Proceedings of the 1st National Conference on

INNOVATIONS AND CHALLENGES IN ENGINEERING AND TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT (ICET2019)

HELD AT

ARBA MINCH UNIVERSITY

ARBA MINCH INSTITUTE OF TECHNOLOGY

APRIL 12-13, 2019

ARBA MINCH, ETHIOPIA

June, 2019

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Sponsored by

Conference proceedings: Vol. 01

Published by Arba Minch University

This conference proceedings publication is produced as a part of the 1st national conference on Innovations and Challenges in Engineering and Technology for Sustainable Development held at Arba Minch University, Ethiopia from April 12-13, 2019. The editors express their gratitude to the members of the organizing committee, reviewers, secretaries and audiences of the conference.

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ABOUT THE CONFERENCE (ICET-2019)

The 1ST National Conference on Innovations and Challenges in Engineering and Technology for Sustainable Development (ICET-2019) organizes to provide a platform to researchers, engineers, and academicians to showcase or present their original research and industrial papers on the theory, design, and implementation of the innovations and challenges in emerging trends of engineering and technologies for sustainable development. Furthermore, it enables the researchers in the various domains to foster the exchange of concepts, prototypes, research ideas and the results of research work which could contributes to the academic arena and also benefits business and industrial community. The ICET-2019 invites original contributions in engineering and related technologies.

FOREWORD

Arba Minch Institute of Technology organizes a national conference, the first of its kind, on Innovations and Challenges in Engineering and Technology for Sustainable Development, ICET-2019. The objective of this conference is to create a forum for researchers, professionals from all fields of Engineering and Technology along with practitioners and decision-makers to come together and share their experiences and knowledge. It is also aimed to disseminate the scientific research results not limited to but towards the advancement of Ethiopian Engineering and Technology sectors by presenting papers, displaying research-oriented products and technology services. The organizing committee received more than 40 papers in four thematic areas. After a blind review process under publication committee moderation, 14 papers were selected for oral presentation and 4 papers for poster display. This conference proceedings contain the full contents of 7 selected papers from ICET-2019 conference. I believe that the research results covered and presented in these papers will be useful and significantly important references for the readers and researchers' community. On behalf of the organizing committee and myself, I express my gratitude to all the researchers, reviewers, editors, organizing committee members and facilitators from different offices of the University who supported and contributed to making this conference mega success.

Muluneh Lemma, PhD

Director, AMiT Research and Community Services Directorate

WELCOME MESSAGE

Distinguished guests, respected colleagues, ladies and gentlemen,

On behalf of the organizing committee, the hosting institution, AMiT, it is my great pleasure to welcome you to Arba Minch University, Arba Minch Institute of Technology, for the first national conference on Innovations and Challenges in Engineering and Technology for Sustainable Development, ICET-2019.

The inception of this conference was initiated due to the restructuring of the former Arba Minch Institute of Technology into the two institutes, Arba Minch Technology Institute, AMiT, and Arba Minch Water Technology Institute, AWTI. With the new restructuring and responsibilities of each institute towards achieving the prime mission of the university, problem-solving research engagement, and focused research areas must be identified based on field of studies in each institute. Our institute, AMiT, has five faculties: Faculty of Architecture and Urban Planning, Faculty of Computing and Software Engineering, Faculty of Civil Engineering, Faculty of Electrical and Computer Engineering and Faculty of Mechanical and Production Engineering. It is composed of more than 5000 students, being served by more than 300 academic staffs and about 500 administrative staffs. Therefore, it is imperative to know the potential capacity of the institute in engaging local staffs, expatriates and professionals from different universities to come together and deliver or showcase their research findings. Currently three thematic areas are being considered at the institute, with more emphasis is given for multidisciplinary research undertakings. With the above rationale, our first national conference is launched. The fourth thematic area considered in our conference is a theme from renewable energy research center. With the launching of AMiT conference, it is believed to specifically address and contribute what is lacking in terms of problem-solving research ideas by Engineering and Technology professionals.

Ladies and gentlemen, we are very proud to have the opportunity of organizing this national conference. We shall do the level best to ensure the success and continuity of this conference. We also aspire to make this national conference to be an international conference in the near future. I wish you many interesting and fruitful scholarly discussions. I do believe that our distinguished guest's speech, and paper presenter's talk will be grasped with great interest by all participants. Last, but not the least, I also wish you a pleasant stay in Arba Minch, our beautiful tourist city with outstanding sceneries known also as "a city of 40 springs".

Alemayehu Chufamo, PhD
Scientific Director, AMiT

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Design and Development of Solar Powered Three Wheeler Car

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Abstract

Environmental pollution and global warming due to the exhaust gases from internal combustion engine has become a global issue that forced automotive industries to develop emission free vehicles or pure electric vehicles. Since the purpose of this work was to develop a prototype of solar electric vehicle, a Bajaj three wheeler (Indian made auto rickshaw) vehicle was modified and changed to solar electric vehicle. The modified solar electric vehicles consists of four solar panels, four charge controllers, four batteries, dc motor controllers, 48v 1500W dc motor, throttle/accelerator, modified differential gearbox and reverse gear assembly and other vehicle basic systems (steering, suspension, brake systems, etc). In this paper, dynamic system parameters like the vehicle speed, torque and power characteristics, parameters of battery, maximum endurance mileage etc, were reasonably determined with a numerical analysis to know the performance of electric vehicle. The result shows that with the gross vehicle weight of 381kg and if the battery is fully charged, the modified solar powered vehicle can run up to 34km per day which is endurance mileage (distance drive range) using 48V 26Ah battery pack at a maximum speed of 30km/hr at level road. The result is very promising and more attention has to be given for the implementation of solar powered commercial vehicles from the government side.

Keywords: *Solar car, Bajaj, solar panel, gear box, battery, DC motor, mileage*

1. Introduction

Transport is one of the largest sources of human induced greenhouse gas emissions and fossil-fuels consumption [1]. Air pollutants from an automobile contribute to not only regional environmental problems such as human-health effects but global environmental issues like climate change due to CO2 emissions]. Thus, the ideal future transport should be directed towards to the use of the zero-emission, no pollution, electric vehicle and/or fuel-cell vehicle, which uses alternative fuel [2]. With ever increasing concerns over environmental protection, carbon emission, energy conservation and energy efficiency in recent years, research and development on various new energy electric vehicle (EV) technologies is being actively conducted [3].

Electricity has been explored as an alternative power source to replace or complement the internal combustion engine for decades. Nowadays, developed countries and big cities throughout the world are embarking on policies to encourage the research and use of EVs [4]. Solar cars depend on PV cells to convert sunlight into electricity to drive electric motors. As an alternative, a battery-powered electric vehicle uses a solar array to recharge the battery pack.

In recent years, greenhouse gas emissions and exhaustion of natural fossil resources have become serious global issue [5]. Energy supply security and global warming continue to challenge all countries around the world in terms of global economy and planet environment. Renewable energy technologies are being explored to meet the challenges of energy security and climate change, as well as to boost regional economic development [6].

Electric vehicles (EV) enabled by high-efficiency electric motors and controllers and powered by alternative energy sources provide the means for a clean, efficient, and environmentally friendly urban transportation system. Electric vehicles have no emission and having the potential to curb the pollution problem in an efficient way. Consequently, EVs are the only zero emission vehicles possible[7].

Thus, in this project, it is aimed to design and develop as solar powered three wheeler car that is fully driven by electric energy with onboard solar charging. The required equipment like solar panels, electric motors and other

necessary materials are selected and the dynamic analysis of the prototype is performed by plotting the torque and power characteristics to know the performance of the vehicle.

The project has the following significances

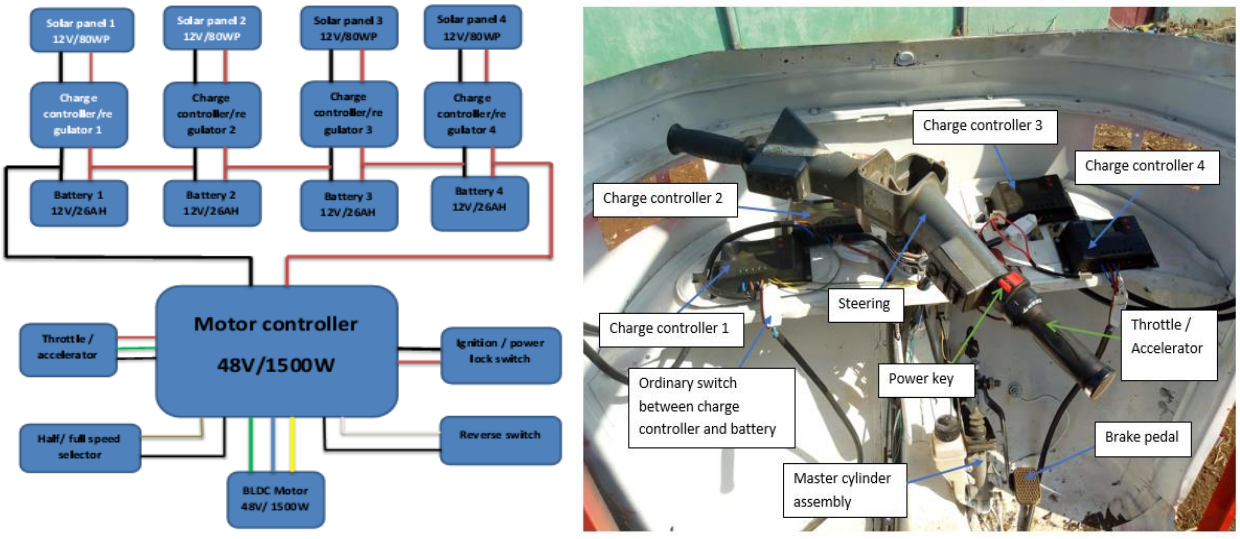
- ✓ Reduce carbon dioxide emission
- ✓ Eliminate fuel consumption
- ✓ Reduces money incurred for fuel
- ✓ Promotes environmentally friendly urban transportation
- ✓ Contributes to the reduction of environmental pollutants

2. Electrical System Components

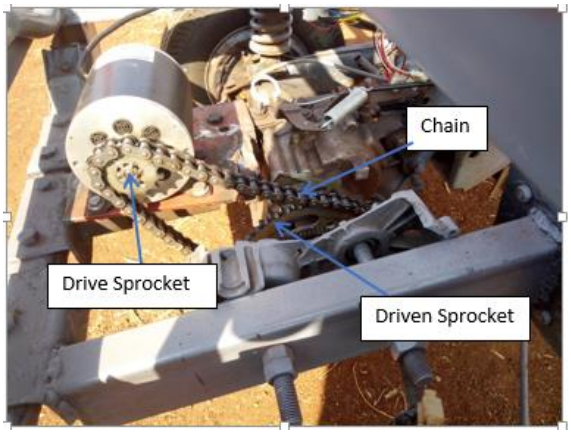
The solar electric vehicle is made of solar panels, charge controllers, batteries, dc motor controllers, dc motor, throttle/accelerator, and other basic systems. The overall electrical system of solar electric vehicle prototype is shown in following figure. The same drive system modification was also implemented by authors [8], [9]. Solar panel is placed at the top of the vehicle on iron frame. Four 80W, 12V panels are used and each are connected to the batteries through the charge controller. The charge controller is installed in the driver cabin which functions to protect the batteries from overcharging and to protect the panel from power going back into it from the batteries at night (assuming no blocking diode fitted). It also helps maintain battery condition by keeping the battery voltage high.

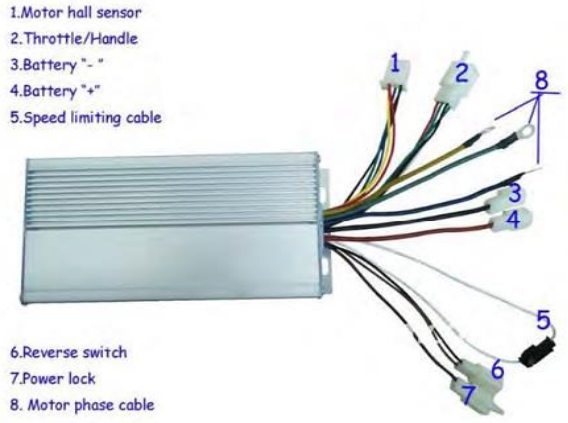
Four 12V, 26Ah rechargeable lead-acid batteries are placed under the driver seats. They are connected in series to supply 48 Volts to the BLDC motor Figure 1(a). The BLDC motor uses throttle to control the speed of the motor. A throttle shown in Figure 1(b) below is a specially designed potentiometer. The motor speed increases as the output voltage increases. A power key Figure 1(b) was used to turn the whole system 'on' or 'off' manually in the system. As shown from the figure ordinary switch is installed in between charge controller and battery positive terminal. The battery gets charge or electricity from solar panel at day time whenever there is sun and can also be charged from grid AC power by battery charger which changes 220V AC power to 48V, 2Amper DC power. The switch is installed to protect a back current from battery to solar panel through charge controller when charged from grid (AC power) by battery charger.

The motor controller shall be capable of controlling the motor from start to maximum speed with no load to full load [10]. A 5600 rpm rated brushless DC motor Figure 1(c) of 48V, 1500W; 31.25A is used in the system. It is attached with the gear box support frame which drives the sprocket on input shaft by chain as shown in Fig below.



a) b)





c) d)

Figure-1. Electric system of solar powered vehicle (a) connection of electrical components (b) charge controllers, throttles/accelerators in the driver cabin (c) dc motor with chain drive (d) dc motor controller

The electric power train system of an electric vehicle is combination of the electric motor, controller and the storage devices like battery. The batteries deliver the power to the motor via power controller. The accelerator knob is coupled to a pair of potentiometers (variable resistors). This provides the signal to the controller estimating the power to be delivered for the particular load condition. By varying the accelerator knob, the controller can deliver zero to full power or any power level in between to the motor. The vehicle is at rest when the controller delivers zero power and the vehicle is at full speed when the accelerator knob is fully raised. By varying the battery voltage with the application of semiconductor, devices variable power can be applied to the EV Motor. Electrical Propulsion System of an Electric three wheeler is shown in Fig. 1.

3. Mechanical System Modification

There are two basic methods for producing EV's—either convert or build for purpose. For the conversion method, the engine and associated equipment of an existing vehicle are replaced by the electric motor, controller, and batteries. This offers some economy because the whole vehicle is already there and the purchase price is quite low. However, in most conversions, the resulting EV has a greater curb weight and may have a higher center of gravity and/or other weight distribution differences that can affect handling. Purpose-built or ground-up EV's have more advantages than conversions. In designing an EV from the ground up, the engineers have the opportunity to integrate various components so that they work most efficiently together [11].

In Ethiopia, the first solar electric vehicle prototype was developed by Mr. Tewodros Fantahun and his colleague's in Ministry of Science and Technology in 2017. The vehicle did not have differential that the dc motor drives only one of the rear wheels. There is also a Swedish citizen called Mr. Svante living in Addis Ababa, has developed a prototype of electric vehicles that has the same drive system with made by Mr. Tewodros Fantahun and his colleague's. However the electric vehicles being produced in china are equipped with a dc motor integrated in the differential gearbox. If the dc motor drives only one wheel, the vehicle would be unstable when it is driven at high speed. Every vehicle should have differential gearbox to provide the necessary torque and power to both rear wheels. In this research the Bajaj transmission gearbox has been modified to use differential with axle and revers gears for the intended system.

a. b.

Figure-2. Dc motor drives only one wheel of vehicle a) electric vehicle developed in the ministry of science and technology by Mr. Tewodros and his colleagues, b) electric vehicle developed by Mr. svante. [12]

Since the aim of this work was to develop prototype of solar electric vehicle in Mettu University, a Bajaj three wheeler (Indian made auto rickshaw) vehicle has been modified and changed to solar electric vehicle.

To change fuel powered vehicle in to solar electric vehicle; the engine, four speed gearbox, clutch system, intake system, exhaust system, fuel system (fuel tank) and electric system like ignition system has to be removed. However there are some basic systems that every vehicle should have such as suspension system, steering system, brake system, body and frame, power transmission system and wheel and tire. These aforementioned basic systems are available in the outdated Bajaj. The reason why outdated Bajaj is preferred to convert and develop proto type is that it would be very cheap as compared to a new vehicle.

While modifying the power transmission system, the driven sprocket is welded on the transmission gearbox output shaft or differential input shaft which receives and transfers drive from the DC motor with a chain drive to the differential gearbox and then axle.

