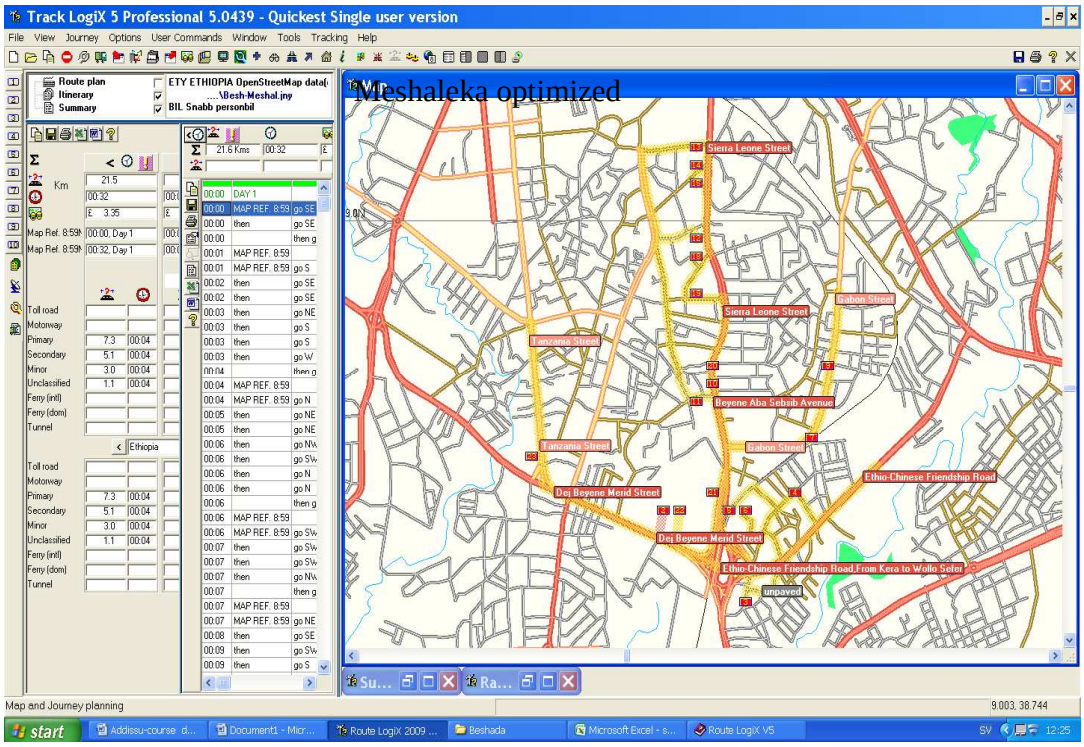
Saris route unoptimised



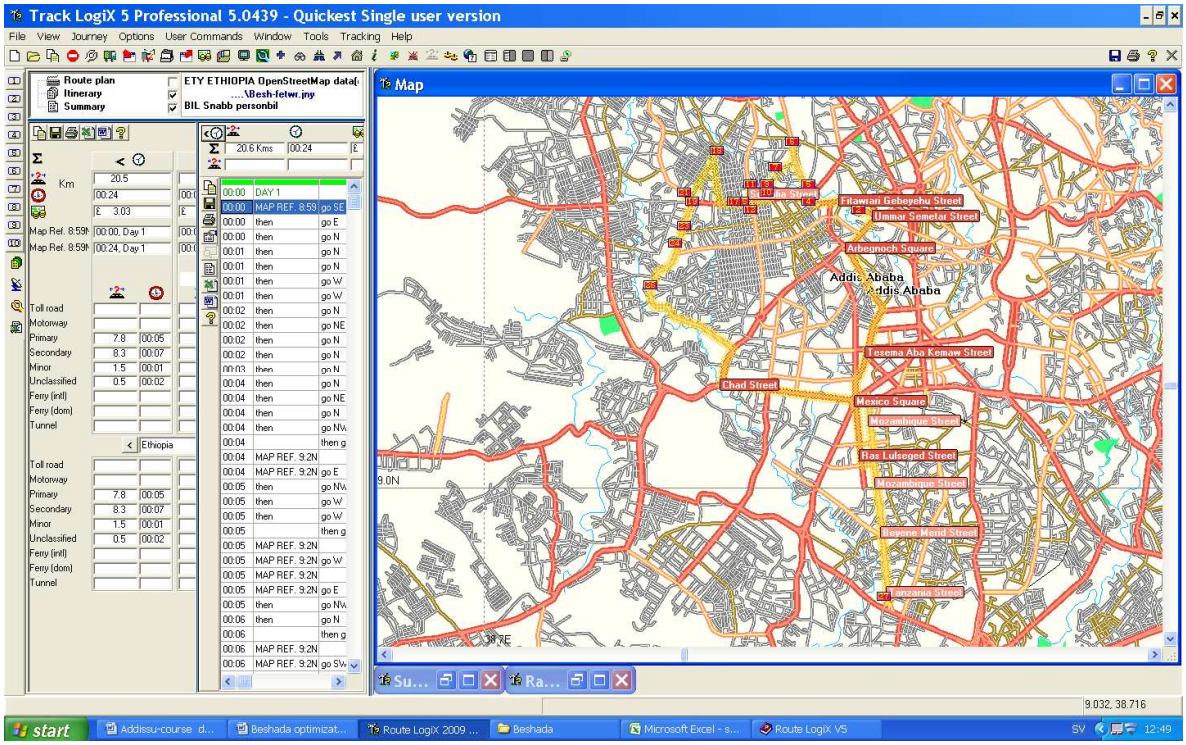
Saris route optimized



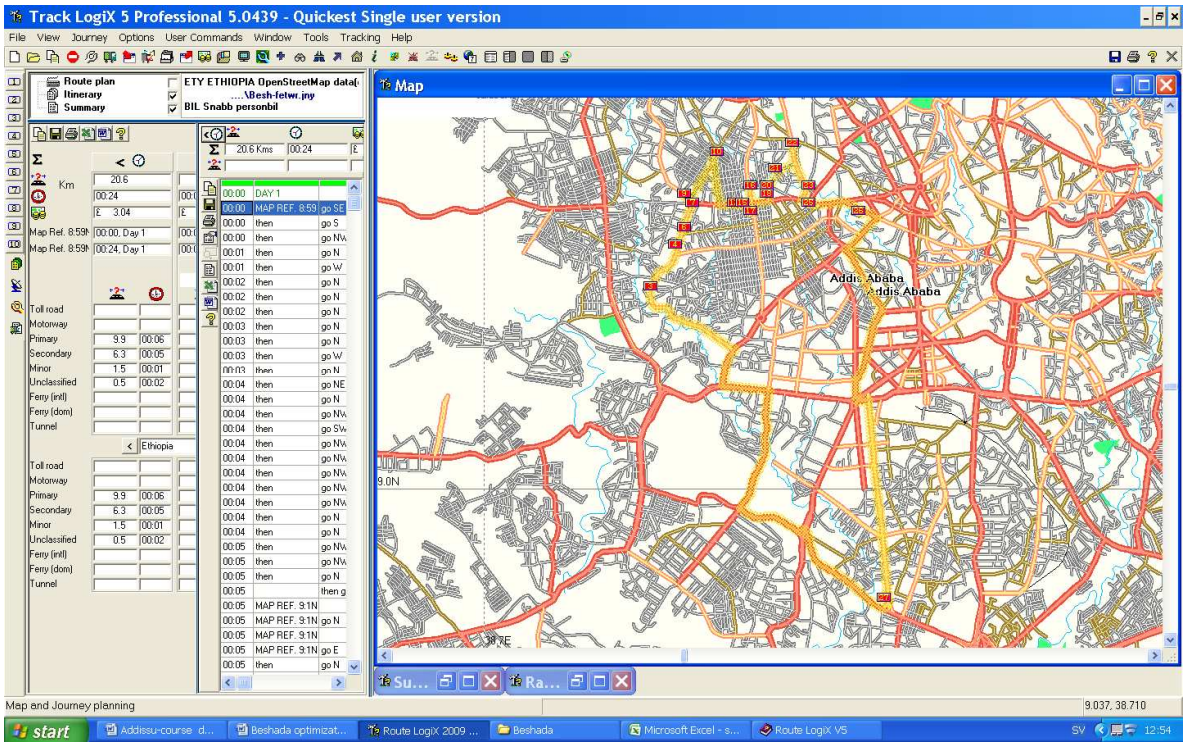
Meshaleka route Unobtimised



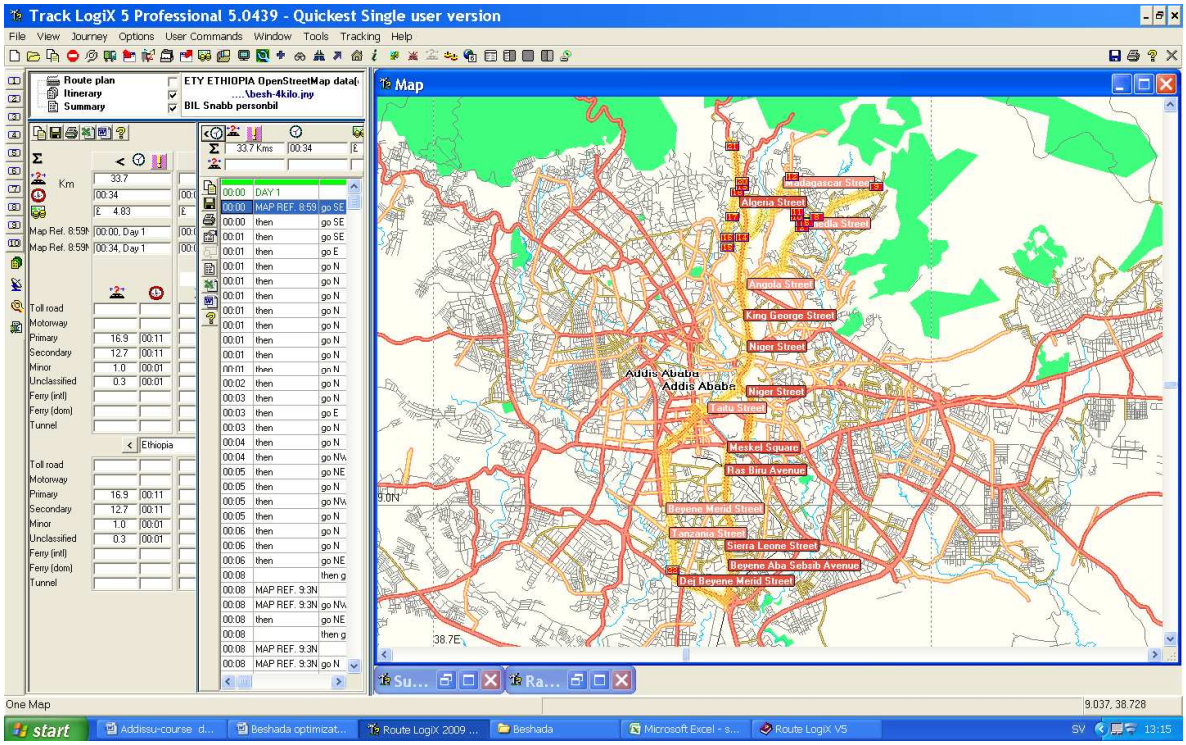
Meshaleka route optimised



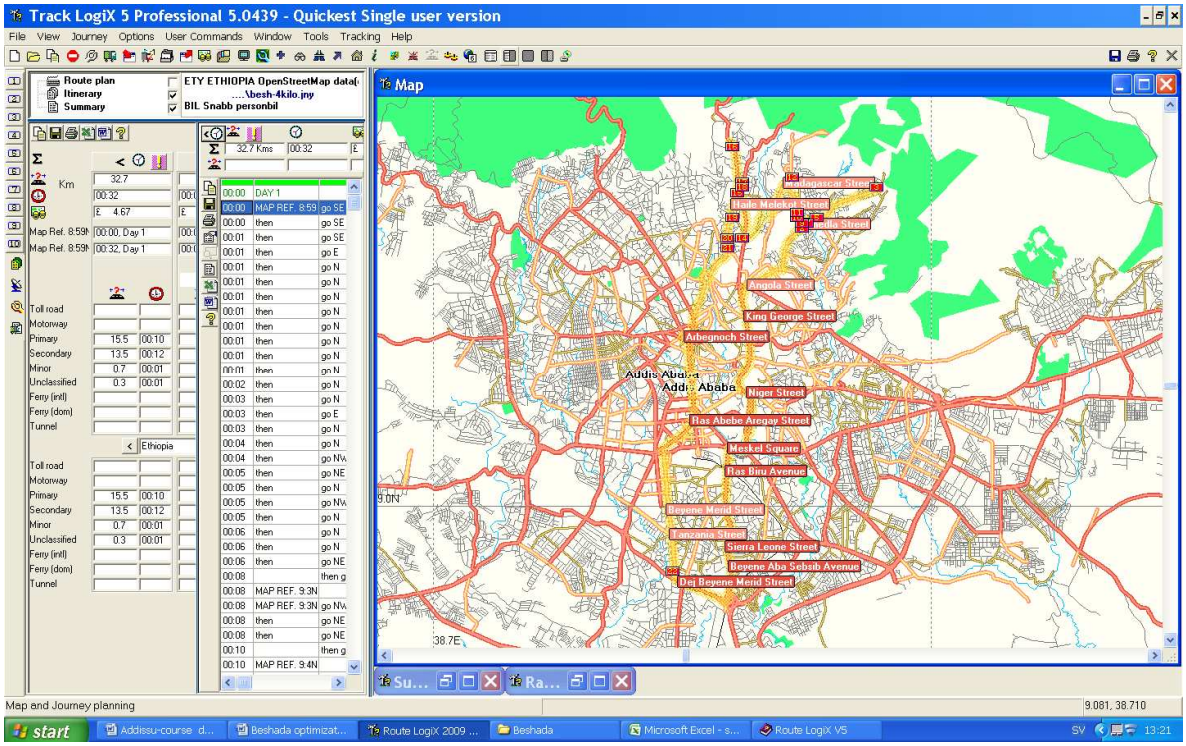
Fetwrary route Unoptimised



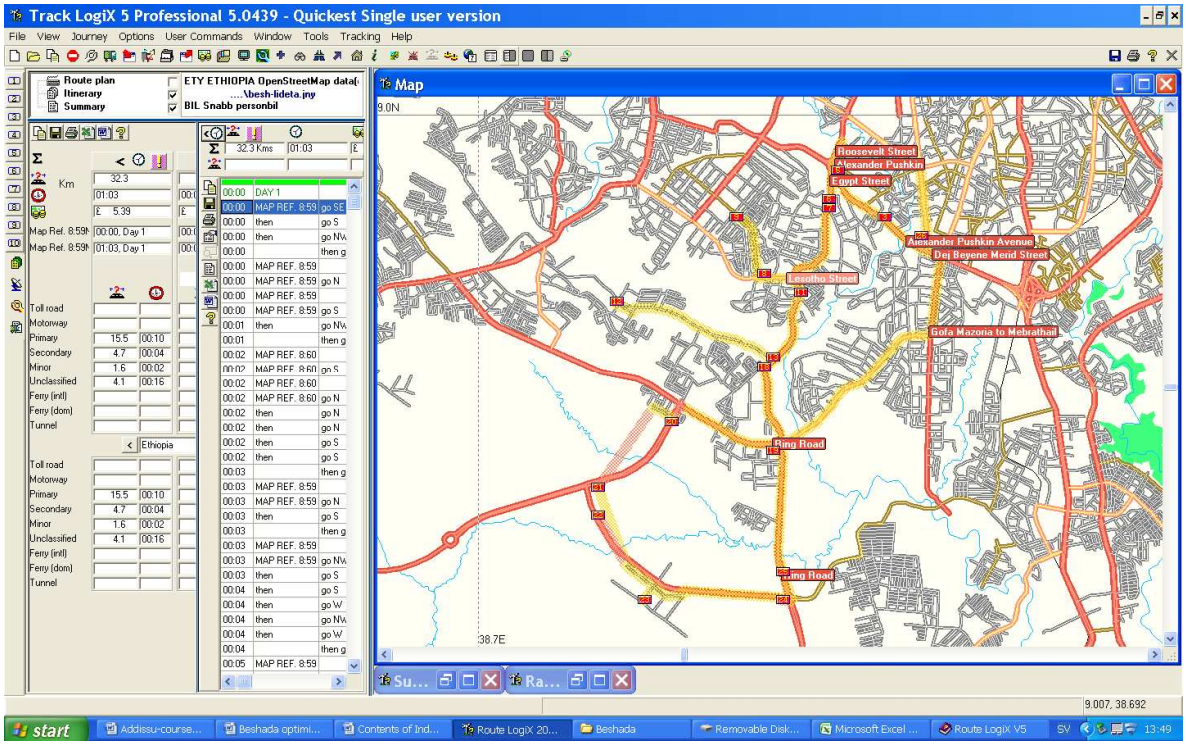
Fetwrary route optimised



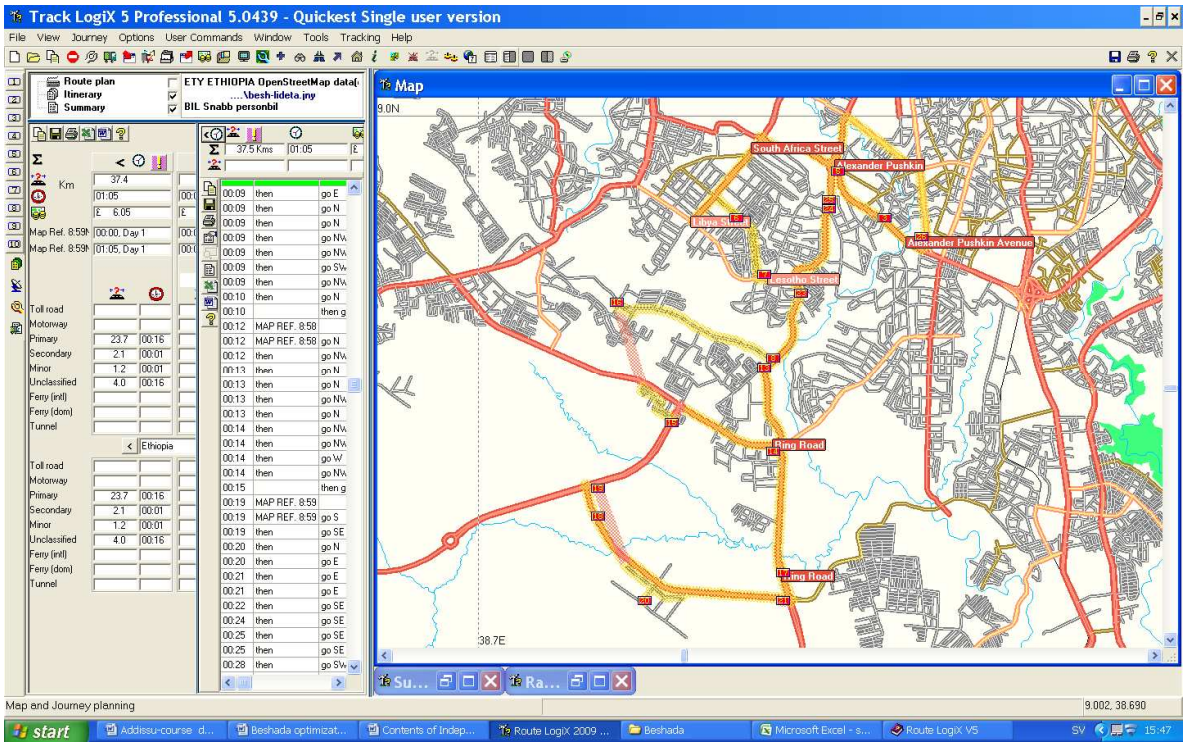
Arat kilo route unoptimised



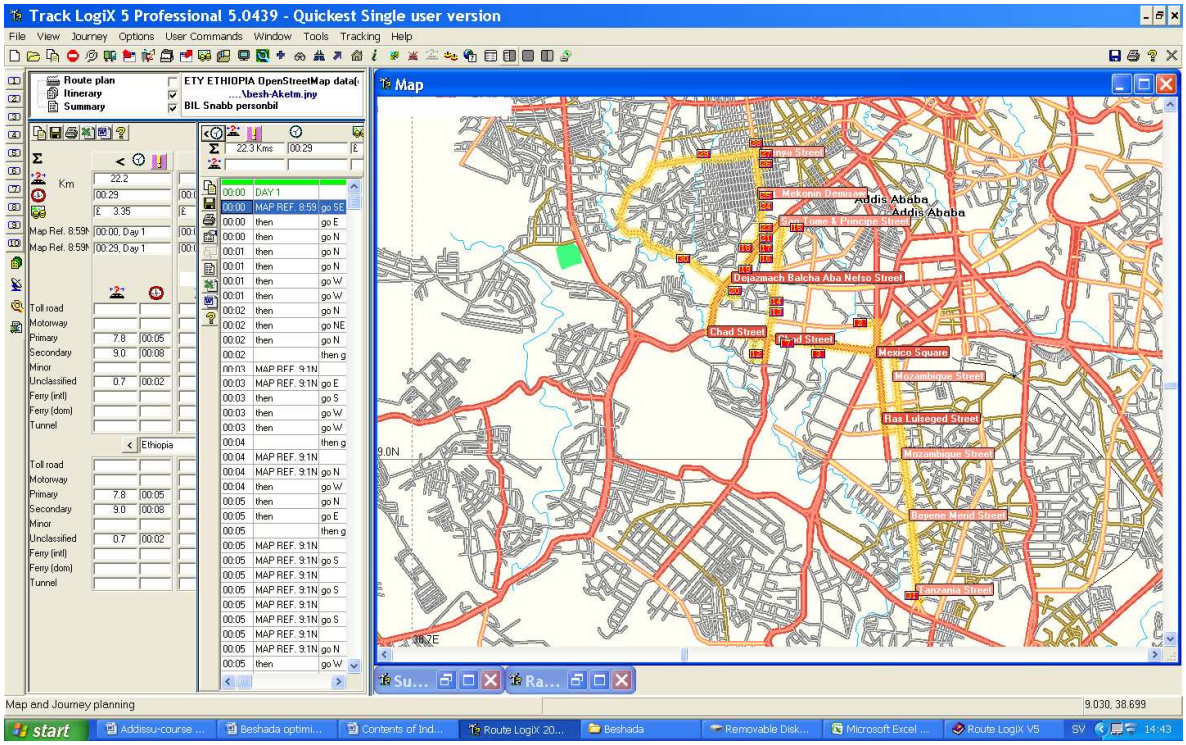
Arat Kilo route optimised



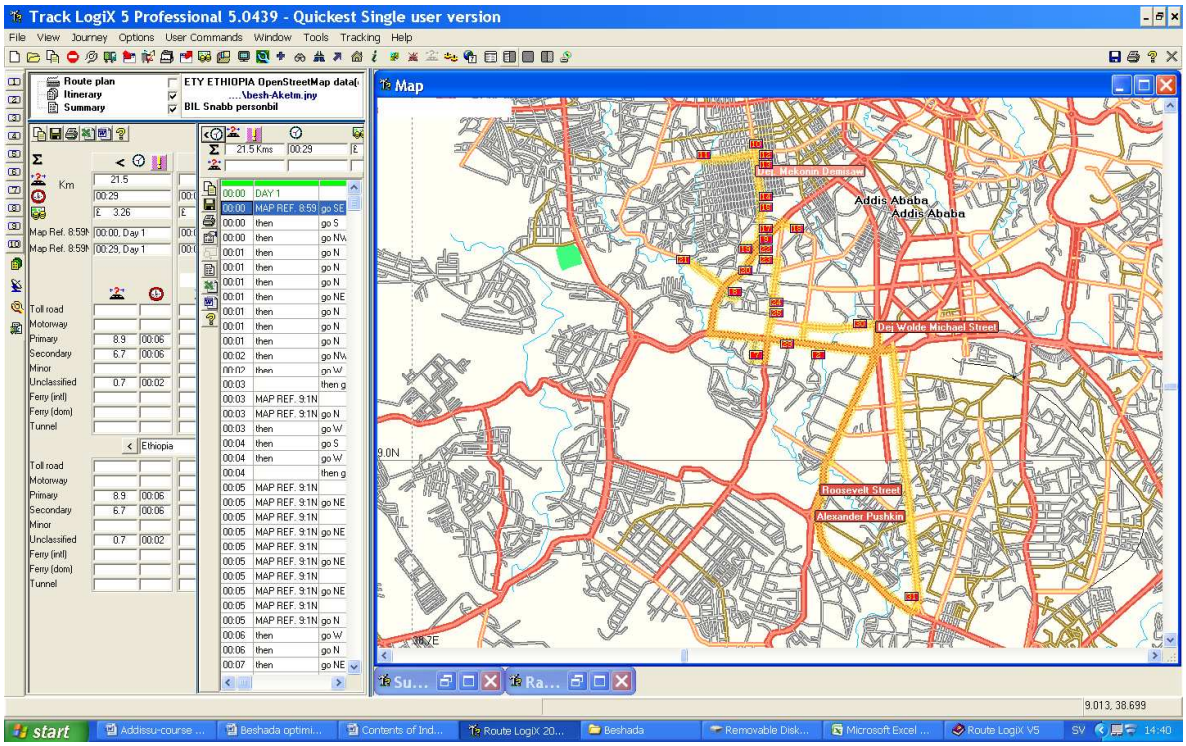
Lideta route unoptimised