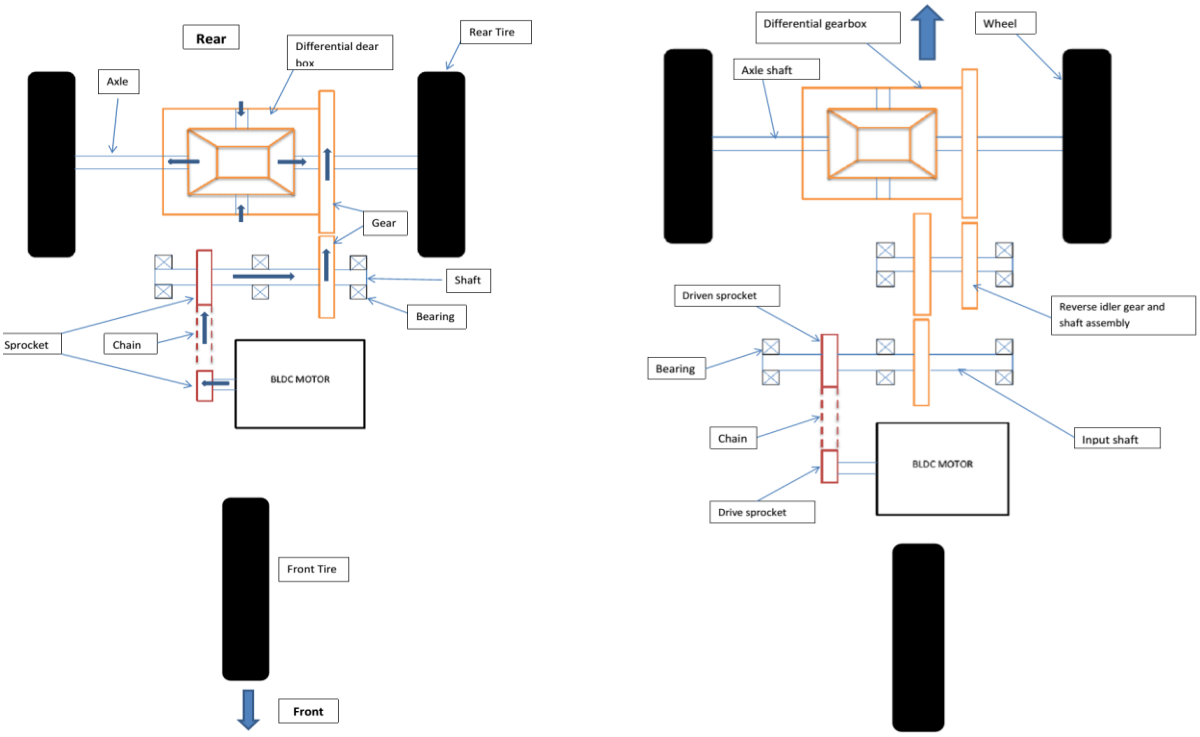
a) b)

Figure-3. Bajaj structure a) before modification b) after modification

As stated before the engine and gearbox arrangement was not suitable to directly couple with Dc motor. The engine and four speed gearbox were removed and we utilized the differential gearbox and reverse system. For the vehicle to

turn curved roads smoothly, differential gearbox is very essential to vary the speed of inner and outer (subtracting some speed from the inner wheel and adding that reduced speed to outer wheels) wheels in addition to splitting power to the right and left wheel.

The power system of solar electric vehicle designed in this paper contains motor, battery, mechanical driving device and control system. The structure diagram of vehicle power system is shown in Figure below.



a. b.

Figure-4. Power flow from dc motor to wheel through differential gearbox and axle: a) Forward movement b) Reverse movement

Figure-5. The modified solar three wheeler car

4. Primary Design

Primarily the required torque and power capacity of dc motor was determined based on some assumptions of taking the average weight of one person 80kg, kerb weight of bajaj 407 kg by considering 48volt 100Ah battery pack, pay load capacity which is driver and four passengers equals to 400kg and the gross vehicle weight becomes 807kg, the maximum climbing capacity of 10o sloped road and maximum speed of 45 km/hr. Thus, the motor capacity was calculated by the resistance forces (aerodynamic, rolling and gradient resistances) against the movement of vehicle.

The torque from the motor is amplified or increased by using a driven sprocket larger than the drive sprocket [12]. The driven sprocket is installed on the input shaft of differential gear box and the drive sprocket is installed on the dc motor output shaft.

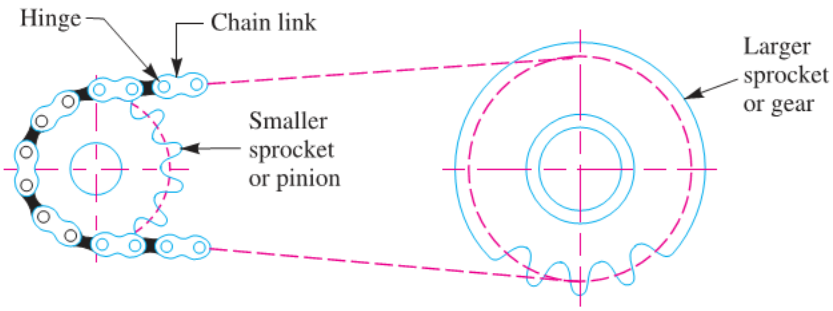


Figure 6. Chain drive system [13]

The number of teeth on drive and driven sprocket is 11 and 38 respectively. The torque amplification factor is the ratio of driven to drive sprocket which is 3.45. The differential gearbox has a purpose of reduction or torque amplification by 4.125 which is obtained from the Indian made auto rickshaw or Bajaj manual.

where $Rs = \frac{No.of\ teeth\ of\ driven\ sprecket}{No.of\ teeth\ of\ drive\ sprecket}$ (1)

$= \frac{38}{11} = 3.45$

Tractive resistance on sloped roads [8] to know the maximum torque requirements is

Frq = Fair + Frl + Fgr

$= (0.5 \cdot \rho_{air} \cdot A \cdot Cd \cdot V^2) + (\mu rl * m * g * \cos ø) + (m*g*\sin ø)$ (2)

Frq = 1615.57N at sloped road

Tw max = Frq*rw (3)

where Tw max is resistant torque at the wheel and r_w is radius of tire. So, the maximum resistance torque at the wheel is 327.96Nm obtained using equation (3)

$$T_{w-max} = T_{m-max} \times Rs \times R_F \times \eta_s \times \eta_F \quad (4)$$

Tm max= 40Nm is the minimum torque that should be provided by the dc motor.

Tractive resistance force determined when the vehicle is running on level road using equation (2) is 240.86N and the resistance power at the drive wheel 3010.75Watt is also obtained from equation (5)

Pw max = Frq*Vmax

where Pw max is resistant power at the wheel

$$P_{w-max} = P_{m-max} \times \eta_s \times \eta_F \quad (5)$$

$P_{m\ max}$ = 5500Watt is the minimum power that should be provided by dc motor. So, the required dc motor capacity to drive this solar car is 40Nm torque and 5500watt power.

where, ρair **= 1.05kg/m3,** A= 2.09m2, Cd=0.5, V=45km/hr, r_w=203mm

The drive range was also calculated by 48volt, 48Ah battery pack

$$C = \frac{Pm*S}{Ub*dod*Vmax} \quad (6)$$

where S is endurance mileage or drive range in km, Pm is the input power of the motor controller (1500W), C is the battery capacity meets the mileage (26Ah), Ub is the average working voltage of the battery (48V), and dod is depth of discharge of the battery.

Once the battery is fully charged, the solar car runs from 50 to 60km per day which is calculated using equation (6). However, in Ethiopian local market 40Nm and 5500watt rated power is not available. So, the actual or real vehicle performance is evaluated and analyzed by using 3.5 Nm, 1500watt rated motor and 48 volt, 26 Ah battery pack.

5. Analysis and Result

The kerb weight of old Bajaj vehicle powered by IC engine was 295 kg. When this vehicle was converted to solar powered electric vehicle, some of the components which equated to 128kg were removed. They include engine, battery, five speed transmission gearbox, fuel tank, bodies and other engine related components weighing 35kg, 10kg, 8kg, 10kg, 55kg and 10kg respectively. After the aforementioned components were removed, necessary components for solar electric vehicles which equated to 143.6kg were added. These components are brushless dc motor, batteries, solar panels, supporting metal frames (for batteries holder, solar panel, motor and differential gearbox) weighing 3.6kg, 32kg, 28kg and 80 kg respectively.

Finally, the kerb weight of solar electric vehicle becomes 311kg. The gross vehicle weight of the solar car is the kerb weight plus its payload capacity of average weight of one passenger or driver 70kg is total of 381kg.

In this research the numerical analysis is performed to determine the performance of the vehicle such as load carrying capacity, maximum speed, gradeability and drive range which depends on the capacity of electric motor, capacity of battery pack and overall mass of the vehicle, including the propulsion unit, all mechanical and electrical components, and the batteries.

5.1 The Motor Rated and Peak Power Matching

The selection of drive motor rated speed and maximum speed should conform to the requirements of the torque speed characteristic of the motor[14]. When the car starts, the motor speed is low and works in constant torque state, as long as speed is higher than the rated speed, it works in constant power state [10], as shown in Figure 7. The motor used in this paper has Tmax=3.5Nm, Pmax=1500Watt, Nrated=5300RPM, Nmax=5600RPM.

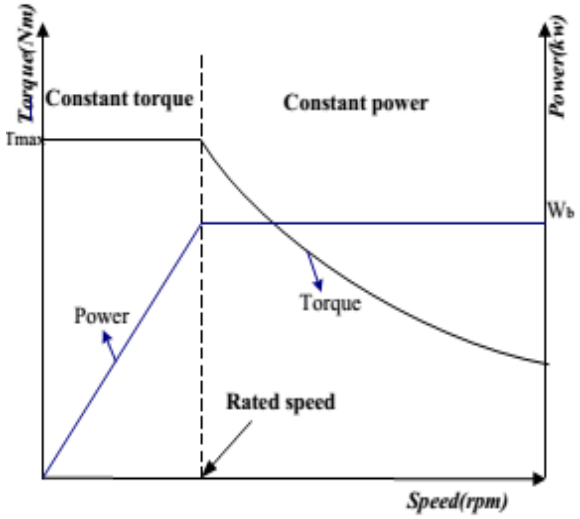


Figure-7. Drive Motor Torque Characteristics [15]

5.2 Force of tractive effort

The force of tractive effort can be described as a function of radius (r) tire and the vehicle electric motor torque (Tm). First the relations of the motor's torque and wheel's torque (Tw) needs to be defined using equation (4):

The Maximum Torque at the driving wheels ($T_{w\text{-}max}$) depends on: the maximum Dc motor torque ($T_{m\text{-}max}$), the Ratios of sprocket (R_s) and the final drive (R_F = 4.125) and the efficiencies of the sprocket (η_s) and the final drive (η_F).

The maximum torque available at the drive wheel which is supplied by the specified electric dc motor is 31.75Nm. The Maximum Power available at the driving wheels ($P_{w\text{-}max}$) depends on the maximum motor power ($P_{m\text{-}max}$), the efficiencies of the gearbox (η_s=75%) and the final drive (η_F=85%).

The maximum power P_{max} available at the drive wheel which is supplied by the specified electric dc motor is 956.25Wat.

5.3 Driving (Tractive) resistance

Driving resistance or road load is important for the calculation involving the driving force of the solar vehicle [10]. Driving resistance (Frq) consists of rolling resistance force (Frl), aerodynamic drag force (Fad), and gradient resistance force (Fgr).

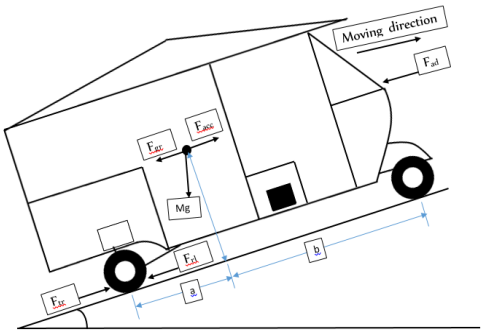


Figure-8. Forces acting on the vehicle ϕ

a) Force of aerodynamic drag

The air drag is a resistance force that air exerts on the solar car. It is called the force of aerodynamic drag Fad. F_{ad} is proportional to the vehicles squared velocity υ^2, and depends on the air density ρ_{air}, the front area A of the solar car and the drag coefficient Cd [15]. The following equation [10] expresses the force of aerodynamic drag: $\mathbf{Fad = 0.5 \cdot \rho_{air} \cdot A \cdot Cd \cdot \upsilon^2}$, the air density varies with temperature, pressure and humidity. In this report the value of air density where it is given a value of $\rho_{air} = 1.20[kg/m^3]$ at Normal Temperature and Pressure (NTP).

b) Force of rolling resistance

The force acting on the moving moped caused by the tires rolling resistance is called the force of rolling resistance. The rolling resistance depends on the road surface, tire pressure, width, diameter and construction. The resistance is caused by the deformation and slipping of the tire over the surface. $\mathbf{F_{rl} = \mu_{rl} * m * g * \cos \phi}$

$F_{rl} = \mu_{rl} \times F_N$ where, F_N is the normal force at the driving wheels in 'N', μ_{rl} is the coefficient of friction.

where, m is mass of the vehicle in kg, g is gravitational acceleration in m/s^2, ϕ is an angle of inclination in degree

c) Gradient resistance

The gradient resistance Fgr must be added if the vehicle is not driving on a horizontal plane, but at an angle of ϕ. The force of incline plane when driving at the angle α is described as:

$F_{gr} = mg \times \sin\phi = W \times \sin\phi$ where, W is the weight of the vehicle in 'N', ϕ is the angle.of inclination

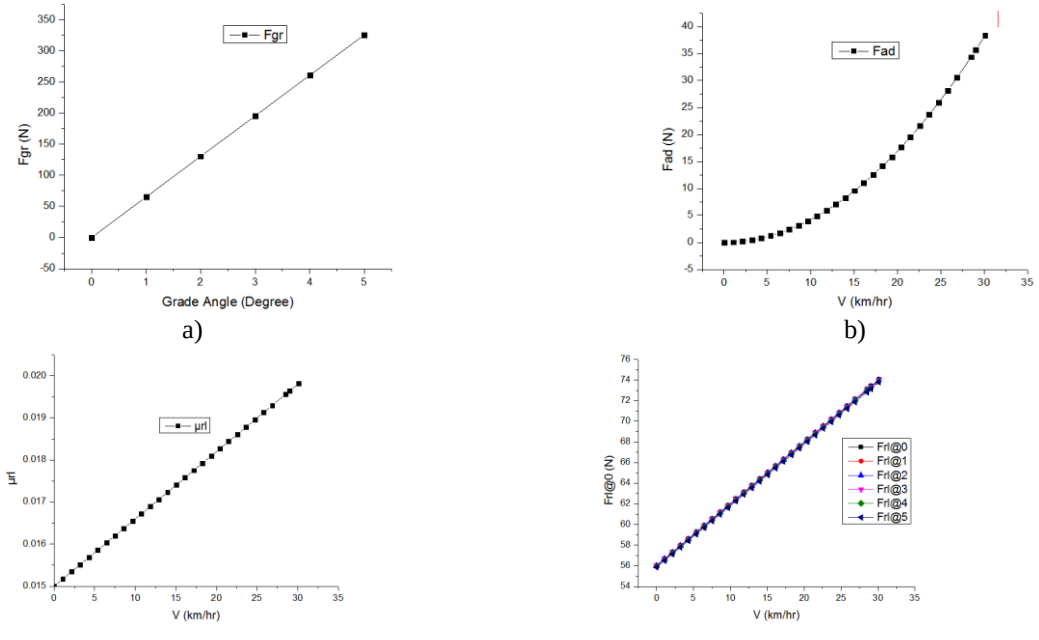


Figure-9. Shows a) Gradient resistance at different angle of slope, b) aerodynamic resistance at every speed, c) rolling coefficient at every speed, d) rolling resistance versus speed at different angle of slope

From the above Figure 9 (a) the magnitude of gradient resistance as a function of the degree of slope is determined from 0 to 5 degree and the result reveals that gradient resistance sharply increases with grade angle or slope regardless of the speed of the vehicle when driven on sloped roads. The magnitude of aerodynamic resistance force on the Figure 9 (b) is determined as a function of speed and increases parabolic ally with square of speed. As compared to other resistance forces, aerodynamic resistance force would be significant if the vehicle is driven at high speed. For this analysis, it is considered as a resistance force even if the vehicle is driven less than 30 km/hr its effect is less. On Figure 9 (c) the rolling coefficient is a function of speed with the empirical formula of $\mu rl = 0.015 + (0.00016 \times v)$ [14] so the magnitude of rolling resistance is determined as a function of speed that it increases with speed and reduces a bit when the gradient angle increases on Figure 9 (d), the reason is the normal force on wheel reduces with an increase in slope of the road.

c) Total Driving Resistance

The driving resistance of the vehicle from 0 to 5 deg slope as a function of vehicle speed is shown in Figure-5. The total driving resistance must therefore, be a sum of all forces caused by the factors above: Frq = Fad + Frl + Fgr, where, Fad = the force of aerodynamic drag [Nm], Frl = the force of rolling resistance [Nm], Fgr = the force of gradient resistance [Nm].

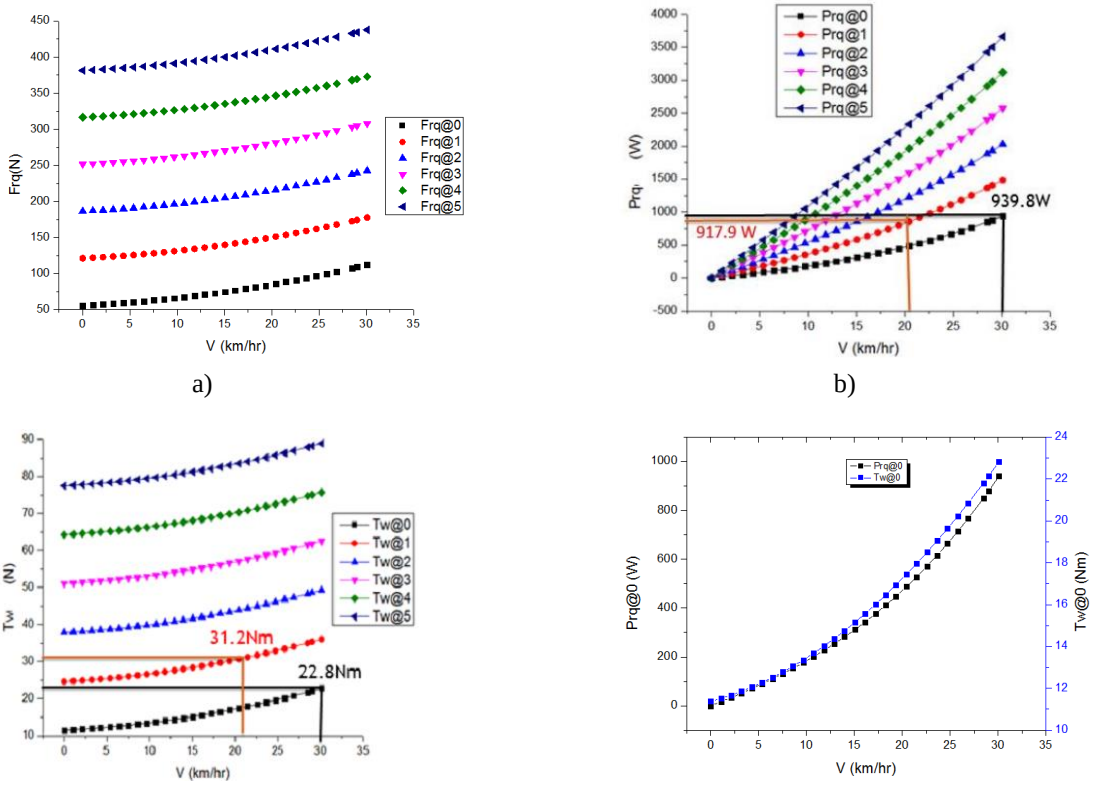


Figure-10 The effect of total tractive resistance forces a) the total required force vs speed at different angle 0 to 5 degree b) the total required power vs speed at different angle from 0 to 5 degree c) the total required torque vs speed at different angle 0 to 5 degree d) the total required torque and power vs speed at level road.

Previously on the figure 8 the effect of individual resistance forces in relation to the speed and degree of slope has been determined and discussed. When all resistance forces (aerodynamics, rolling and gradient resistance) come together and sum-up, the total resistance forces act against the direction of movements of the vehicle. To drive the vehicle the force, torque and power that come from the dc motor at the drive wheel (available power) have to be at least equal to the total resistance forces, torque and power (required power). The power and torque available at the road which is supplied from the dc motor has been determined 956.25 W, 31.75Nm respectively. The magnitude of maximum required or resistance power and torque when the vehicle is driven on a level road at 30 km/hr is 939.8W and 22.8Nm respectively. At gradient angle of 1 degree the vehicle would run at a maximum speed of 21.5 km/hr with the resistance or required power and torque of 917.9 W and 31.2Nm respectively. Again at gradient angle of 2 degree

the resistance or required power and torque is 927.6 W and 42.04Nm respectively. Here at 2 degree of gradient angle even if the required power is less than the available power, the required torque is highly greater than the available torque at the wheel from the dc motor. Thus to drive the vehicle on sloped roads torque is more essential than power, so the solar car cannot run on 2 degree and beyond. By installing more powerful motor, it is possible to increase the speed and climbing performance even on highly sloped roads.

6. Matching Power and Battery Parameters

The power source of the pure electric vehicle is battery pack. Therefore, the selection of battery parameters must meet the demand of endurance mileage requirements and maximum power of vehicle driving [16], [17]. Lead acid battery is selected as the power source for electric vehicles due to its long life and mass energy density. The nominal voltage of Lead acid battery on the market is 12 V 26 Ah and four batteries are connected in series, then the battery voltage level is Ub= 12 *4 = 48V. The maximum speed of the solar car at level road is 30km/hr and the maximum power obtained from the dc motor is 1500W. By using the following equation [10] the maximum endurance mileage or distance (s) that the vehicle can be driven once the 48V 26Ah battery pack is fully charged has been determined 17km. So, if the battery is fully charged, the vehicle can be driven in a range of 17km.

7. Charging with Solar Panel and AC Charger

This solar car can be charged either by solar panel or ac charger [6]. The solar panel we used has a power of 80 watt, nominal voltage 12V, and number of cells 36, maximum power voltage 18V and open circuit voltage 22V. The maximum output current of the solar panel can be calculated as maximum power divided by maximum power voltage equals to 4.4Amper. The charging time by the solar panel six (6) hour is calculated by dividing battery ampere hour over to charging current of the solar panel [6]. The charging time by 48V, 2Ampere ac charger thirteen (13) hour is a charging time throughout the whole night. If the battery pack is fully charged during night time with ac charger and sunny day with solar panel, the vehicle can be driven a drive range or distance or mileage of 34 km per day. By increasing the size of battery pack, it is possible to increase the drive range or mileage.

8. Conclusion

The aim of this project was to develop solar powered three wheeler car which is modified or converted from Indian made auto rickshaw or Bajaj. The developed solar car has chain drive system, differential gearbox and mechanical reverse system by modifying the Bajaj power transmission system. The numerical analysis shows that the solar car can run with a maximum speed of 30 km/hr. and load carrying capacity of one person on an average weight of 70 kg at level road and with this speed, it is possible to drive a distance of 34Km per day if the battery pack is fully charged with battery charger full night and with solar panel at day time. The unavailability of dc motor and its accessories in Ethiopian local market forced us to use less power dc motor, so the climbing capacity of the solar car is limited only with one degree of sloped road at a maximum speed of 21.5km/hr. By using more power full Dc motor we can increase the speed and climbing capacity of the solar car and also by increasing the size or ampere-hour capacity of the battery pack we can increase the mileage or drive range of the solar car. The developed solar car has the capacity of carrying two persons including the driver on level road but the maximum running speed would be less. The result is very promising so more attention has to be given for the implementation of solar powered commercial vehicles from the government side. Thus, the ideal future transport should be directed towards the use of the zero-emission, no pollution, electric vehicle which uses alternative fuel.

Acknowledgements

This work was financially supported by Mettu University.

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Performance Evaluation of Sensible Heat Energy Storage System for High Temperature Solar Application

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Abstract

It is the fact that uniform solar radiation is hardly available Hence, designing a Sensible Heat Energy Storage is found to be necessary to tackle the inconsistency and also to bridge the gap between energy supply and demand. The prime motive behind this investigation is to numerically investigate for a 50 MJ sensible heat storage unit in-order to store heat in the range between 525 and 650 K for high temperature solar power plant application. The developed sensible heat energy storage unit is a type of regenerative heat exchanger in which heat is stored when the hot fluid passed and released when cold fluid passed through the tubes. The developed model has cylindrical configuration with a number of embedded tubes and uses cast steel and concrete as the medium of storage. Based on charging time, the number of tubes required inside the energy storage bed for charging/discharging is optimized with the help of ®COMSOL Multiphysics 4.3a. The model created shows sound agreement with earlier published work.

Performances of the Thermal Energy Storage System have been evaluated using two different storage materials. They are based on charging and discharging time, rate of energy storage and discharge. The variation of axial temperature along the length of the storage bed is carried out by varying the charging/discharging time. The study is done by varying the flow rate of heat transfer fluid. The result revealed that increasing heat transfer fluid velocity causes the reduction of charging/ discharging period for cast steel bed but it is less for the concrete bed, due to low thermal conductivity.

Keywords: *Axial temperature; Heat transfer fluid; Sensible storage, Charging/Discharging time*

1. Introduction

Fossil fuel continues to be the main source of energy production across the world. Due to a number of reasons, like varying prices, emission of harmful gases (environmental concern) and projected fossil fuel depletion, several researchers are exploring the development of technologies to utilize solar energy sources [1] to fulfill the energy requirements. Since the solar energy fluctuates continuously, the Thermal Energy Storage System (TESS) appears to be a sustainable option of storing the energy and supply the energy at a uniform temperature for later use [2]. Among the various TESS, Sensible Heat Energy Storage (SHES) is most commonly used.

In SHES, system energy is stored by means of temperature raise in a material. Charging and discharging of SHES system uses the heat capacity of the material. A review regarding cost effectiveness of the sensible heat storage (SHS) materials was reported [3, 4]. Anderson et al. [5] carried out performance evaluation of alumina thermal energy storage (TES) as SHS medium and pressurized air as heat transfer fluid (HTF). Sragovich [6] made a thermal storage model using air as HTF and magnesia as SHS material for estimating the transient heat transfer rate of the system.

Tamme et al. [7] employed concrete and ceramic as SHS medium for higher temperature application using synesthetic oil as HTF and compared their results with numerical values. Laing et al. [8] evaluated the performance of 350 kWh capacities of SHS using high temperature concrete and ceramic as a medium of storage. The result revealed that concrete exhibited higher performance, lower exergy loss, and low cost compared to ceramic. Skinner et al. [9] investigated TESS with high temperature concrete using molten nitrate HTF.

Selvam and Castro [10] developed a computer code to estimate the rate of heat transfer from concrete bed TES and found acceptable range of charging time using heat transfer augmentation technique. Aly and El-Sharkawy [11] investigated the influences of the storage medium properties numerically, on the packed beds related to the thermal performance at the time of charging cycle. The analysis was carried out based on one dimensional two phase model using air as HTF. The result indicated that increasing volumetric heat capacity, reduces the rate of temperature increase in the storage medium.

Majority of the investigations in this area were focussing on the importance of storing sensible heat at high temperature for various application using different storage materials. However, a good number of investigation were not done to optimize the quantity of charging/discharging tube required for SHS system with respect to charging/discharging duration. Therefore, in this work, the thermal storage capacity of SHS system is investigated by using a high and low conductivity materials such as Cast Steel (CS) and concrete. Based on the charging duration, optimization is done for the required quantity of tubes to charge SHS bed using COMSOL Multiphysics. SHS system is evaluated for various charging/discharging duration, and the flow rate of HTF.

2. Sensible Heat Storage Bed Design

The designing of SHS consists of arriving proper diameters of the charging tubes and bed, quantity of tubes and storage bed length. The present work is aimed at designing of SHS bed having a capacity of 50 MJ and a fixed charging temperature range of 100 K. The volume necessary to store 50 MJ is obtained by the expression:

$$Q = \rho_s V_r Cp_s \Delta T \qquad (1)$$

where, Q, ρ_s, Cp_s and ΔT are storage capacity (J), density (kg/m^3) and specific heat (J/kg K) of solid state of SHSM and charging temperature range.

The actual volume (V) needed for SHS including charging/discharging tubes is obtained by the relation:

$$V = \left[\frac{\pi}{4}\left(D^2 - nd\right)\right] L \qquad (2)$$

Based on the thermo-physical characteristics, easy availability and low cost, concrete and cast steel are preferred as storage media [12], [13]. Moreover, these storage materials can be easily modified for high capacity storage. The tube inner diameter and thicknesses for the HTF fluid is 0.012 m and 0.002 m, respectively are selected for the present investigation. The selected HTF is Hi-Tech Therm-60 which passes through the charging/discharging tube for the heat exchange. HTF properties are specified in Table 1. Table 2 indicates the determined sizes of the storage bed materials.

Table 1. Thermo physical properties of the HTF [14]

T(K)	Cp (J/kg.K)	k (W/m.K)	μ (Pa.s)	ρ(kg/m^3)
313	2081	0.1314	0.0172	860
373	2306	0.1238	0.003144	823
423	2493	0.1175	0.001383	790
473	2680	0.1119	0.00068	755
523	2867	0.1049	0.00049	717
573	3054	0.0985	0.000339	678

2.1 Optimization of charging tubes in the storage bed

The charging duration of the SHES depends on the quantity of charging tubes. As the quantity of charging tube increases, the storage capability and charging duration of the bed decreases. The number of charging pipes varied from 11 to 35. Figure 1 plots the simulation results of the variation of charging duration versus quantity of charging tube. From this, the quantity of charging tubes can be decided depending on the charging duration required. The number of charging tubes were adjusted based on the diameter of storage bed.

Table 2. Properties [4, 15] and predicted mass of SHSM.

Storage Material	**k_s (W/m.K)**	**ρ_s (kg/m^3)**	**C_{ps} (kJ/kg.K)**	**V_s (m^3)**	**V_{sf} (m^3)**	**m (kg)**
Cast Steel	40	7800	0.6	0.06	0.08	600
Concrete	1.5	2200	0.85	0.16	0.19	422

Figure 1 below indicates that the charging duration does not vary significantly in the ranges of 23-25 and 33-35 tubes, where the charging duration differences were 95 and 30 s, respectively. Figure 1 also indicates that there are two ranges of charging tube arrays at which the charging time does not vary significantly. If 33-35 range is preferred, then it minimizes the charging duration of storage bed about 20 min. But, it requires an additional cost for 8–10 tubes and also decreases the storage volume less than the minimum volume necessary to store 50 MJ of heat. Hence, 23-25 quantity of charging tubes provides the optimum bed configuration.

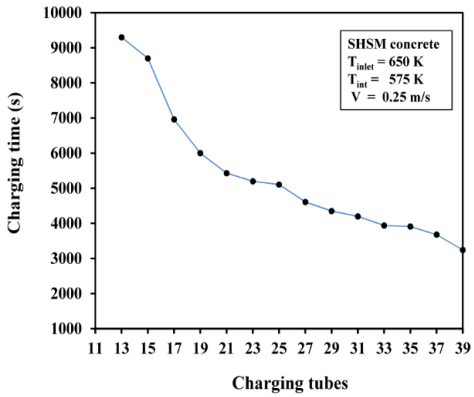


Figure 1. Optimization of number of charging tubes

3. Thermal Modelling of SHS unit

The SHS model developed for the present investigation is regenerative heat exchanger type where heat energy is absorbed /released when the cold/hot fluid passed through the charging/discharging tubes. At the time of charging/discharging, the HTF at high/low temperature is supplied alternatively to storage bed from inlet side of the SHS bed. The fluid transfers the heat to the storage bed and leaves through the outlet. Figure 2 (a) and (b) presents the SHS model and its sectional view with charging/discharging tubes. Since the model is symmetrical with both x and y axis, it is sufficient to consider only quarter part for the analysis.

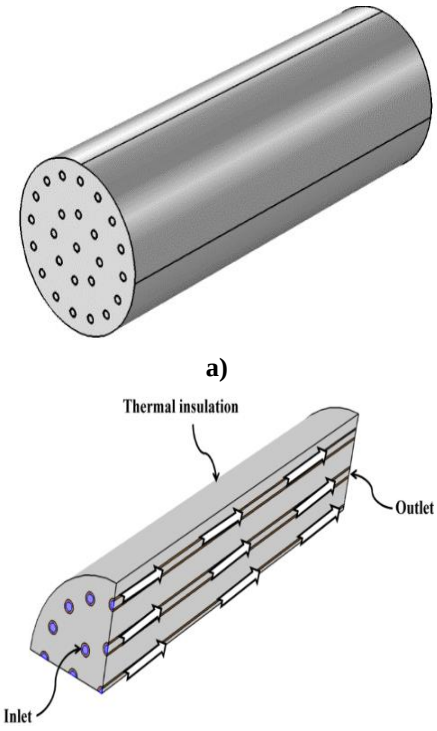


Figure 2. Schematic diagram (a) physical model of SHS (b) sectional view of SHS

3.1 Governing equations

Assumption followed for the simulation of SHS model:

(i) The fully developed velocity is at the inlet side of the HTF.
(ii) Axial conduction is not taking place along the HTF.
(iii) The SHS material is isotropic.
(iv) SHS bed is adiabatic at the outer surface.

The governing equations used for the fluid flow and heat transfer between the HTF and SHS bed is given as:

The continuity and momentum equations are calculated by the expression:

$$\nabla.\vec{v} = 0 \qquad (3)$$

$$\rho_f \frac{D\vec{v}}{Dt} = -\nabla P + \mu \nabla^2 \vec{v} \qquad (4)$$

Convection between solid liquid interfaces is obtained by the expression:

$$\rho_f Cp_f \frac{DT}{Dt} = k_s \nabla^2 T \qquad (5)$$

Conduction on the solid region is obtained by the expression:

$$\rho_s Cp_s \frac{\partial T}{\partial t} = k_s \nabla^2 T \qquad (6)$$

where, $Cp_{f,}$ ρ_f, μ and k_s are specific heat in J/kg K, density of SHS material in kg/m^3, and dynamic viscosity in Ns/m^2 of HTF and solid state SHS material's thermal conductivity in W/m K.

3.2. Boundary conditions

(i) No slip between the flow of HTF and SHS bed.
(ii) Storage bed is considered to be insulated at outer surface except the HTF tubes inlet and outlet.
(iii) Initiation of charging/discharging is assumed to start at 650 /525 K and HTF velocity is constant.
(iv) HTF does not circulated initially, and all the domains are assumed at 525/650 K temperature at the time of discharging / charging process, respectively.