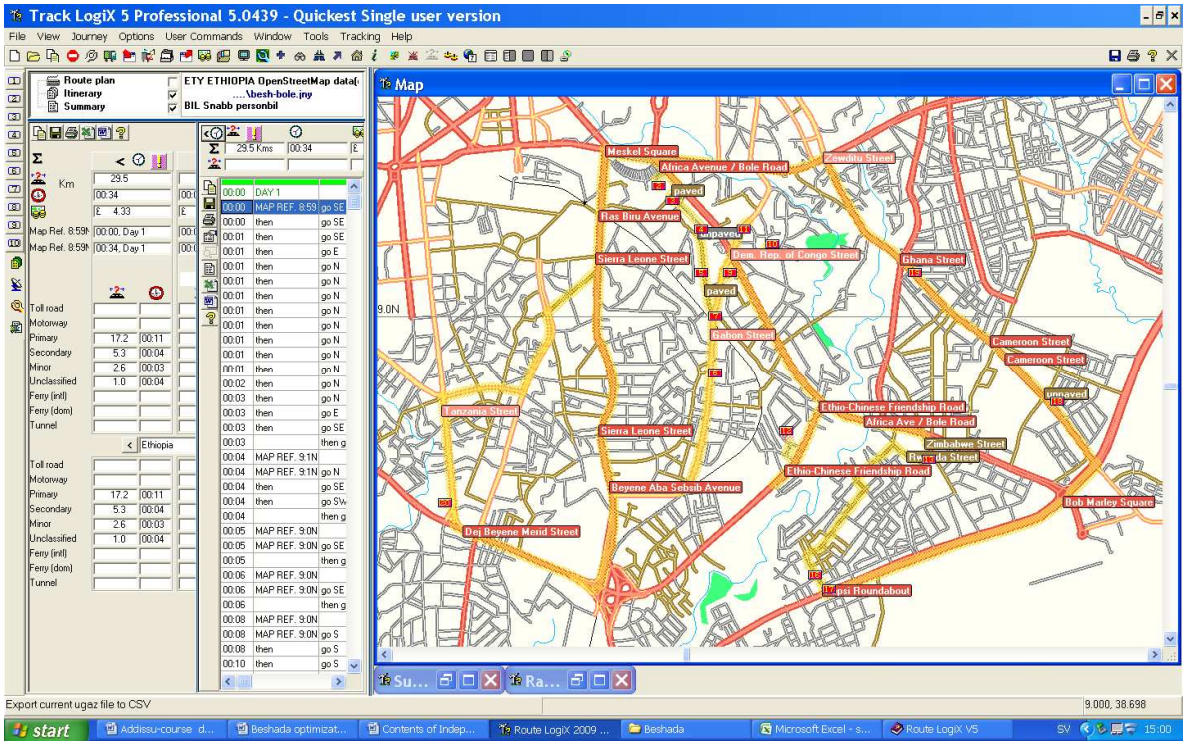
Lideta route optimised



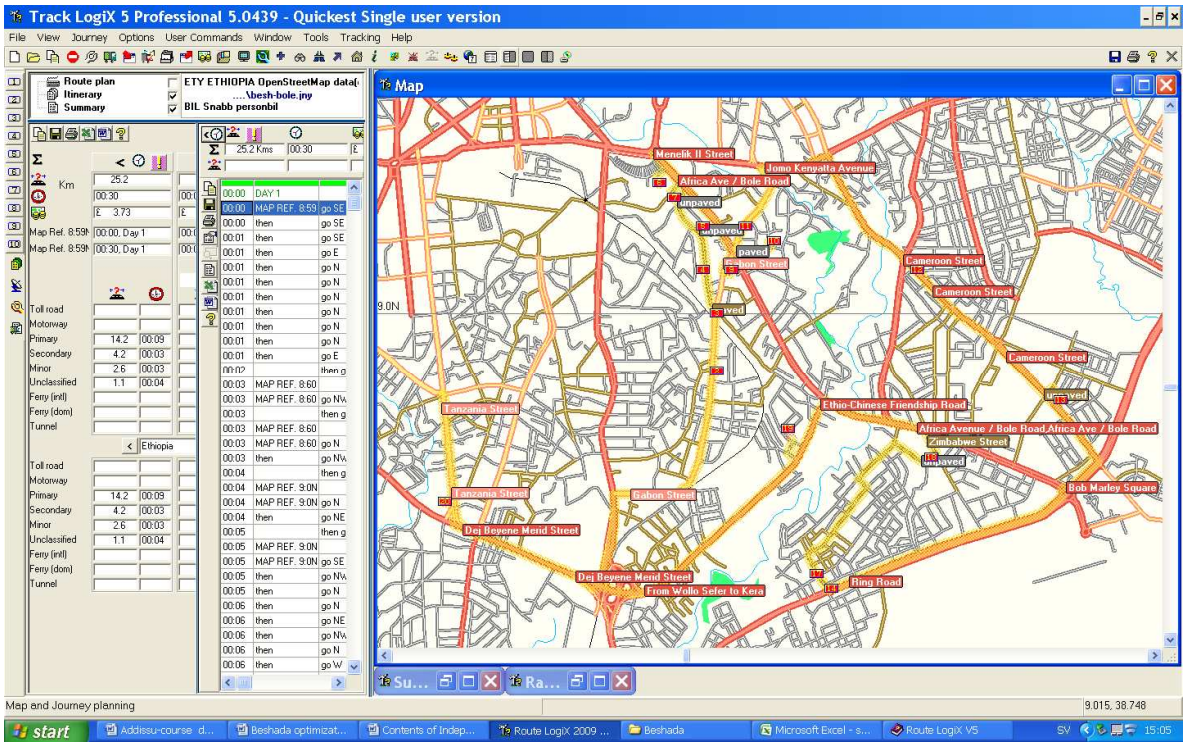
A/Ketema route unoptimised



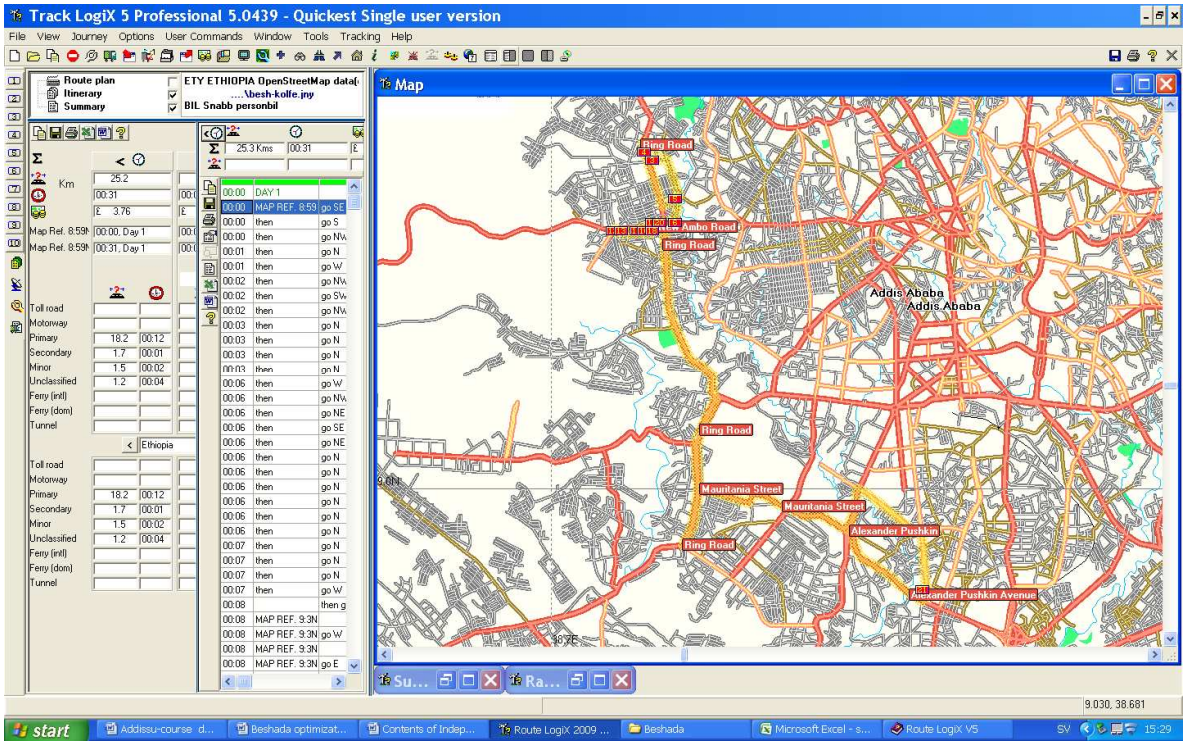
A/Ketema route optimised



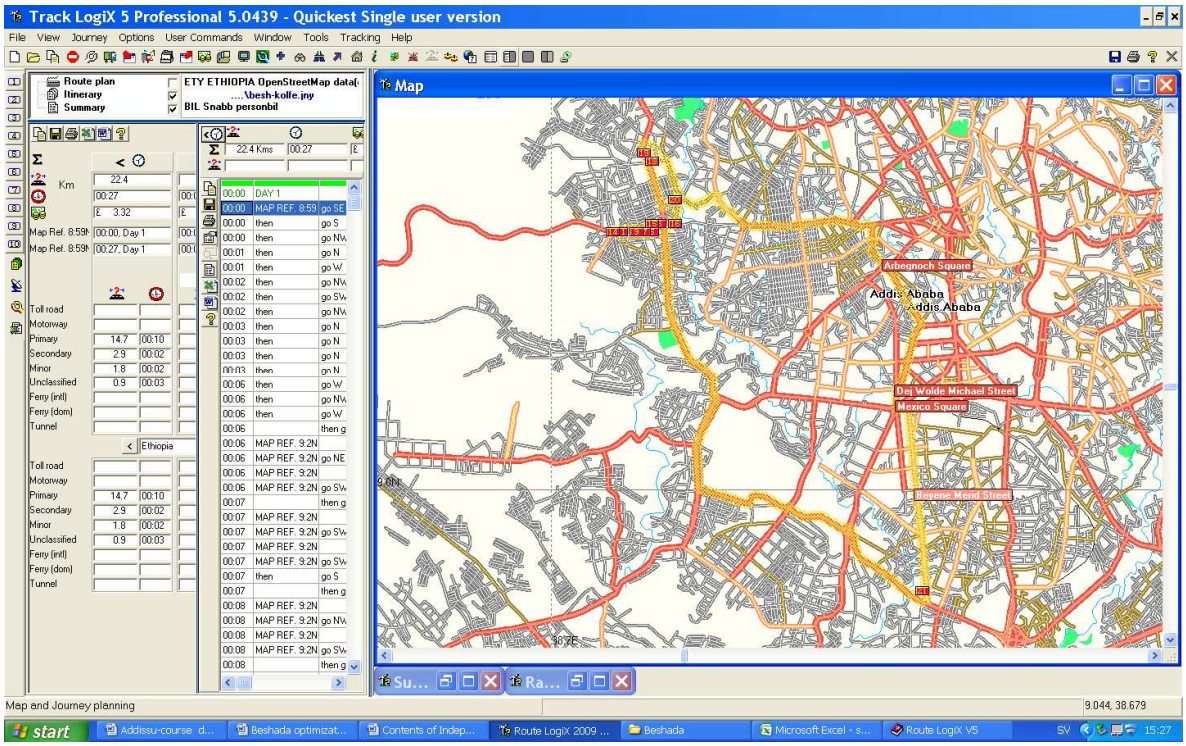
Bole route unoptimised



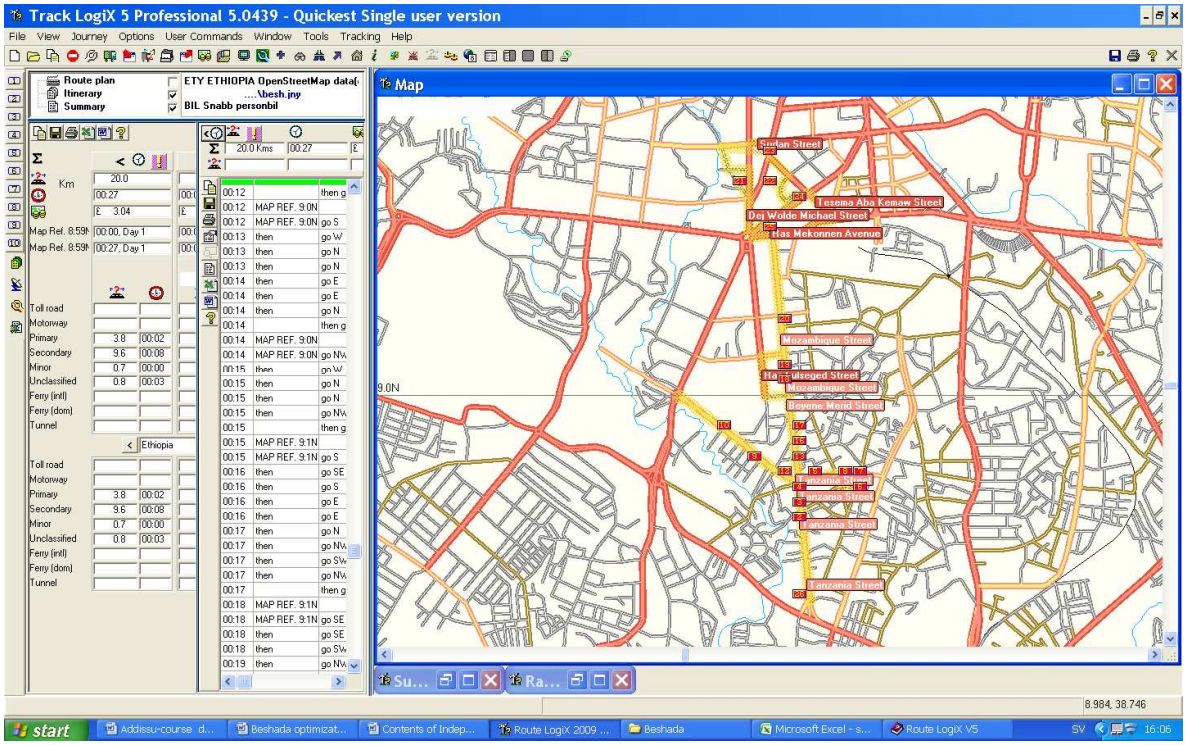
Bole route optimised



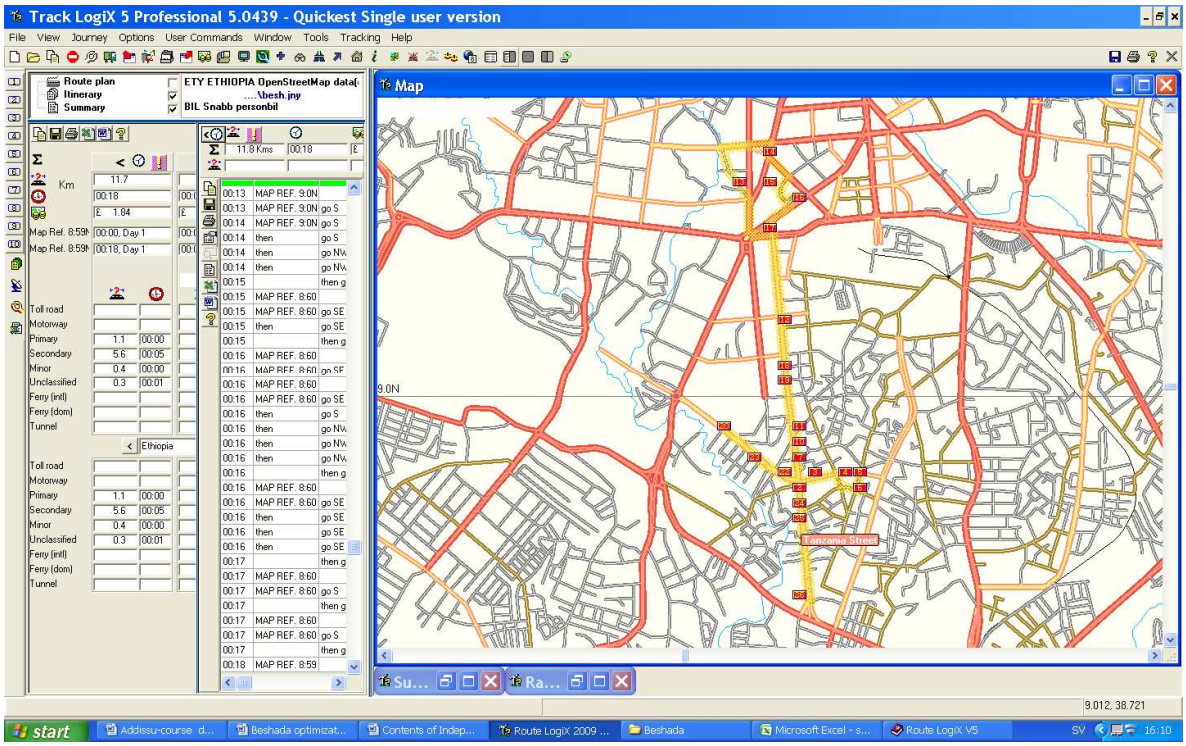
Kolfe route unoptimised



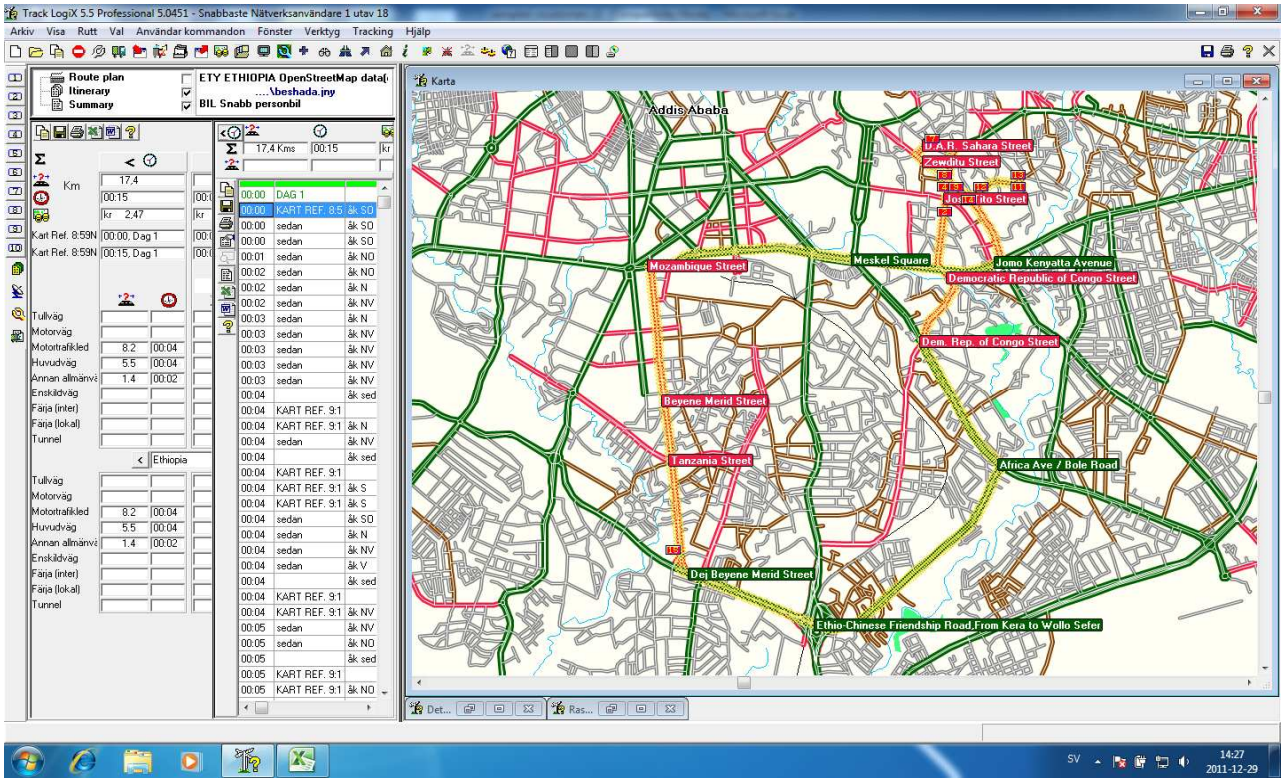
Kolfe route optimised



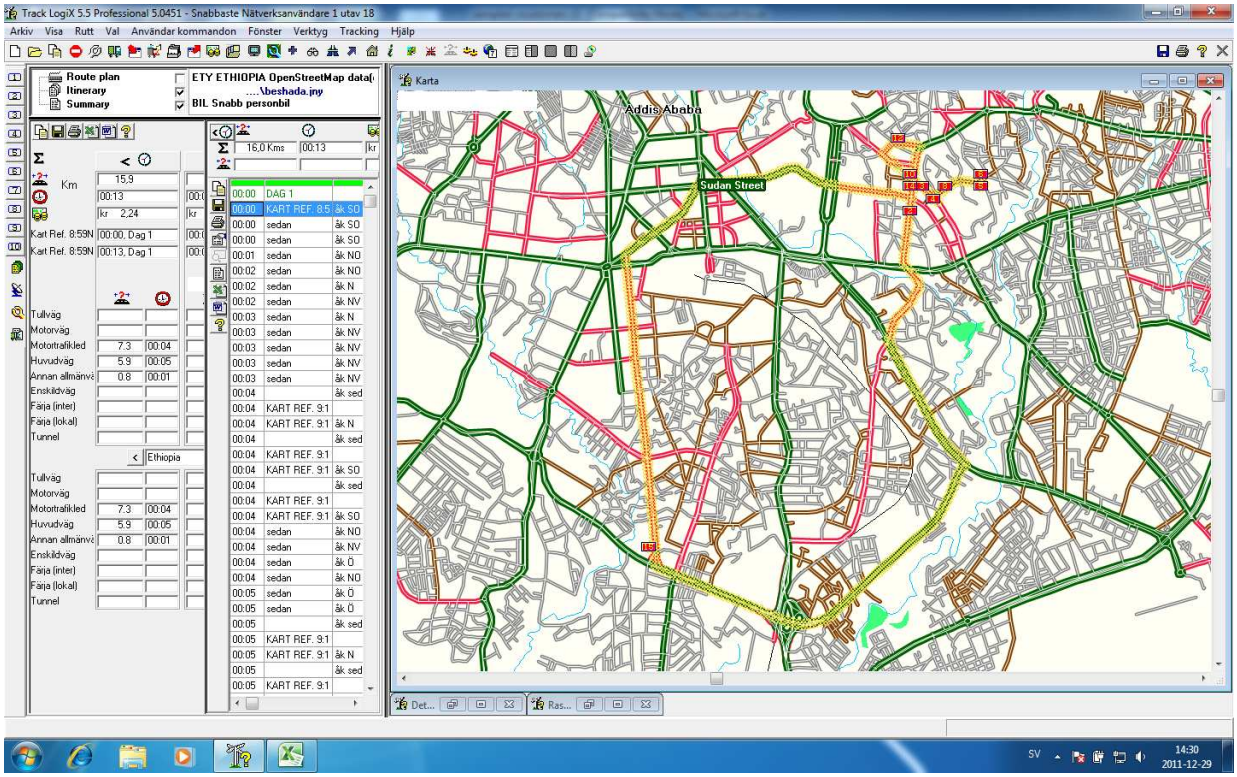
Teklaymanot route unoptimised



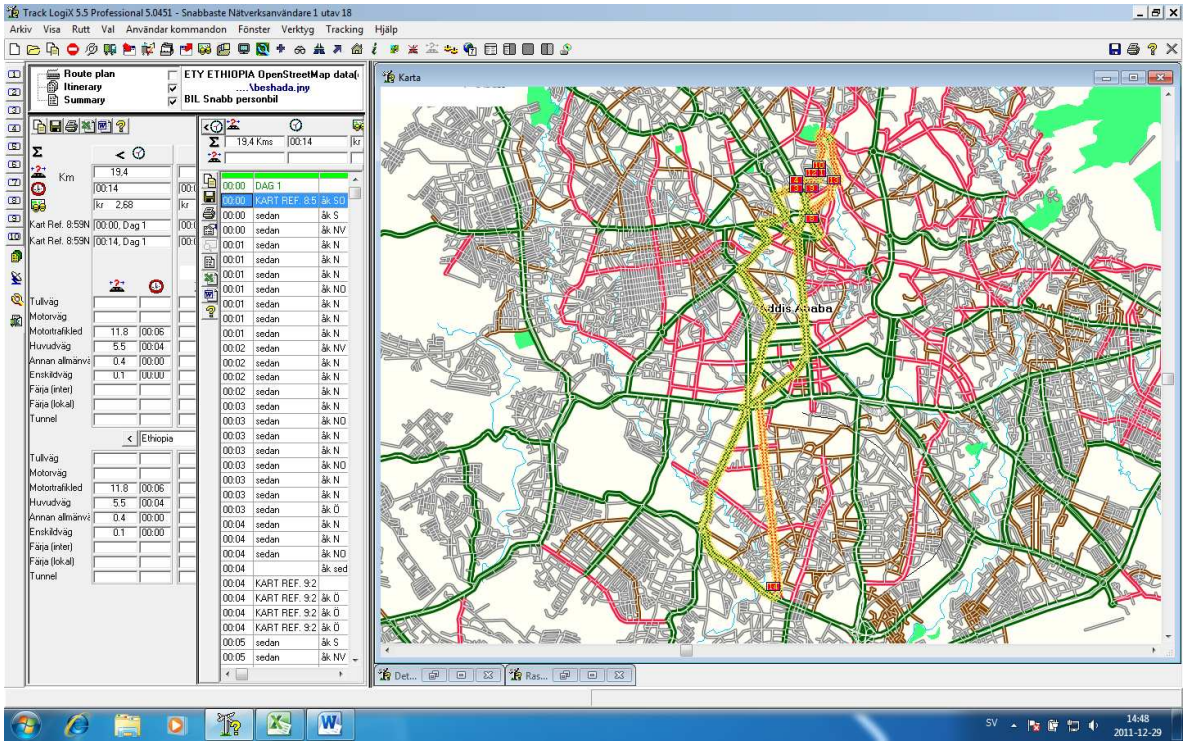
Teklaymanot route optimized