4. Performance Parameters

The parameters considered for the analysis are charging duration, energy stored, discharging duration, energy retrieved and charging/discharging efficiency. They are defined as follows;

Charging duration

Charging duration in this study refers to the time required for the SHS bed to reach 100 K temperature, i.e. full charging is assumed if the entire SHS volume reaches to 650 K.

Energy stored

Thermal energy stored in the storage materials at their respective charging duration is calculated using Eq. (7).

$$Q = \rho_s V_{sf} Cp_s (T(t) - T_{initial}) \qquad (7)$$

Discharging duration

The time required for the SHS bed to reach the mean temperature of 525 K is called as discharging duration. There is no substantial temperature decrease in the storage bed, when the temperature of the storage bed reaches to 525 K.

Energy recovered

Energy retrieved from the SHS bed at particular discharging duration is determined using Eq. (8). The bed temperature decreases during the discharging process.

$$Q = \rho_s V_{sf} Cp_s (T_{ch} - T(t)) \qquad (8)$$

where, T_{ch} is the mean temperature of the SHS bed volume at the end of charging duration.

5. Result and Discussion

The performance parameters evaluation of the SHS system such as charging/discharging time, energy efficiency, bed temperature and HTF temperature variation along the bed length are presented in detail below.

5.1 Charging time

SHS bed is charged by circulating HTF with high initial temperature (T_{int}) through the charging tubes. The mean temperature of the SHS bed over the whole volume is the only time function.

Variation of bed temperature for concrete versus time is given in Fig. 5.1.1. It can be noticed that the increase in the SHS bed volume mean temperature is more and decreases with time due to more driving potential existing at the start of the charging process. It decreases due to increase in SHS bed heat over the time. Cast steel has superior charging rate over concrete because of its high thermal conductivity and low heat capacity. Cast steel is fully charged within 790 s whereas concrete bed requires 5040 s.

Concrete bed charging with time is depicted in Fig. 5. 1.2 at different intervals of charging viz., 0 s, 180s, 360 s, 720 s, 1440 s, 2160 s, 2880 s, 3600 s, 4140 s and 5040 s.

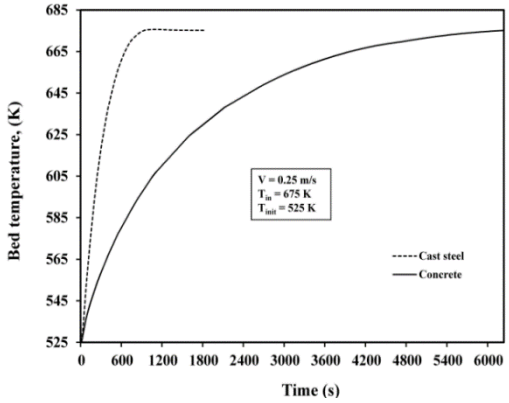
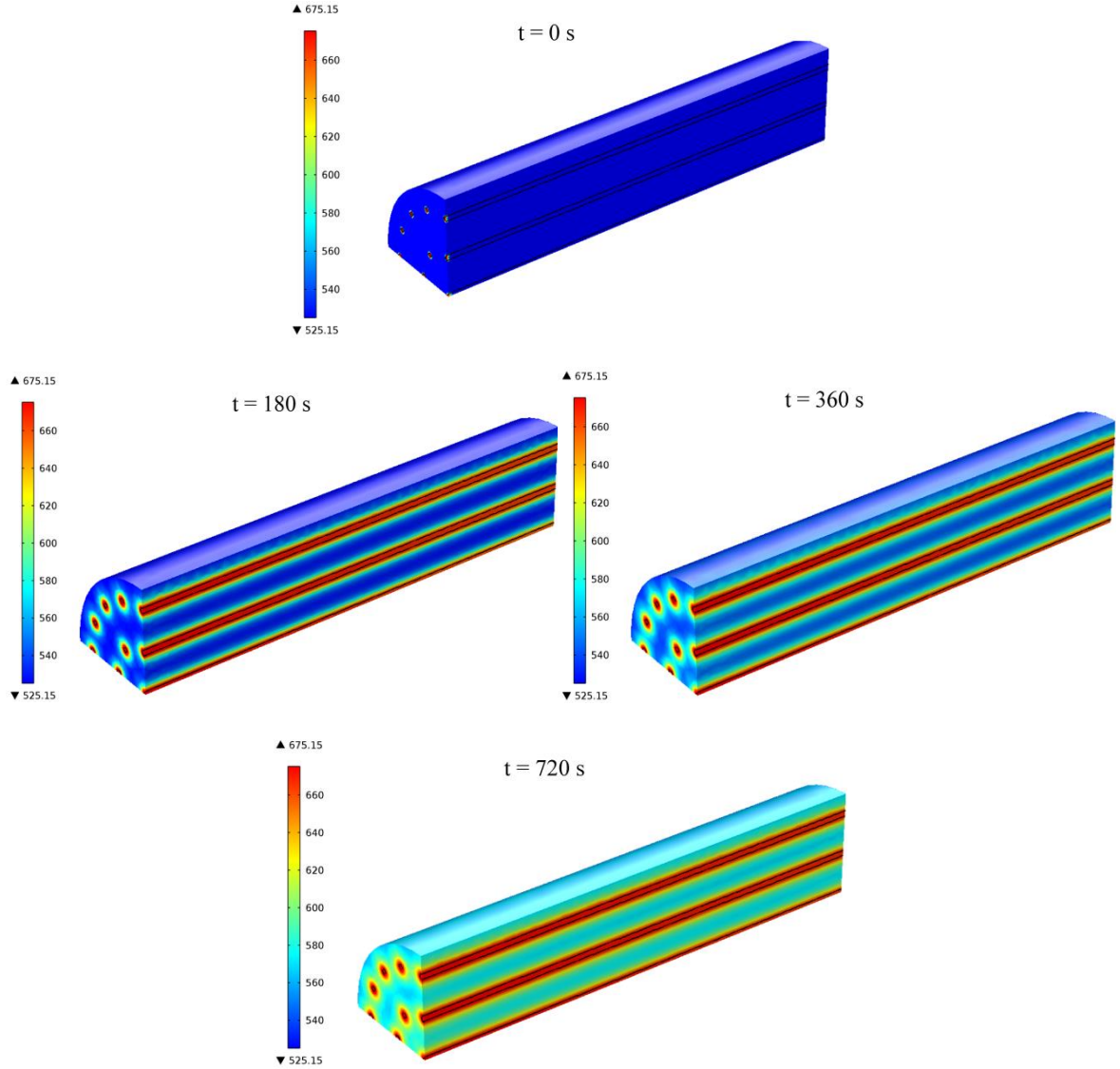
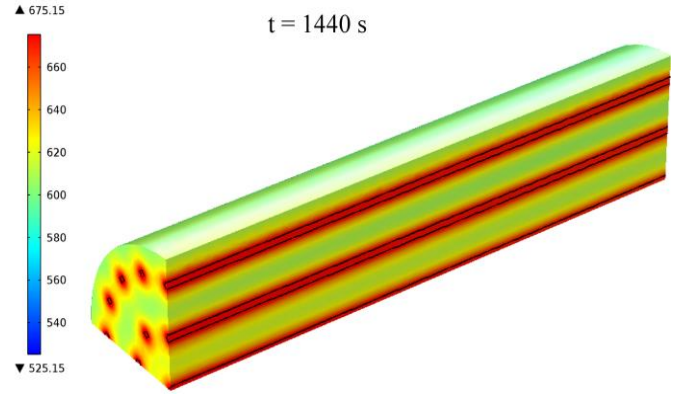
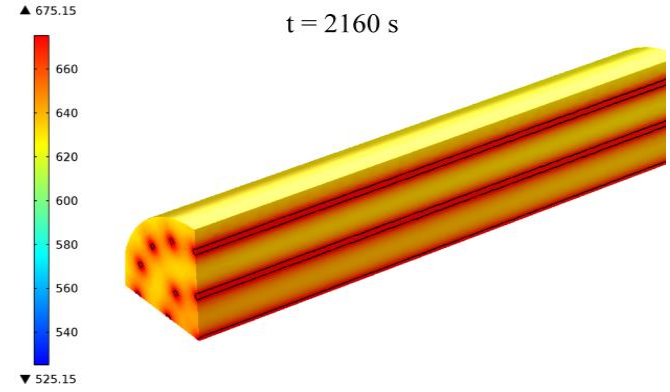
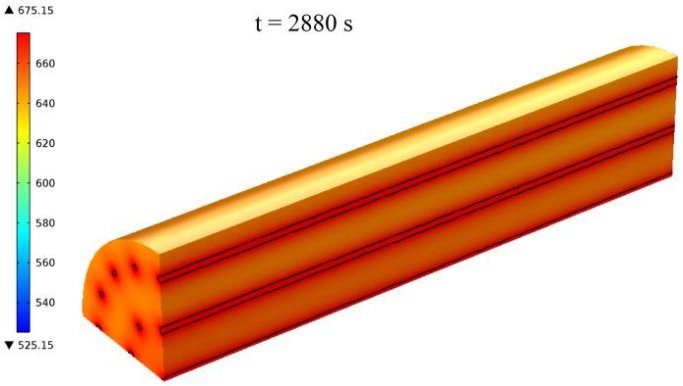


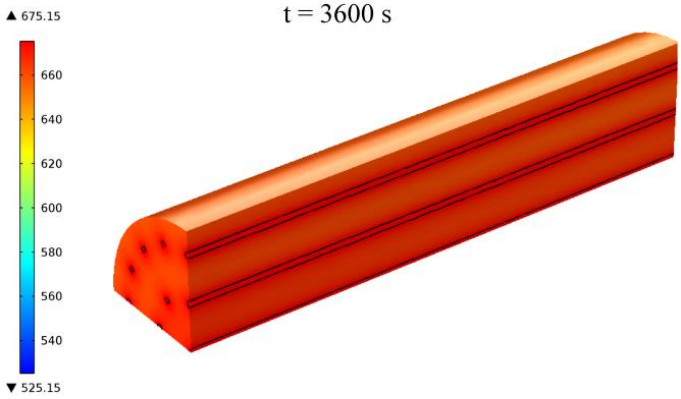
Figure 5.1.1 Charging time of concrete and cast steel beds




t = 1440 s
▲ 675.15
660
640
620
600
580
560
540
▼ 525.15


t = 2160 s
▲ 675.15
660
640
620
600
580
560
540
▼ 525.15


t = 2880 s
▲ 675.15
660
640
620
600
580
560
540
▼ 525.15


t = 3600 s
▲ 675.15
660
640
620
600
580
560
540
▼ 525.15

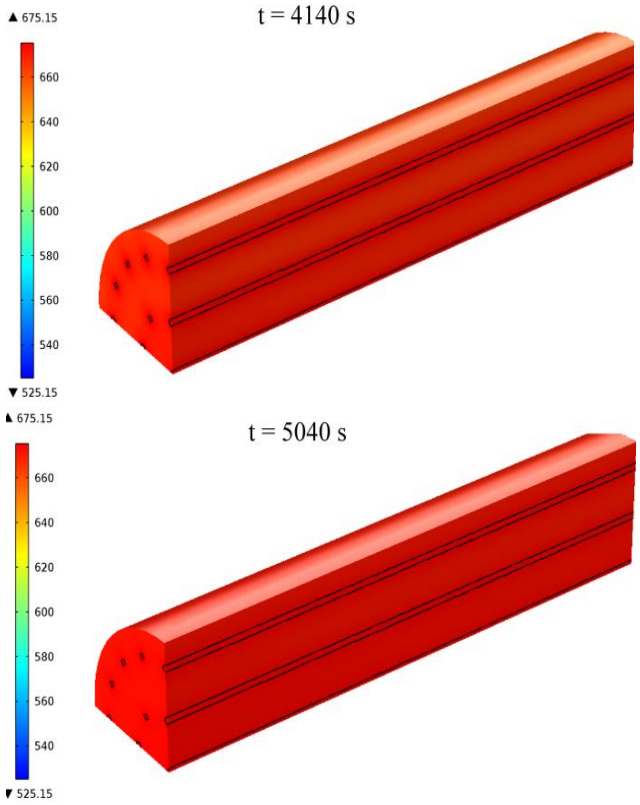


Figure 5.1.2 Temperature contours of concrete SHS bed during charging

5.2 Energy stored

The heat storage rates for the CS and the concrete beds are illustrated in Fig. 5.2. The heat energy stored in the storage medium at their particular charging times is estimated based on Eq. (7). Heat energy stored in CS and concrete beds are 53.8 and 51.9 MJ at their particular charging times.

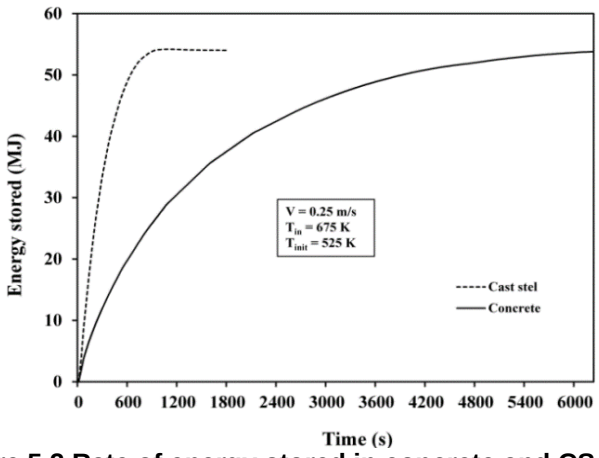


Figure 5.2 Rate of energy stored in concrete and CS beds

5.3. Temperature variation in HTF axially during charging

The variation of fluid temperature in the HTF along the axial direction of the storage bed for various time periods for CS and concrete beds are given in Fig 5.3 (a) and (b), respectively. A steep temperature gradient along the storage bed is observed for the initial period which decreases with time. The temperature drop (ΔT) across the bed after 1 minute of charging was 145 and 40 K for the CS bed and concrete beds, respectively. The temperature gradient observed across the bed length after 20 minutes is marginal for CS bed, but to achieve the same temperature drop, concrete bed needs 75 minutes.

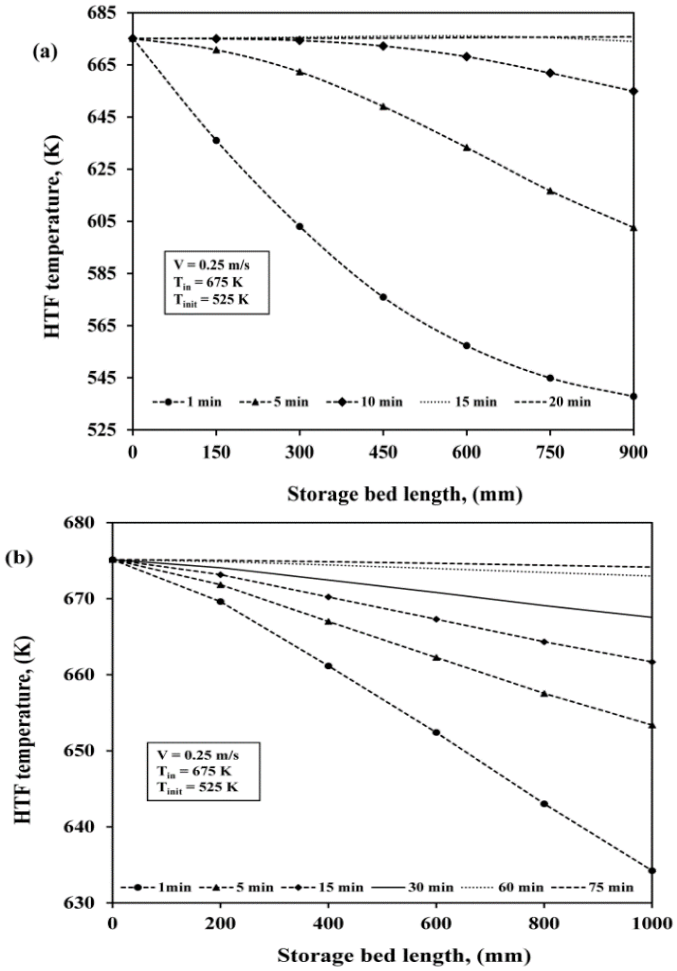
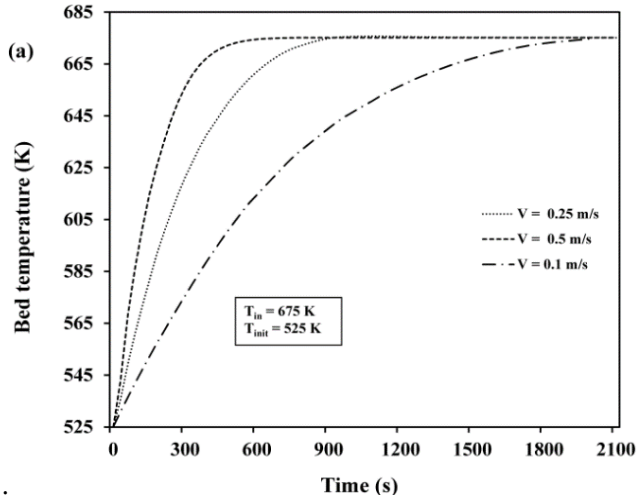


Figure 5.3 Axial variation of HTF temperature in (a) CS and (b) concrete bed.

5.4. Influence of HTF velocity on charging duration

The influence of HTF velocity on charging duration for CS and concrete beds are depicted in Figs. 5.4. (a) and (b) respectively. Overall heat transfer coefficient increased with increase in the velocity of HTF which paves way to enhance the heat exchange and reduction in charging duration.

The decrease in charging duration for HTF velocities of 0.5 and 0.25 m/s is less than the decrease in charging duration for the velocities of 0.25 and 0.1 m/s. The influence of HTF velocity above 0.5 m/s shows insignificant reduction in charging times. Charging time of concrete for HTF velocities of 0.1, 0.25 and 0.5 m/s are 7200, 5400 and 4900 s respectively whereas for CS bed the corresponding values are 2100, 980 and 670s



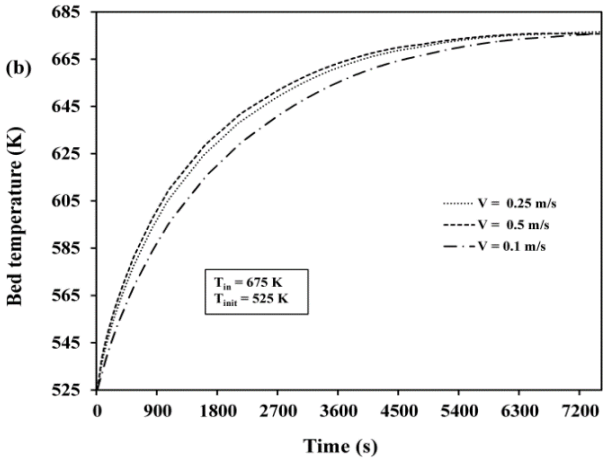


Figure 5.4 Effect of HTF velocity on charging time of (a) CS bed, (b) concrete bed.

5.5. Discharging Duration

The change in mean bed temperature versus discharging duration for CS and concrete is shown in Fig 5.5. The figure indicates that the decrease in temperature of storage bed is quick for the initial 7200s because of high conduction driving potential and there is no significant change in the discharge curve beyond 6300 s. Therefore, effective discharge duration can be considered as 6300 s for concrete bed. CS attains the inlet temperature of HTF quickly due to its high thermal conductivity, and the complete discharge of CS takes 1800s.

5.6. Energy Recovered

The variation of energy retrieved versus discharging duration for concrete and CS beds ploted using Eq. (8) is depicted in Fig.5.6. The thermal energy retrieved is 53.7 MJ for CS bed within 1800 s whereas concrete storage bed requires at least 5400 s to retrieve 52.1 MJ.

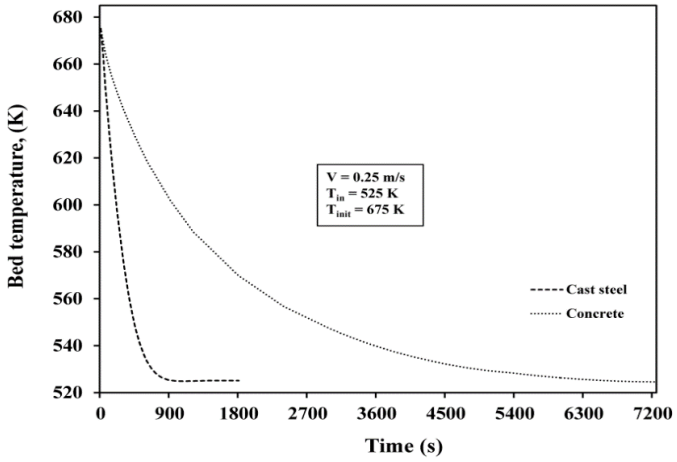


Figure 5.5 Discharging time of CS and concrete beds

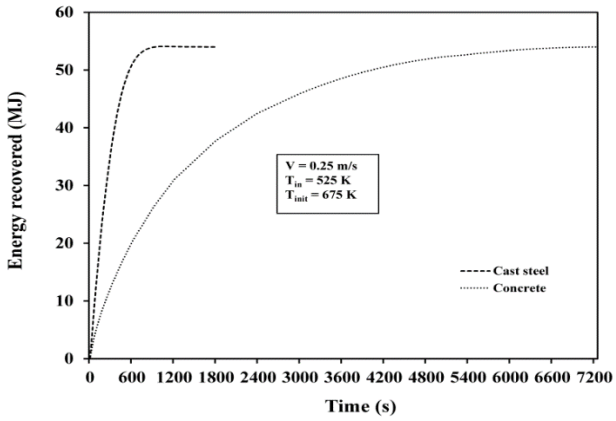


Figure 5.6 Rate of thermal energy recovered in CS and concrete beds.

5.7 Temperature variation of HTF axially during discharging

The temperature variation of HTF axially for the concrete and CS beds are shown in 5.7 (a) and (b), respectively.

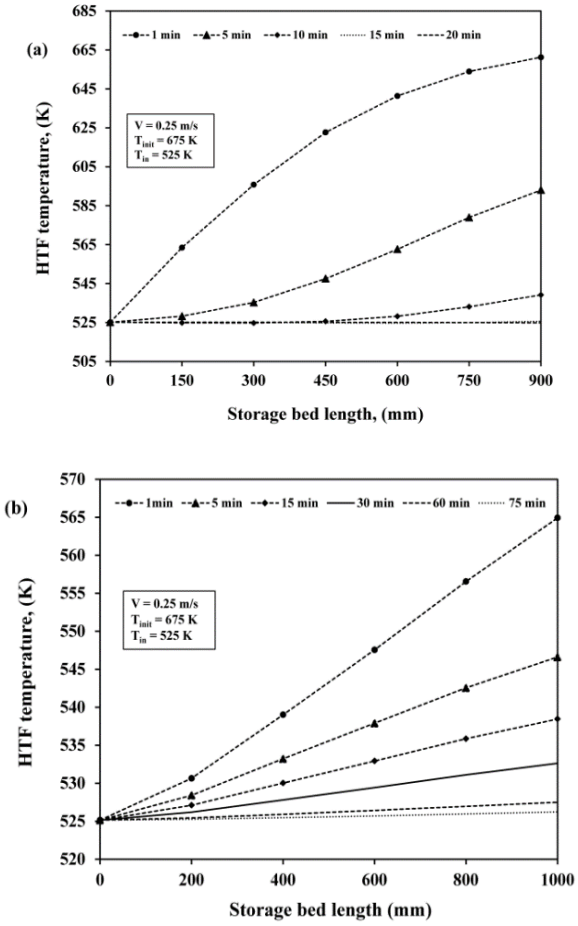


Figure 5.7. Axial variation of HTF temperature in (a) CS bed (b) concrete bed

A sharp temperature rise of the HTF along the storage bed was observed for the initial periods which decrease with time. The temperature rise (ΔT) of the HTF across the bed after 1 minute of discharging was 40 and 140 K for the concrete and CS bed, respectively. For the cast steel, the temperature gradient of the HTF across the bed (between inlet and outlet) was observed to be only marginal after discharging for 20 minutes whereas for concrete bed storage it took almost 75 minutes for achieving the same temperature.

5.8. Influence of HTF velocity on discharging duration

The influence of HTF velocity on discharging duration are depicted in Figs 5.8 (a) and (b) for cast steel and concrete beds respectively. The discharge duration for CS is 2000 s for 0.1 m/s HTF velocity and it decreases to 1200 s and 900 s for the velocities of 0.25 and 0.5 m/s, respectively.

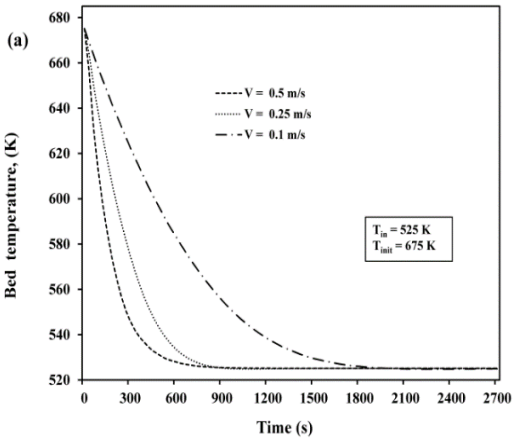


Figure 5.8. Effects of HTF velocity on discharging time of (a) CS and (b) concrete bed

The influence of HTF velocity above 0.5 m/s shows insignificant reduction in the discharging duration. The discharging duration of concrete storage bed for 0.1 m/s HTF velocity is 8600 s and it decreases to 15393 s and 4900 s for the velocities of 0.25 and 0.5 m/s respectively.

6. Conclusions

Developing the thermal physical model to estimate the charging and discharging duration for CS and concrete for sensible heat storage unit was the prime motive of the current investigation. The quantity of charging/discharging tube optimized depending on the charging duration. The temperature variation of HTF axially at the time of charging/discharging of SHSS were investigated. The influence of HTF velocity on charging/discharging duration has been examined and it was established that duration can be reduced substantially up to o.5 m/s HTF velocity. For CS bed, HTF velocity increase provides reduction in charging/discharging duration whereas for concrete these influences were less due to less thermal conductivity. Also, the time required for charging/discharging of Concrete was much higher when compared with CS bed. This provides hope to use CS bed and concrete in line to minimize time required for complete charging/discharging duration for industrial applications.

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A PLC Based Remote Monitoring and Control of Pumps & Water Level for Arba Minch University Main Campus

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Abstract

The objective of this paper was to develop a system that monitors the water level of the water tank in Arbaminch University, main campus so that it operates according to the requirement. Controlling of water level in water tanks makes potential significance in home, institutions, industries, and town municipalities. It minimizes the loss of water and power. It is observed that, Supply and management of water resource is a major problem in Arbaminch University (AMU) at main campus. One can observe that overflow of water occurs sometimes and shortage of water happens in other times to the extent that water is unavailable in the water tank. Thus, it would be possible to control the overall process by PLC (Programmable logic controller).The water level sensed by sensors. For this, the prototype of the actual system has been developed.

Keywords: *Water tank, PLC, water level sensor, pump motor.*

1. Introduction

Water is major substance that determines the life of a human being. It is commonly used in houses for domestic purpose, in industries & institutions for multi purposes. Therefore, saving water for proper use is an essential task for everyone. Especially the water is stored in tanks in industries, institutions, and apartments. Controlling of water flow in such places is an essential work.

Big water tanks are placed in AMU main campus to supply the water to the whole campus. The tanks are on the hills at the back side of the campus. The motors are placed at various places near to the water wells. As per the observation made for long time, tanks are being filled in the mid night. Sometimes the water is overflowing and sometimes there is no water in the water tanks. Controlling the operation of pumping motors up to filling as the required level of water is an essential task. For this purpose, an automatic controller of water level in the tanks is mandatory.

Many control processes have been introduced in the past. Out of that, a PLC based control of pump motor by fetching the signals from sensors which are placed in the water tank is the best suitable for our project. This is because the tank size is big and the rating of the motor is also high. The distance between the motor and the tank is large. A PLC is rugged device mainly uses for industrial processes where the rating of the motor are high. It is programmable and some PLCs can operate with screen. The output of the PLC can be changed with input and programming. In this paper a relay control of motor is used and the control signals to the relay is given by the PLC.

2. Problem statement

The same phenomenon of mismatching the water supply management is happening in Arbaminch main campus i.e. lack of efficient use of water resources due to the unskilled man power and absence of state of art of technology. At some time, there is no water in the tank due to the absence of supervision. However, the newly devised controlling mechanism is assumed to alleviate the problem. The switching ON and OFF of the mechanism is done with the signals from PLCs .For this controlling devise, an automatic action is unavoidable.

3. Objectives

i. To use the suitable type of water level sensor which can provide a continuous analog data reads based on the different water level in a tank.
ii. To control the actuator which is connected to the motor

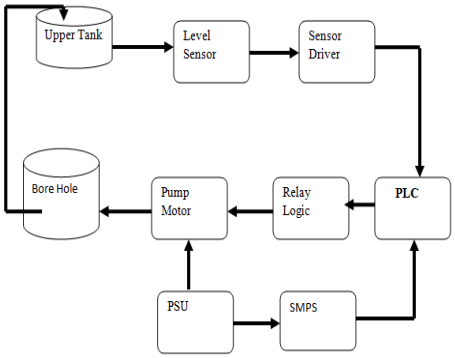

Figure1.Block Diagram of process

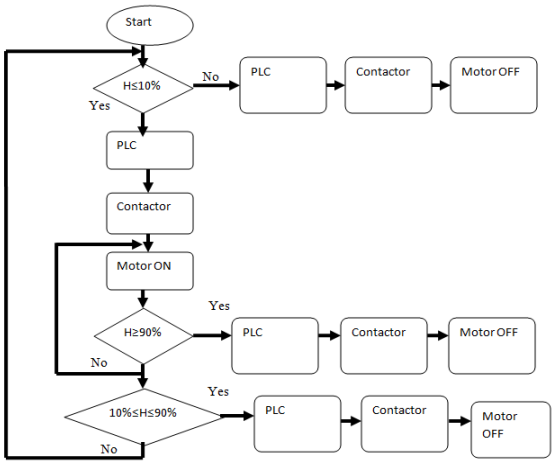

Figure 2. Flow chart

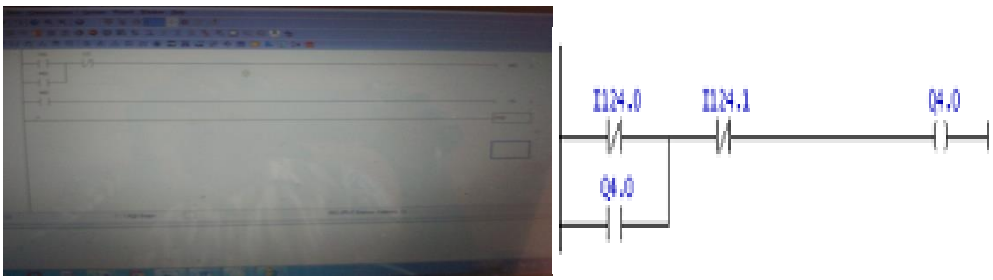

Figure 3. Ladder Diagram

4. Description of Different components in the block diagram

4.1 PLC (Delta): which has a set of serial transmission and receiver pins, I/O ports and logical functions and timers, which are the basic requirements system proposed.

Figure 4. PLC with 8 input and 16 out put

4.2 Level Sensor (switch): - The level is sensed with a conducting metal strip. It works on the principle of electrical conducting property of water. When a signal is sensed by the level detector, it is fed to the PLC for further action. The level sensor which is used in this is a float switch

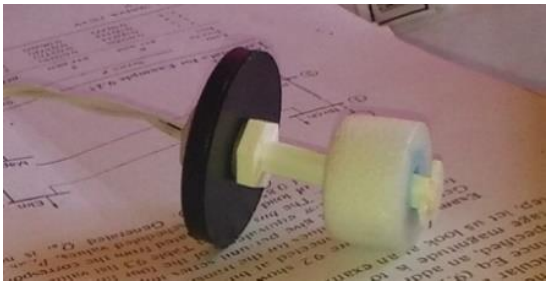

Figure 5. Float switch

4.3 Contactors with solenoid: The signal from PLC drives the motor through contactors and solenoid.

Figure 6 contactor

4.4 1-Phase motor

0.5 H.P single phase motor is used for demonstration. For real implementation, 3-phase motor is used.

4.5 SMPS (Switching Mode Power supplies):

SMPS is used to supply power to the PLC i.e this changes 230 v A.C in to 24V D.C which drives the PLC.

Figure 7. SMPS

5. The Process Descriptions

5.1 Tank is Empty: When water in the tank is below 10%, lower sensor senses this and sends the signal to PLC. The PLC sends signals to solenoid valve which in turn turns ON the water pump. Water is filling the tank once the motor gets ON. Water fills in the tank to the level it reaches to the upper float sensor.

5.2 Tank is Full: When the water is above 90% of the water tank, the upper sensor senses this and sends signal to PLC. The PLC sends signal to solenoid valve which in turn gets the Pump motor OFF.

5.3 Water can be used by customers: Once the water is filled in the water tank, the people can use the water till the water level will come up to 10% of the tank level. At this moment again the lower sensor gives signal to PLC to switch the motor ON.

6. Methodology

First, the suitable components connecting with the control of motor like flow sensors, PLC, RF transmitters and receivers etc. will be selected. PLC programming is done in the Ladder logic considering various parameters such as signal stay time, water flow rate. Then, the ladder diagram in the laboratory will be checked and a prototype project for testing will be designed. The required software will be identified and implemented. The program is then run in the software to check whether the simulation result is in line with the reality. After verifying the functionality of the program, hardware (input and output module) units will be constructed and wiring of system components will be made. Two points in the tank will be set i.e. the low (empty) and high (tank full) points.

7. Proto type

Lower and Upper Tank connections

Figure 8. Lower and upper tank connection

Figure 9. Electrical panel box

8. Results and Discussions

The wastage of water by overflow was controlled and lack of water for people use has been maintained. The automatic control of water level in water Tank has achieved i.e. when the water level in the water tank is below 10%, the motor will start and when the water level is above 80% of the water tank the motor gets switched OFF.

9. Future work

1. Researchers can do the project in conjunction with the Non-conventional energy sources such as photo voltaic to save the water and power energy.
2. The project can be done in more automated manner with wireless control and can be connected to Internet for continuous monitoring of the water from remote place.