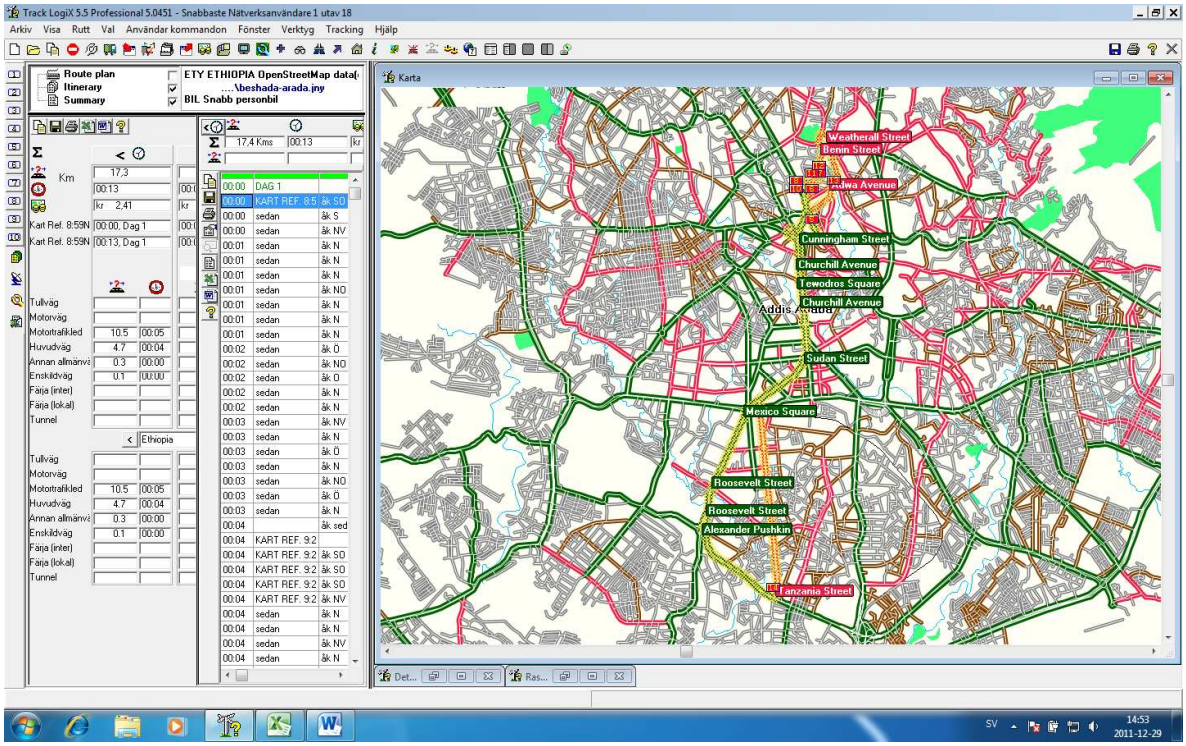
Kebena route-unoptimised



Kebena route optimised



Arada route-unoptimised



Arada route-optimised

APPENDIX -J LOCATION ANALYSIS FOR LIVESTOCK MARKET CENTERS AND ABATTOIRS USING FACTOR RATING METHOD

Gate Name	Market/Abattoirs	Coordinates for Alternative Sites					
		Site 1		Site 2		Site 3	
		X	Y	X	Y	X	Y
Dessie Gate	Market	485576.35	1000833.44	486118.88	1000865.24	485727.90	999964.09
	Abattoir	485419.72	1000180.54	486038.66	1000669.05	485723.94	999730.73
Gojam Gate	Market	470973.04	1002283.51	471100.10	1003127.99	470200.23	1003506.80
	Abattoir	470755.91	1002014.60	471259.20	1002914.20	470342.01	1003484.77
Ambo Gate	Market	466485.42	1002341.12	465880.67	1002162.79	466053.28	1002715.83
	Abattoir	466528.52	1002216.04	465957.96	1002080.45	466205.37	1002671.37
Jimma Gate	Market	465540.92	989183.21	464170.62	991395.40	463883.47	990809.59
	Abattoir	465669.84	989029.00	464120.98	991197.07	463920.89	990562.86
Akaki Gate	Market	476427.96	980775.44	476753.65	79679.40	477685.38	978830.59
	Abattoir	476350.61	980331.66	476954.80	979390.90	477887.24	978654.93

Location Factor Rating for Livestock Market on Dessie Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	85	90
Land Use	0.2	65	70	80
Proximity to Customers	0.15	75	80	70
Effect on Traffic	0.15	70	65	75
Labour Availability	0.1	65	70	85
Proximity to Suppliers	0.1	75	70	80

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	25.5	27
Land Use	13	14	16
Proximity to Customers	11.25	12	10.5
Effect on Traffic	10.5	9.75	11.25
Labour Availability	6.5	7	8.5
Proximity to Suppliers	7.5	7	8
Total Scores	69.75	75.25	**81.25**

Site 3 has the highest factor rating compared with the other locations

Location Factor Rating for Abattoirs on Dessie Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	85	80
Land Use	0.2	65	70	85
Proximity to Customers	0.15	75	80	70
Effect on Traffic	0.15	70	65	75