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A Reflection on Where ICT and Education can Meet: The case of a Computer Assisted Course in a Teacher Education Program at Arba Minch University, in Ethiopia

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Abstract

Basic IT courses for Ethiopian teachers and students are criticized for being provided as IT for IT sake. On the one hand, Teachers in Ethiopia are expected to integrate ICT tools in their lessons. Yet there are not many tailored trainings for both pre-service and in-service trainees on how to do this. This article, therefore, reports the researcher's experience of introducing a Computer Assisted Language Learning (CALL) course into a Master of Arts Degree of Teaching English as a Foreign Language (TEFL) curriculum and describes the classroom implementation of the designed syllabus at Arba Minch University, Ethiopia. The report, specifically, presents the initiation and processes of the CALL syllabus design and re-design. In addition, it highlights some of the classroom issues observed during the implementation process of the syllabus. It also presents the users' frequency of online participation in the CALL course. The study involved 202 participants of the course and the 14 online activities they involved in. The study tools used were the researcher's reflection-on-action, a document (syllabus) analysis and the digital log data of the course. As a result, it was discovered that the re-designed syllabus included more contents of training than the first syllabus. The reflection also identified implementation issues such as the issue of who teaches the course, the issue of the trainee-teachers' pre-requisite ICT skills, the issue of how the trainee-teachers would view the course and the issue of availability of reference materials. Evidencing their participation, the participants most frequently participated in practicing the online examinations (6718) followed by online lecture notes (5946). The total frequency of participation in the fourteen activities by the 202 participants of the course was 24,267. This shows all participants participated in each activity with a mean value of 120.1337. In conclusion, as this reflection presented a contextually working case of CALL course from design to implementation, Ethiopian universities should consider incorporating technology-assisted courses into their curricula of English Language Teacher Education.

Keywords: *CALL, Curriculum, Syllabus, Reflection, TEFL, Quality of learning experience*

1. Introduction

Even if teacher educators understand that the curricula for teacher education are expected to be updated consistently to respond to new demands in a society, they do not seem to recognise what this currently entails. In fact, this may mean incorporating technology assisted courses that can enhance the quality of the students' learning experience. According to UNESCO-UIS (2009, p.23), adaptation of curricula to ICT integration and deliberate mass teacher training programs on using ICT to teach other subjects are some of the requirements before wide use. These requirements can be achieved in language teacher education context through the introduction of Computer Assisted Language Learning (CALL) into the curricula for in-service and pre-service teachers. CALL being "concerned with teaching and learning of second-languages through computer technology" (Chapelle, 2006, p. VII), has become an important tool in enhancing the quality of language learning nowadays. In the actual design process of Teaching English as a Foreign Language curriculum, the design model or the approach we follow is an important aspect. Wette (2011, p.136) states, "ELT theory classifies curricula as belonging to one of the two contrasting approaches: either process or product." Clark (1987) and Finney (2002), on the other hand, mention the three models of language curriculum development. These models are "the content, the objectives and the process models" which in other words named as "Classical Humanism, Reconstructionism and Progressivism models," respectively.

Regarding the syllabus design processes, Graves (2000) suggests a cyclical model, which include four stages as indicated in Figure 1 below. The essence of this model seems to be applied to the course reported in this paper because the course has gone through planning to re-planning after teaching it.

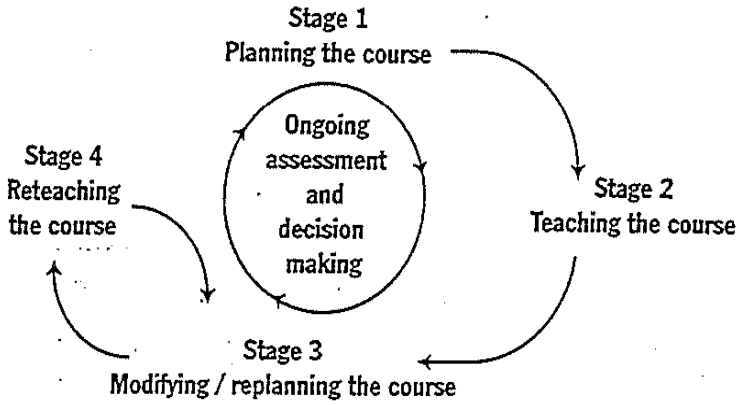


Figure 1: The Cycle of Course development adopted from Graves (2000)

Considering the newness of CALL to the context a number of questions comes to the, then proposer and now the researcher of the CALL course into the syllabus. These questions include what goes into the syllabus, who teaches the course, do students have the required skills, do we have enough resources for the course, how will the students feel about it and what will their participation look like. In fact, these are the questions related to the course offering process that this paper tried to address.

Since the researcher often uses ICT tools for communicating with his students, for preparing for the courses he teaches, for providing reading, audio and video sources and for designing e-learning platforms of the courses he teaches, he sees a great deal of advantages of it. In fact, a special emphasis on English Teacher Education is important in Ethiopia because quality English Language Teachers can influence the learning of all other subjects since English is the medium of instruction. Williams (2011, p. 45) otherwise believes "---if teaching the language of instruction is ineffective inside the school, then low quality education is inevitable."

One may ask that we already have Basic IT courses for Ethiopian teachers and students. However, these are criticized for being provided as IT for IT sake. Students and teachers do not know when and how they use these IT skills for the learning and teaching of other subjects (Bass, 2011).

The following diagram presents the conceptual and process framework of the study.

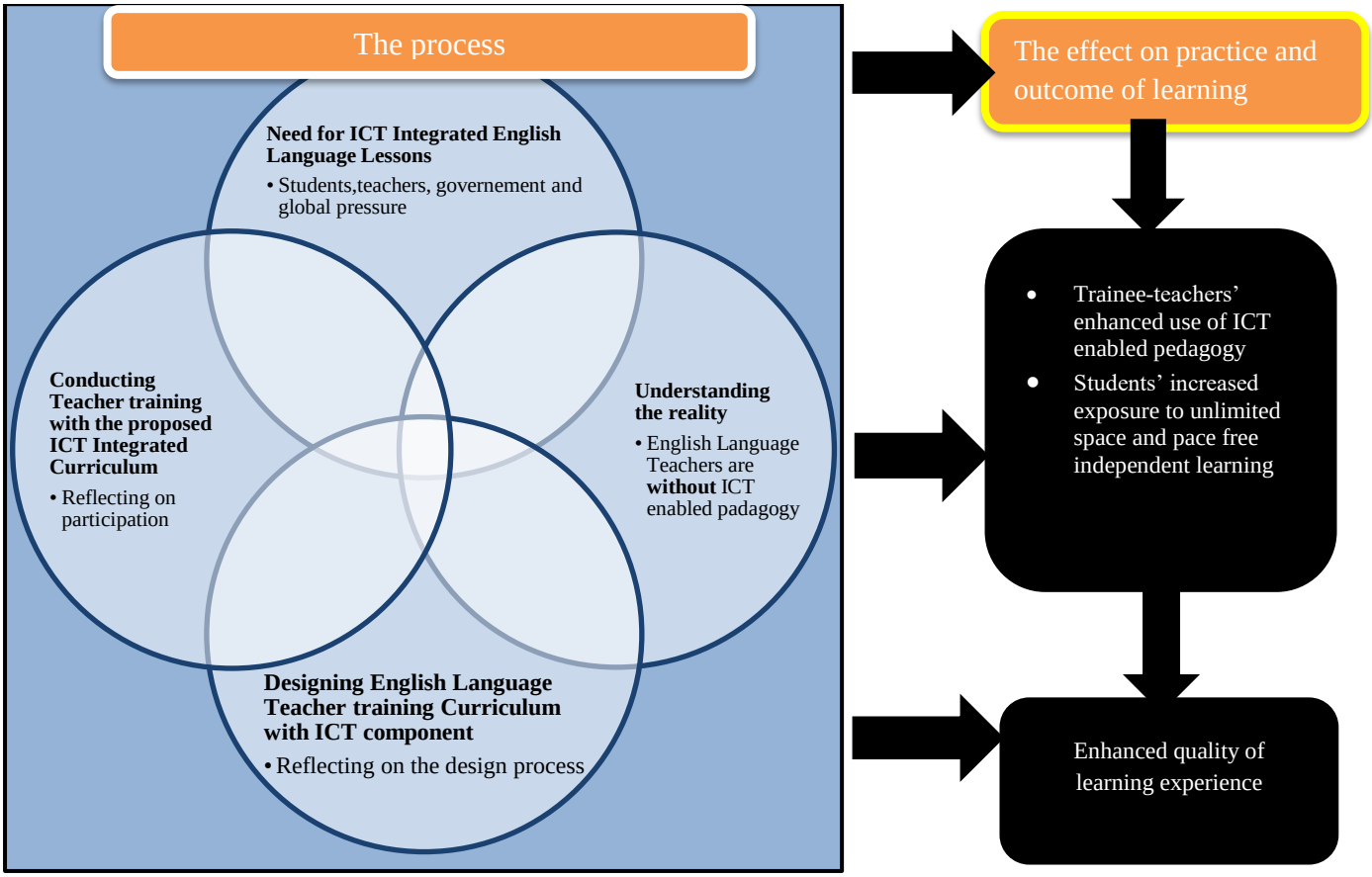


Figure 2: The conceptual and process framework of ICT enabled teacher education

2. Research Questions

The specific questions this study aimed to answer, therefore, were:

1. What were the contents of the Computer Assisted Language Learning syllabuses of the first and the revised one?
2. What were the initiation, processes and implementation issues of the introducing Computer Assisted Language Learning course in a teacher education curriculum?
3. How frequently did the students participate in the online contents of CALL?
4. What is the relationship between the students' online participation and examination results?

3. Methods

The study followed a reflection-on-action approach. Therefore, the data for the study came from tools involving the design and implementation of a CALL course. The data sources for the study were 202 participants of the CALL course and 14 online activities. The research tools, therefore, included the teacher's unstructured observation, document analysis and digital report data.

3.1. Tools of data collection

3.1.1. Teacher's unstructured Observation

The first research tool was the researcher's personal observation of the process of designing and revising CALL syllabus. This tool was used to present the initiation and processes of the CALL syllabus design and re-design. In addition, it was used to highlight some of the classroom issues observed during the implementation process of the syllabus.

3.1.2. Document analysis of the CALL curriculum

The second tool was a document analysis of the CALL curriculum which was meant to present the syllabus contents and assessment plans of the first and the revised syllabus. This tool was used to describe the contents of the CALL syllabuses of the first and the revised one.

3.1.3. The digital log data of the course CALL

The third tool was the digital log data of the course CALL computed from the e-learning portal of the university from Friday, 16 October 2009, 2:20 PM to Wednesday, 30 January 2019, 2:44 PM. Moodle (the learning management software) provides digital report of use on logs, activities and course participation. The course participation report was used for the purpose. This report shows frequency of online views and posts made by each participant. Since the participants included teachers, course creator, students and guests, the online participation was filtered for including only students and all cases of views and posts.

3.2. Data analysis

The data from the different tools were analysed differently. The data from document analysis and reflection-on-action were verbally described while the access rate was analysed using frequency count.

4. Results and Discussion

4.1. The Design Process of the Teacher Education Curriculum with ICT Component

4.1.1. The Initiation of TEFL Curriculum

A team of three teachers from the Department of English Language and Literature were given a task of proposing a TEFL curriculum in October 2012 where the writer of this report was the team leader. Once the needs and means were established, the team mainly looked at the Curriculum of Department of Foreign Languages and Literature (DFLL) at Addis Ababa University for courses to include in the new TEFL Master of Art Degree Curriculum of the University. For the purpose of this paper, my focus is on the CALL course. The DFLL curriculum did not include this or any course related. Therefore, the writer of this report proposed the inclusion of CALL into the new Curriculum and the team and the department council welcomed it. This course was taught for five years and then proposed for revision. Graves (2000) perceives course development as a Cycle where modifying or re-planning holds an important stage. The CALL course that was introduced to the TEFL Curriculum has reached this stage in the cycle. The reporter who happens to be the team leader of the revision process after five years of the first syllabus revises the CALL syllabus. The reasons for the revision were the failure of the first syllabus to consider the contextual needs reflected in local accessibility of some ICT tools, the students' current ICT skills and the need for practical skills as observed by the teacher, this time the researcher himself.

4.1.2. The Contents and skills covered in the two *syllabi*

The contents and skills covered in the first and revised syllabi of the five units of the course are presented in Table 1 below.

Table 1: Contents of the first and revised syllabus of the CALL course

Units	Content of the first syllabus	Content of the revised syllabus
1	**Unit one: Introduction** • Definition of CALL • History of CALL: Behaviouristic, Communicative and Integrative CALL • Why CAL in language learning and teaching and Strengths and weaknesses of CALL for teaching Language	Unit one: Introduction to CALL • Definition of CALL • History of CALL • Areas of CALL • Why CAL in language learning and Weaknesses of CALL
2	**Unit two: Kinds of CALL** • Speech-enabled CALL • Intelligent CALL • Mobile Learning (exploring the potential)	Unit two: Kinds of CALL TOOLS and how they are used • Cell phones (MALL) • PCs • Internet and MOOCs
3	**Unit Three: Presentation software** • Kinds of presentation software • Moodle as a presentation in ELT (What is Moodle, Why Moodle and Understanding features of Moodle)	Unit Three: MS Office tools for CALL • Word processing • PowerPoint • Publisher and MS picture manager
4	**Unit Four: Computer-assisted language testing** • What is the role of Computer in Assessment in ELT? • The strengths and weaknesses of computer in testing Language Skills and kinds of online Assessment and Preparing online assessments (practical)	Unit four: Collaborative Web2.0 tools for CALL • Emails, blogs, wikis, chats, forum, Facebook, YouTube, SlideShare, Podcasts, bigbluebutton, etc.
5	**Unit Five: The potential of internet as a language learning tool** • Internet as a communication tool (virtual communities, blogs, wikis, podcasts) • Exploring websites for language learning (practical) • The concept of E-learning and its application in ELT • Blended learning in ELT • E-course development using Moodle (practical)	Unit Five: E-learning and LMs in CALL • The concept of E-learning and its application in ELT (What is e-learning, what are the forms of e-learning (ODL, BL, Flipped Classroom, etc.) • Moodle (What is Moodle, why Moodle and Understanding features of Moodle) • Installing Moodle as LMS and Designing courses and tests on Moodle and issues with assessment (tests, quizzes, etc.) online

According to Table 1, some differences are observed in the contents covered and the way they were structured. Major differences are observed in unites two to five. The revised syllabus provides more tools implicitly providing the method of teaching i.e. presenting concepts and providing practices for almost all the contents covered in the syllabus. Moreover, the contents of the revised syllabus are very detailed with a long list of Collaborative ICT tools.

4.1.3. The Assessment Methods in the two syllabi

The assessment methods used during the first and revised syllabuses are presented in the table below.

Table 2: Assessment methods in the two syllabuses

The first syllabus	The revised syllabus
Students are assessed on the following areas: 1. Presentation from reading (20%) 2. Group project (practical) (20%) 3. Portfolio work (20%) 4. Final Exam (40%)	Students are assessed on the following areas: 1. Mobile for Language Learning- practical Group assignment (15%) 2. PPT for Learning - practical Group assignment (15 %) 3. Blogging – Creating lessons Individual assignment (10%) 4. Identifying websites and MOOCs for ELT- Individual assignment (10%) 5. Designing online lesson - group assignment (20%) 6. Online Final exam (30%)

Table 2 is a list of the assessment methods used during the first and the revised syllabuses. As the table indicates, some differences are observed in the assessment methods proposed in the two syllabuses both on the areas of assessment and number of assessment tasks. The revised syllabus includes more assessment tasks than the first. It also focuses on assessing practices unlike the first where presentation from reading takes 20% of the assessment. The value of the final exam has decreased from 40% to 30% in the revised syllabus.

4.2. Issues with the course offering process

Even if a number of issues arise when one tries to introduce a CALL course in a relatively limited e-skills and strange environment, the main issues the researcher felt worth discussing here are four. These are "The issue of who teaches the course, the issue of the students' pre-requisite skills, the issue of how students would view the course and the issue of availability of reference materials."

4.2.1. The issue of who teaches the course

Despite the enthusiasms to include the CALL course into TEFL course, who teaches it was the primary issue. The assumption was someone from a TEFL terminal degree and ICT qualification could teach. However, finding such a teacher was difficult. The second option was finding someone with a terminal degree from Computer science department who can co-teach with a TEFL teacher. The second option was not taken by the teacher from Computer Science department because he liked to teach the course by himself. This was not liked by the students because they could not find a TEFL connection in the course. As the researcher had been a third year PhD candidate researching on "Effects of Moodle-Made Blended Listening Lessons on Students' Listening Skills and Attitude: A Blended Approach to CALL in EFL Classrooms", he was felt appropriate to teach the course. He took this happily since he could do his readings and practices both for his research and for teaching the students at the same time. After teaching the course for three years to different groups of regular and summer students, he now realizes what kind of concepts and skills of CALL Ethiopian TEFL teachers' need. That is partly why he comes with a contextualised revised CALL syllabus. This implies that other universities trying to adapt a CALL course may need to train their faculty before introducing the course.

4.2.2. The issue of the students' pre-requisite skills

The other issue was whether students have some of the pre-requisite ICT skills for attending and involving in the course. Some of the students of the different cohort found it difficult to involve at the start as they did not have the basic ICT skills such as using the keyboard and mouse, browsing downloading and uploading files, installing software, creating usernames, etc. Recognising this the researcher provided a one-hour orientation to the online learning.

4.2.3. The issue of availability of reading materials

The fourth issue was whether a teacher can get related reference materials that he/she can provide to the students. Considering the relative newness of the course, lack of reference materials was also a big issue. However, he could collect some related references materials from different sources mostly from colleagues and some from online sources during the design of the first curriculum. All the resources are in PDF format and are available on the e-learning portal of the course for download. Below is a snap shot for this.

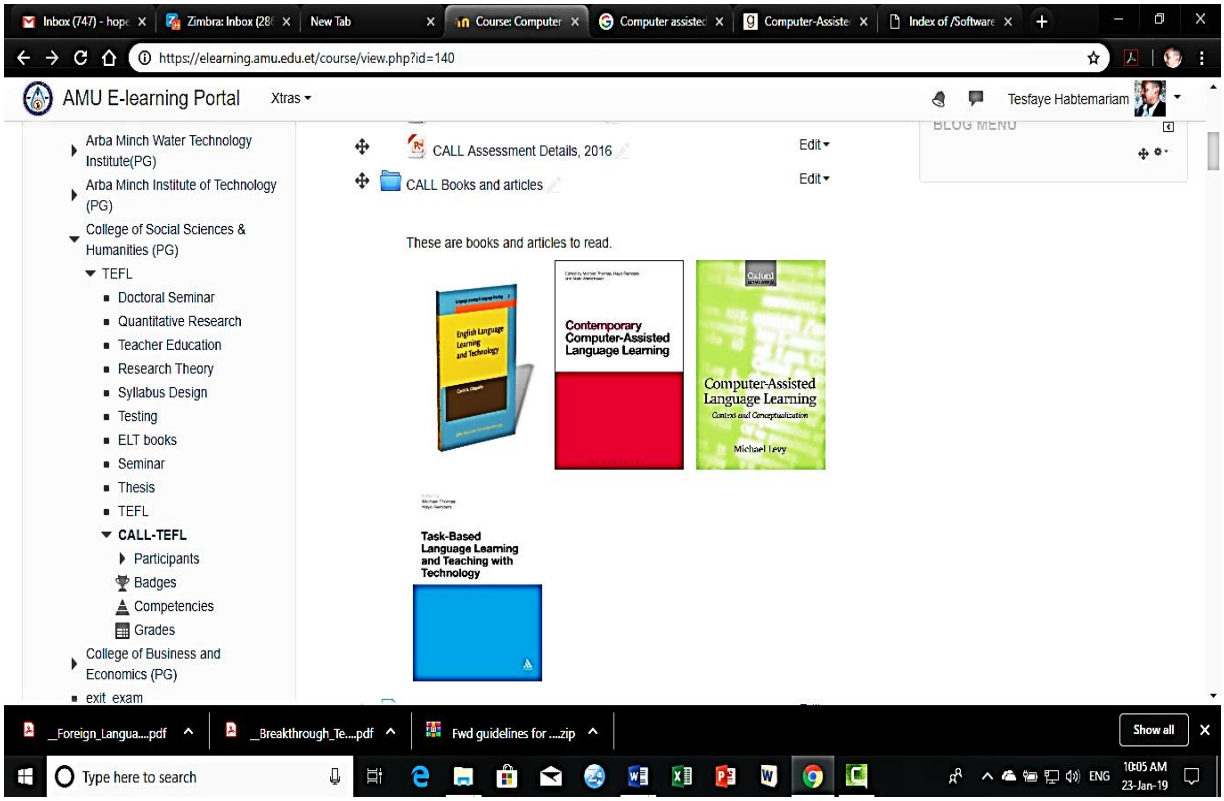


Figure 3: Screenshot of e-books and articles for Computer Assisted Language Learning

As shown in figure two, students can download a book they are interested in from the list of 38 books in a folder and visit the links to data bases and journals listed in PowerPoint slides. These resources can be shared across universities in Ethiopia through a data base at the Ministry of Education if required.

4.2.4. The issue of how students would view the course

The other issue with the course was uncertainty about how the students may feel about the course. As observed during the course some felt a varied degree of anxiety because they felt they did not have the required skills to take the course. However, most were very happy at the end feeling lucky for having such a course in the syllabus unlike other Ethiopian universities providing a similar degree with no CALL component. As Humphries and Burns (2015) suggest curriculum changes should not minimize the importance of the expectations and beliefs of the teachers (student-teachers) who must implement the change. Nevertheless, this requires ascertaining through data from participants on their perception and acceptance of the course.

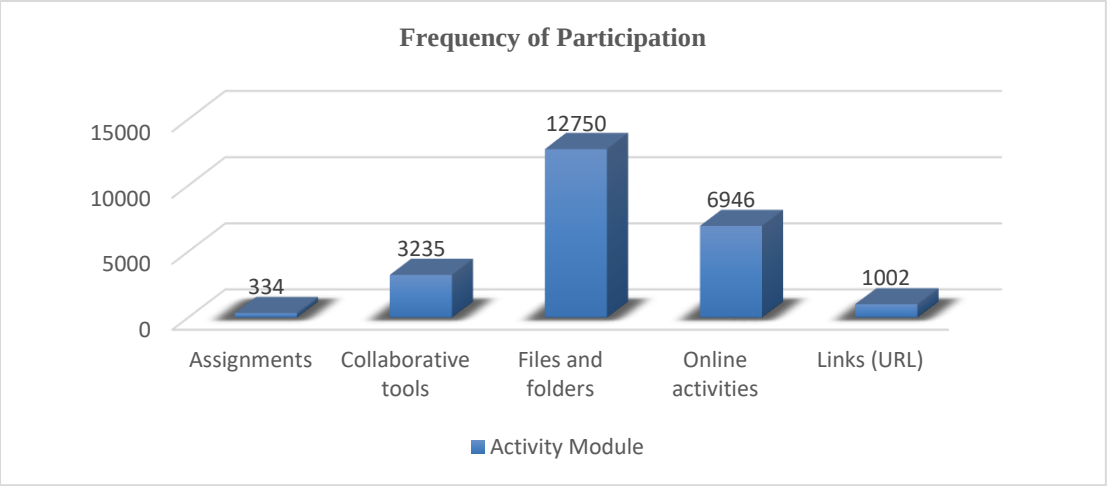
4.3. Participation in the CALL Course

The discussion so far focused on the description of the first and the revised CALL syllabi and analysed the issues with the implementation of the course. This section presents the online participations computed from the digital report from Friday, 16 October 2009, 2:20 PM.to Wednesday, 30 January 2019, 2:44 PM. This is presented below.

Table 3: Frequency of participation in the online activities

Activity Module	Activities	Frequency of participation (views and posts)
Assignments	Assignment on MALL for teaching reading and listening	92
	Assignment on PPT for learning	138
	Assignment on office tools	104
	Total of this activity module	**334**
Collaborative tools	Web conferencing tool (BigBlueButton)	208
	Chats	1972
	Forums	1055
	Total of this activity module	**3235**
Files and folders for download	CALL books and articles	692
	Audio texts for listening	518
	Course outline, course overview and Assessment details	1625
	Lectures notes	5946
	How to do files (task description, explanations on how to install and tips	3969
	Total of this activity module	**12750**
Online practices	Practicing uploading assignment	228
	Practicing online exams (quizzes)	6718
	Total of this activity module	**6946**
Links (URL)	Links to different related websites (CALL, ICT4LT, how to model, Moodle, WampServer)	1002
	Total of this activity module	**1002**
Grand total of the frequency of participation		**24,267**
Mean of the frequency of participation by the 202 participants		**120.1337**

Table 3 shows the total frequency of participation in online activities of 202 participants. The participants most frequently participated in practicing the online exams followed by lecture notes. The total frequency of participation in the fourteen activities by the 202 participants of the CALL course was 24,267 with a mean of 120.1337. The table in general shows the participants have participated in all the activities with some variation in the frequency of participation ranging from 92 to 6718. This variation is observed across the activity modules as well. The following graph shows this.



5. Conclusions

Some differences were observed in the contents covered, teaching methods used and assessment techniques employed between the first and the revised syllabi of CALL. The revised syllabus provides more tools implicitly providing the method of teaching i.e. presenting concepts and providing practices for almost all the contents covered in the syllabus. The participants most frequently participated in practicing the online examinations *(6718)* followed by online lecture notes *(5946).* The total frequency of participation in the fourteen activities by the 202 participants of the course was *24,267*. This shows that all participants participated in each activity with a mean value of 120.1337. It can be then concluded that all the participants have involved in the activities provided in the course. Hence, as this reflection presented a contextually working case, Ethiopian universities should consider incorporating technology-assisted courses into their curricula. This has to involve the practicing teachers both for facilitating their professional growth and for promoting ownership of the curriculum. However, the relevance of the course to the trainee-teachers and their future job should be evaluated to ascertain adoption in wider contexts.

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Predicting Link for Stable Communication, Data Dissemination, and Routing Procedure in Mobile Ad-Hoc Networks via Dynamic Source Routing Protocol

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Abstract

Wireless network is an essential technology for communication between one or more mobile nodes; such type of wireless network which does not require infrastructure is called mobile ad-hoc network (MANET). Due to the behaviour of nodes, in MANET there is no clear measurements during joining/leaving a node to the network. To establish the communication, broadcast routing is used. This study deals with predicting link failure from each node due to the presence of selfish node. Such misbehaving nodes do not share their source to increase their life expectance. In this paper, we design a new reactive technique/algorithm that manages the behaviour of nodes in the network. The algorithm counts when the route discovers the amount of dropped control message (RREQ). By using the proposed algorithm, the simulation result minimizes 4.301 % on the dropped packet, and the number of rediscovering routing table and the amount of packet delivery ration increase 0.043% in one simulation scenario. During designing the proposed algorithm, the nodes do not understand the past history of nodes. Therefore, a further study on developing an algorithm by using proactive approach which understands the previous history of nodes is needed.

Keywords: *DSR, Link prediction, MANET, Packet Drop Node*

1. Introduction

An ad-hoc network is a self-configuring network of wireless links connecting mobile nodes. In MANET routing is a big challenge because of mobility, energy power level, behaviour of nodes, and transmission range of nodes (Bakht, 2011). There are different routing protocols recommended by scholars (Grover and Saini, 2015). The main aim of these protocols is to discover routing table by predicting the link status for achieving and having a better performance values. The failure of a link between nodes affects network performance such as consumption of bandwidth for useless, consumption of battery level etc.

To solve such like problems, reactive routing protocol is used (Grover and Saini, 2015) to discover the path from source to destination and it uses route maintenance procedure in case the route fails. This is because reactive routing protocols have lower overhead compared to proactive routing protocol. In addition to that, reactive routing protocols have the characteristics of discovering multiple paths (K. Zahedi and Ismail, 2011) which act as active and reserve for the given communication from the target nodes. It is useful for fault tolerance if the active path fails.

The intention of this paper is to predict link failure in reactive routing protocol for ad hoc network because of misbehaving node. Selfish nodes are unwilling to forward a packet via packet drop node because the packet forwarding cost takes the nodes resources. For forwarding the packet, a node takes the lowest cost to deliver the packet measured by the number of nodes.

However, to maximize their life (utility) selfish nodes may not forward the message to their neighbour nodes. This motivated the researchers to propose a new technique of link failure prediction mechanism using multipath routing protocol. Link failure prediction is a useful technique in ad hoc network for minimizing the repetition of route discovery process (Zahedi and Ismail, 2011).

2. Material and Method

In this study, we use the most known model for ad hoc network which is RWP (Random Waypoint Model) model. In this mobility model, the entities are selected at a random destination in specified coordinate and at a random speed. This model is widely used in MANET research studies (Cooper and Meghanathan, 2010). In RWP model, when the node reaches to destination area, it alerts a pause time randomly between two movements of interval. Since the work is empirical study, it simulates the proposed new technique on Network Simulator version 2. Selecting and using of routing algorithm is a big task because it depends on the type of network, number of nodes, type of application and where the network is deployed. Due to the fact that the work is vast, the researchers

adapted the existing model and proposed a new mathematical algorithm which counts the amount dropped in control packet.

2.1 Proposed algorithm

In this study an attempt is made to propose algorithm that enables to manage malicious nodes with random distribution and form the network on the fly creating temporary connectivity, route discovering and memory allocation. Such misbehaving nodes cause high amount of packet drop rate, useless bandwidth consumption, disturbance of the whole system. The proposed algorithm manages the participants of misbehaving nodes in undeserved area that cannot exchange information based on the specified routing caches information.

In this paper, we use RSSI type to adapt Two Ray Ground model for calculating the signal strength of the given network. The formula is given below based on Two Ray Ground model. Received signal strength can vary due to multi-path, interference or other environmental effects. It may not give a true indication of communication performance because these factors tend to fluctuate the RSSI values. The mathematical formula is given below.

$$\mathbf{Pr}\,(\mathbf{d}) = \frac{Pt*Gt*Gr*ht^2*hr^2}{d^4L}$$ (Oliveira, Li, Almeida, and Abrudan, 2014)

In this study to say a node is a misbehaving node causing a link failure if a node drops a packet for three consecutive times at route discovery time because a link is failed by the amount of dropped packet.

In general, our proposed algorithm (see algorithm 1 below) is aware of the amount of dropped packet to reactive MANET routing protocol which works in the following way: during route discovery source, it continuously counts the consecutive dropped packets in each time interval to discover a valid path.

Algorithm 1: Details of the proposed algorithm

Output: Routing handover procedure to simulate link status:

Set Source Node: S // Source Nodes

Set Destination Node: D // Destination Node

For ← *i 0 t Val (nn)*

 # Discover the routing table

If *val (nn) sends Hello message*

Then *val (**nn**) stores network information.*

If *S sends RREQ message to **D***

If D *is next to **S***

Then S *directly connects to **D***

Else if *node (**i**) rebroadcast on behalf of **S***

Then *path is discovered*

If *S* ← ***RERR***

Then *the path is not discovered*

If RERR<=2

Then *S sends RREQ to val (nn)*

Else *node (i) node identifies as packet drop node* ***# RERR==3← node (i)***

Then *All valid paths are checked; node_id is discarded from route information* ***#All valid paths are saved***

In DSR, source node sends Hello message to all of the neighbours' node, then each node that receives the message stores node_id. Good characteristics of DSR protocol is that it creates multipath route discovery procedure. Then the source node cheeks its routing table to send or to rebroadcast RREQ message and counts the number of dropped RREQ message.

The works by Sivavakeesar and Pavlou predict link failure by using RSSI for three consecutive times. Based on this knowledge, the proposed work when the source node has information about the network and if RERR is replied for three consecutive times by specified node_id ($i) that is identified by predecessor of the intermediate node, then the source node mark the node_id ($i) as malicious node.

3. MANET Attackers and Their Issues

Attacker is one big issue in ad-hoc network (MANET) research area (Bharti, Singh, 2014), and it is one of the important task for personal computer user both in infrastructure and in infrastructure-less network. Since studding attacker is a vast task because they upgraded their behaviour from time to time, so this study covers on MANET specified with link discovering from source to destination including the intermediate node.

There are a number of attackers in ad-hoc network because of the different weak points observed in MANET. Due to its decentralization, it is vulnerable for attack, especially the routing procedure, on upper and lower layers for disturbing a whole network (End-to-End communication). Since the packet drops, they cause for link failure which leads for low packet delivery ratio, throughput, and delay.

Based on their behaviour, MANET attackers join to the network (Bharti, Singh, 2014);

- ✓ To consume resources uselessly
- ✓ To interfere with any system resource's intended function like attack in the middle
- ✓ To save their resources and stabling their life for long time.

So based on this concept, the detail description of attackers in MANET are:

Dropping Attacker: The malicious node drops the packet which is not intended for the attacker/for themselves. From their behaviour during end-to-end communication, they act as a normal node, but they drop packets, then they cause a reduction in network performance (Sevil, Clark, and Tapiador, 2012) for the purpose of saving its own resource like power.

Ad-Hoc Flooding Attack (AHFA): AHFA is a type of DoS (Denial of Service) attacker to denial End-to-End communication when the network uses On-demand type of routing protocol like DSR and AODV. These attackers sends a lot of broadcast route request packet message to slow down the communication with none existed node ID, so the valid communication minimize the throughput, increase delay with high packet dropping ratio.

Gray Hole Attack: The aim of Gray Hole attacker is to drop a packet/message sent by a source to target node. To this end, the attacker node acts as a legitimate node to forward a packet, but it drops a packet intentionally because of its maliciousness. Source node wants to communicate with the target node if control message are passed through the attacker, then the connection is lost to reach to the destination because the attacker drops the message, and the process repeat again and again by sending RREP messages (Bharti, Singh, 2014).

Black Hole Attack: Another type of attacker is Black Hole attacker which causes to absorb all packets to itself (Bharti, Singh, 2014).

Worm Hole Attacker: An attacker type which spy and disturb the whole network intentionally is worm hole attacker. This attacker tries to combine itself with selective forwarding and eavesdropping. Due to the presence of worm hole attack in MANET it is difficult to analyse, authenticate and non-repudiation the traffic that is going on (Kumar, 2012).