Labour Availability	0.1	65	70	85
Proximity to Suppliers	0.1	75	70	80

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	25.5	24
Land Use	13	14	17
Proximity to Customers	11.25	12	10.5
Effect on Traffic	10.5	9.75	11.25
Labour Availability	6.5	7	8.5
Proximity to Suppliers	7.5	7	8
Total Scores	69.75	75.25	**79.25**

Site 3 has the highest factor rating compared with the other locations

Location Factor Rating for Livestock Market on Gojam Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	80	90	85
Land Use	0.2	75	80	65
Proximity to Customers	0.15	65	75	70
Effect on Traffic	0.15	65	70	60
Labour Availability	0.1	70	80	75
Proximity to Suppliers	0.1	75	90	85

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	24	27	25.5
Land Use	15	16	13
Proximity to Customers	9.75	11.25	10.5
Effect on Traffic	9.75	10.5	9
Labour Availability	7	8	7.5
Proximity to Suppliers	7.5	9	8.5
Total Scores	73	**81.75**	74

Site 2 has the highest factor rating compared with the other locations

Location Factor Rating for Abattoirs on Gojam Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	80	90	85
Land Use	0.2	75	75	65
Proximity to Customers	0.15	65	85	70
Effect on Traffic	0.15	65	70	60
Labour Availability	0.1	70	80	75
Proximity to Suppliers	0.1	75	85	70

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	24	27	25.5
Land Use	15	15	13
Proximity to Customers	9.75	12.75	10.5
Effect on Traffic	9.75	10.5	9
Labour Availability	7	8	7.5
Proximity to Suppliers	7.5	8.5	7
Total Scores	73	**81.75**	72.5

Site 2 has the highest factor rating compared with the other locations

Location Factor Rating for Livestock Market on Ambo Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	80	95
Land Use	0.2	65	75	85
Proximity to Customers	0.15	75	85	90
Effect on Traffic	0.15	70	65	75
Labour Availability	0.1	65	70	85
Proximity to Suppliers	0.1	75	70	80

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	24	28.5
Land Use	13	15	17
Proximity to Customers	11.25	12.75	13.5
Effect on Traffic	10.5	9.75	11.25
Labour Availability	6.5	7	8.5
Proximity to Suppliers	7.5	7	8
Total Scores	69.75	75.5	**86.75**

Site 3 has the highest factor rating compared with the other locations

Location Factor Rating for Abattoirs on Ambo Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	85	80
Land Use	0.2	65	70	85
Proximity to Customers	0.15	75	80	70
Effect on Traffic	0.15	70	65	70
Labour Availability	0.1	65	70	85
Proximity to Suppliers	0.1	75	75	85

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	25.5	24
Land Use	13	14	17
Proximity to Customers	11.25	12	10.5
Effect on Traffic	10.5	9.75	10.5
Labour Availability	6.5	7	8.5
Proximity to Suppliers	7.5	7.5	8.5
Total Scores	69.75	75.75	**79**

Site 3 has the highest factor rating compared with the other locations

Location Factor Rating for Livestock Market on Jimma Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	85	90
Land Use	0.2	65	70	95
Proximity to Customers	0.15	75	80	70
Effect on Traffic	0.15	70	75	80
Labour Availability	0.1	65	80	90
Proximity to Suppliers	0.1	75	70	65

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	25.5	27
Land Use	13	14	19
Proximity to Customers	11.25	12	10.5
Effect on Traffic	10.5	11.25	12
Labour Availability	6.5	8	9
Proximity to Suppliers	7.5	7	6.5
Total Scores	69.75	77.75	**84**

Site 3 has the highest factor rating compared with the other locations

Location Factor Rating for Abattoirs on Jimma Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	85	95
Land Use	0.2	65	70	85
Proximity to Customers	0.15	75	80	70
Effect on Traffic	0.15	70	65	75
Labour Availability	0.1	65	80	95
Proximity to Suppliers	0.1	75	70	65

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	25.5	28.5
Land Use	13	14	17
Proximity to Customers	11.25	12	10.5
Effect on Traffic	10.5	9.75	11.25
Labour Availability	6.5	8	9.5
Proximity to Suppliers	7.5	7	6.5
Total Scores	69.75	76.25	**83.25**

Site 3 has the highest factor rating compared with the other locations

Location Factor Rating for Livestock Market on Akaki Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	70	85	75
Land Use	0.2	65	85	90
Proximity to Customers	0.15	75	90	95
Effect on Traffic	0.15	70	65	75
Labour Availability	0.1	65	70	85
Proximity to Suppliers	0.1	75	70	80

Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	21	25.5	22.5
Land Use	13	17	18
Proximity to Customers	11.25	13.5	14.25
Effect on Traffic	10.5	9.75	11.25
Labour Availability	6.5	7	8.5
Proximity to Suppliers	7.5	7	8
Total Scores	69.75	79.75	**82.5**

Site3 has the highest factor rating compared with the other locations

Location Factor Rating for Abattoirs on Akaki Gate

Location Factors	Weight	Scores(0 to 100)		
		Site 1	Site 2	Site 3
Effect on Environment	0.3	75	85	80
Land Use	0.2	65	75	90
Proximity to Customers	0.15	75	80	85
Effect on Traffic	0.15	70	65	75
Labour Availability	0.1	65	70	85
Proximity to Suppliers	0.1	75	80	90

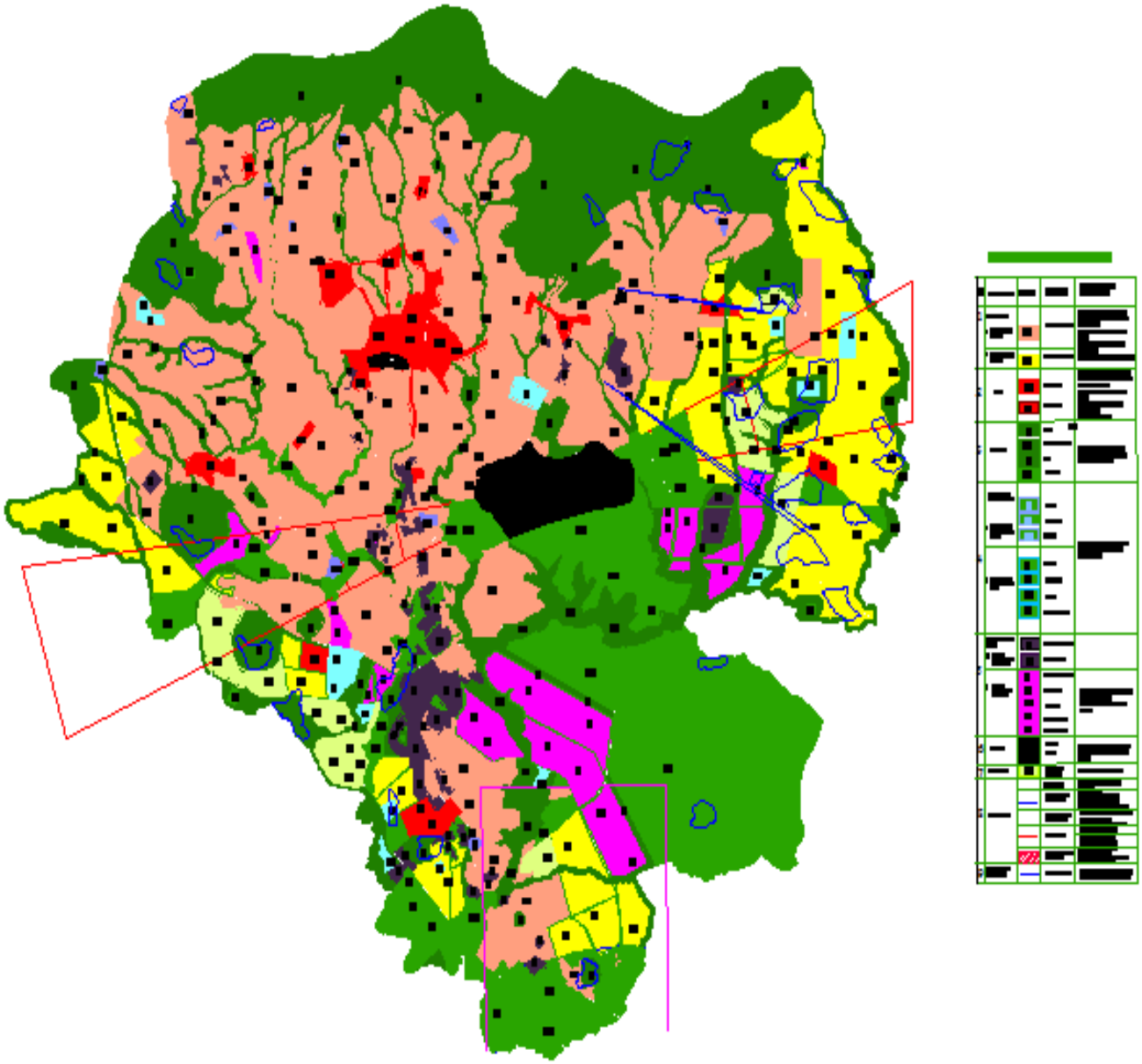
Location Factors	Weighted Scores		
	Site 1	Site 2	Site 3
Effect on Environment	22.5	25.5	24
Land Use	13	15	18
Proximity to Customers	11.25	12	12.75
Effect on Traffic	10.5	9.75	11.25
Labour Availability	6.5	7	8.5
Proximity to Suppliers	7.5	8	9
Total Scores	71.25	77.25	**83.5**

Site 3 has the highest factor rating compared with the other locations

APPENDIX-K DIGITIZED MAP OF ADDIS ABABA CITY

a). Road network map

b). Land use map



c). Centrality map