4. Simulation Environment

The proposed algorithm was implemented and tested on NS-2simulator tool and Ubuntu (14.04 version) operating system, and we have set DSR protocol for node configuration. Prior notification in the .tcl code is added.

4.1 Simulation Evaluation and Parameters

In this study, the nodes in the network are either packet drop node or a normal node. To identify the behaviour of the nodes, each node was set to read their Maliciousness value for identifying its amount of dropped packets (see figure 2) based on which maliciousness of the node was evaluated.

For evaluating the proposed algorithm and design, in is conducted and the result is analysed and evaluated by the parameters metrics given below

In this research work, each node in the network reads a text value for comparing the result after running using NS-2.35 simulator. Accordingly, each node generates its value and knows the result of the neighboring node .Based on the result, the normal node selects another route.

Predicting link failure uses different performance evaluation parameters such as the number of dropped packet, end-to-end delay, link between nodes and packet delivery ratio. Detail description of evaluation metrics for this study are presented in table 4 below:

Table 4 Sampling parameter Values

Parameters	Value
Simulator Tool	Network simulator 2 (NS-2)
Simulation Area	1200 * 1200 cm
Number Of Nodes	16
Routing Protocol	DSR
Packet Size	512 bytes
Traffic Type	CBR
Mobility	RWP
Simulation Time	500 sec

Packet Delivery Ratio (PDR): PDR is determined based on the received and generated packets as recorded in the trace file. It is the ratio of packets that are delivered to the destination and generated packets by the source node. Mathematically, packet delivery ration (PDR) is computed as follows.

$$\text{PDR} = \frac{\textit{sum of packets received by destination node}}{\textit{sum of generated packets from source node}}$$ (Xia, Xia, Yu, Jia, 2014, Bakht, 2011).

Average End-to-End Delay: is defined as the average time taken for the generated packet to reach the destination. It includes all possible delay causes such as route discovery, queuing and retransmission delay. Packet drop is discussed in detail on (Xia, Xia, Yu, Jia, 2014, Bakht, 2011).

Throughput: in Ad-hoc networks, there is a node to maximize total network throughput by using all available nodes for routing and forwarding. However, a node may misbehave to forward packets. Misbehaving nodes can be a significant problem that affect throughput.

$$\text{Throughput} = \frac{\textit{Average rate of successfully delevered message}}{\textit{communication channel}}$$

5. Discussion

In this section, we discuss the simulation result of the proposed algorithm for link failure prediction on DSR protocol. For generalizing the result based on the proposed algorithm and procedures, 16 nodes are randomly distributed. To measure and compare the efficiency of the DSR protocol, the proposed algorithm is integrated using different tools and scripts such as trace graph generator tool and Perl script. Table 2 below shows the result of End-to-End delay, Dropped packet, and Packet delivery ratio of the original and the proposed algorithm.

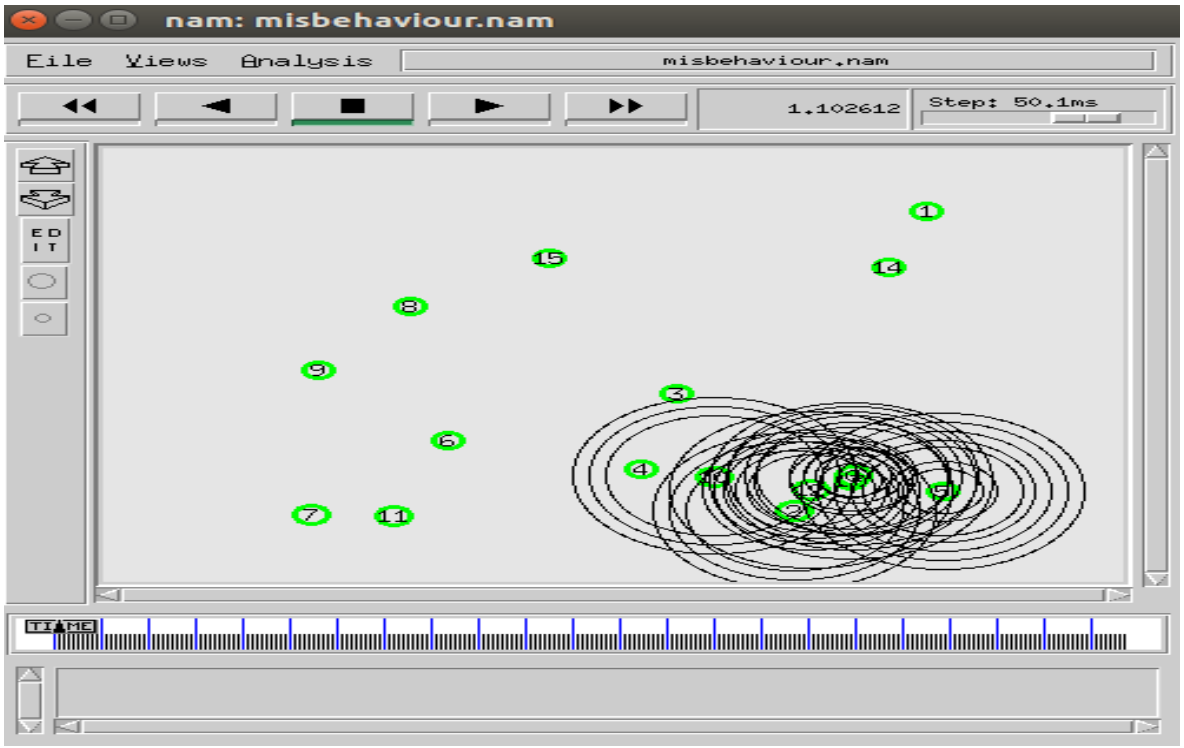

Figure 1 Assigning the Percentage Malicious Values for Each Node

As we have seen in figure 1 the number of node participants are 16, those nodes join and leave the network. Then the proposed algorithm manages the behaviour of nodes based on the amount of dropped packet which controls packet RREQ message.

For generalizing the result based on the proposed algorithm and procedures, 16 nodes are distributed randomly. From those nodes, we get the assessment result of node 10 is -1. We conclude that node 10 is a malicious node that causes a link failure on the networked nodes. We show the result of nodes in Figure 2 below. The other nodes do not send a packet to node 10.

```
 modified_dsr.nam  modified_dsr.tr  Node_valuation.txt  result.txt  result.txt~
musie@musie:~/Documents/dsr-modified$ ns Modifieddsr@malicious.tcl
num_nodes is set 16
INITIALIZE THE LIST xListHead
Node #0 : Malicioues Value 0.00
Node #1 : Malicioues Value 0.00
Node #2 : Malicioues Value 0.00
Node #3 : Malicioues Value 0.00
Node #4 : Malicioues Value 0.00
Node #5 : Malicioues Value 0.00
Node #6 : Malicioues Value 0.00
Node #7 : Malicioues Value 0.00
Node #8 : Malicioues Value 0.00
Node #9 : Malicioues Value 0.00
Node #10 : Malicioues Value 0.00
Node #11 : Malicioues Value 0.00
Node #12 : Malicioues Value 0.00
Node #13 : Malicioues Value 0.00
Node #14 : Malicioues Value 0.00
Node #15 : Malicioues Value 0.00
SORTING LISTS ...DONE!
channel.cc:sendUp - Calc highestAntennaZ_ and distCST_
highestAntennaZ_ = 1.5,  distCST_ = 550.0
musie@musie:~/Documents/dsr-modified$
```

Figure 2 Assigning the Percentage Malicious Values for Each Node

Table 5 Simulation Result of the Original and Proposed protocol

Simulation Result	Packet Sent	Packet Received	Dropped Packet	Packet Delivery ratio	End-to-End Delay
Original Protocol	5967	2071	2276	0.6186	1.9235
Modified Protocol	5934	3926	2008	0.6616	1.1208

The generated result which is found in figure 2 and 3 compares the result between the proposed algorithm which is the modified protocol and existed protocol, not only these figures but also as we view in table 2.

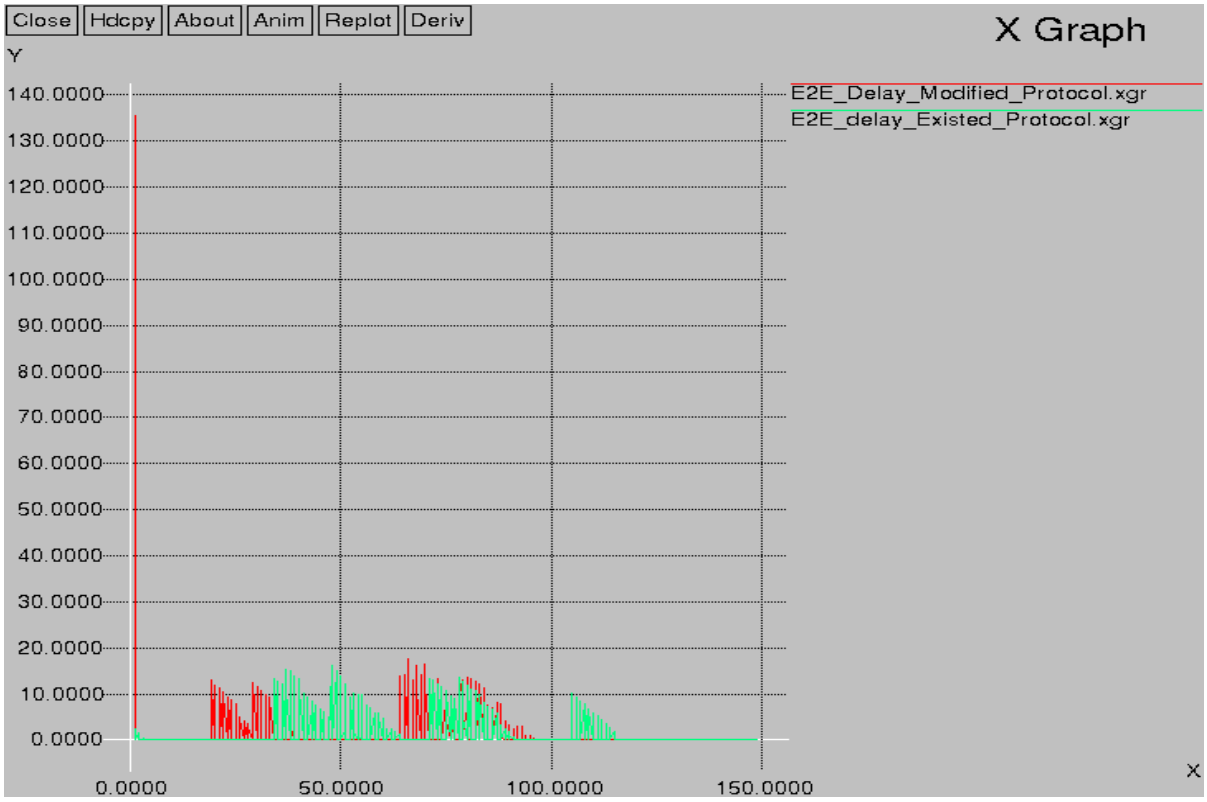

Figure 3 Average generated End-to-End delay

In all simulation, the random movement of nodes have been generated by built in functionality in NS2called **Setdest.** The **CBR** traffic generated using built in functionality is **cbrgen.tcl**, and the amount of signal strength is also determined using the built in function in NS2 called **propagation/Two ray ground Model**.

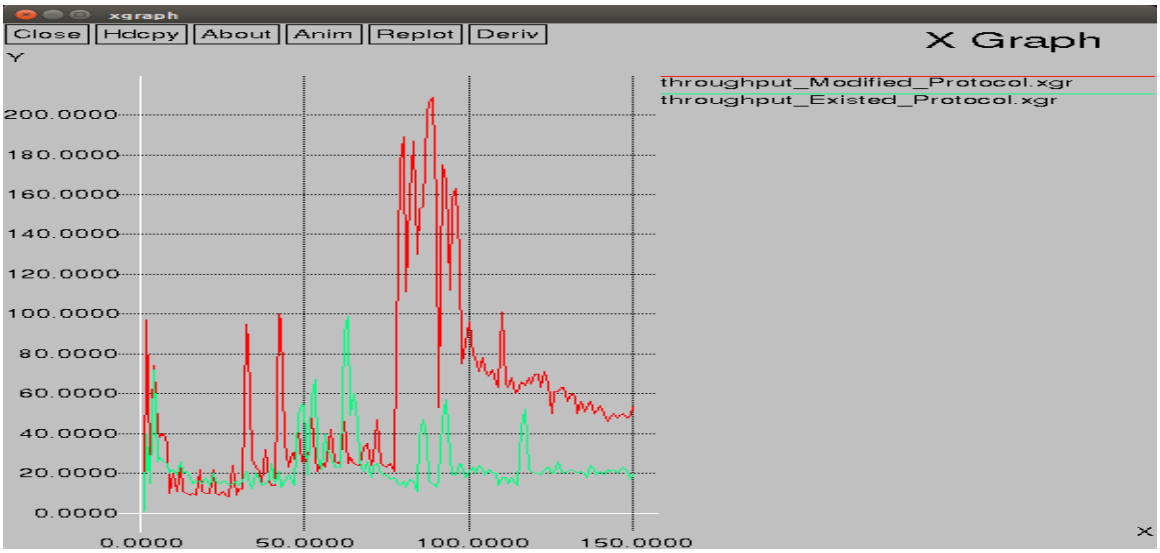

Figure 4 Throughput of the network

6. Conclusion

The purpose of this study was developing an architectural algorithm for forming stable communication and long life network communication between participant nodes. This is critical for forming stable communication and long life of the link during data dissemination. To predict link failure, first we calculated the amount of confirmed and dropped packets. This was followed by an assessment of malicious nodes based on their behaviour. To this end, DSR protocol was modified for counting the amount of dropped packets by specific node. Avoiding the amount of link failure minimizes the amount of route maintenance, to have a long life of the path for delivering the packet by using the proposed solution and using the exited methods.

The proposed algorithm is implemented by modifying the C++ files of DSR on NS-2 simulator tools, on 16 nodes which are distributed randomly for tracing their behaviour from the trace file (.tr) with setting of source and destination nodes, and integrating the TCL file with other external file. Within the specified amount of time or at a single simulating time, the node which causes link failure is detected and it is assigned 1 for indicating its status.

7. Recommendation

The simulation result obtained is a promising one for link failure prediction based on malignancy value of nodes. During designing the algorithm, we faced different challenge like integrating the algorithm, and making interconnection with other external file format. Since this paper works for reactive approach which is done for a single configuration scenario, it needs further study to control those misbehaving nodes by designing proactive approach based algorithm.

On the modified protocol, they can do for other malicious nodes like packet flooding attacker by adding other techniques and methodology which make network connectivity stable by measuring the amount of battery power level.

In the meantime, this work is implemented for text data, and it needs further study and measurement on the amount of packet loss rate and link status for real data and QoS traffics like video, and Audio. Further studies are needed.

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Spatial Changes in the Local Development Plan of Mekelle, Ethiopia (Case of Debri-Dingur Area)

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Abstract

Urban spatial expansion is very common and principally increasing in fast economic growing developing countries. Ethiopia is not only least urbanized, but also most urban areas in the country are predominantly unplanned. Currently, Ethiopian cities are experiencing unprecedented growth and Mekelle a regional capital city of Tigrai province is one of the fast growing city which engulfing the nearby suburbanized fringe kebelles like Debri-Dingur area. The objective of this paper is to assess and evaluate the spatial changes in the newly developed local development plan (LDP) of Debri-Dingur area in Mekelle city. The main research method applied here is qualitative and quantitative analysis besides spatial analysis done using aerial photo, AutoCAD, GIS computation and field observations, archival, survey, questionnaires and interview were used to collect the primary and secondary data from dwellers and stakeholders as different relevant sources. The result reveals that in Debri-Dingur area the rate of urbanization is growing fast with exponential augmentation of population, lack of regularization, poor infrastructure development and unplanned squatter housing construction as a leap-frog is becoming common, unless the newly developed LDP is implemented in a revised way as fast as possible. The local development plan (LDP) has recommended a fancy spatial neighborhood design with higher land use coverage of mixed residence, excluding pure residence areas, though economically unfeasible to implement by local administration and the dwellers unless it is realized in phase based approach with pure residence as an alternative land use. The proposed and implemented spatial coverage has also discrepancy with the main structure plan of Mekelle city.

Keywords: *Debri-Dingur, Ethiopia, Land use, Local Development Plan, Mekelle, Spatial, Tigrai*

1. Introduction

Following preparation of structure plan or master plan, Local Development Plan (LDP) is a next step that leads the biggest and brief plan to implement it into practice. Local Development Plan (LDP) is a detailed development plan of a defined locality. It is a statutory instrument that zooms out the general and broader proposals of a citywide Structure plan of an urban area. It serves as a transition between a structure plan and projects in the process of implementation of urban planning. The local development plan is a planning instrument that facilitates the implementation of the structure/master plan by focusing on selected strategic intervention areas. This tool is generally approached by various methods which include urban renewal, urban upgrading, urban redevelopment and new development. The local development plan (LDP) of Dingur-Debri is approached as the urban fringe upgrading LDP approach by regularization and upgrading of tenure security which intended to prescribe the functions, urban design principles and spatial organization of a given locality. It combines urban design with planning proposals and regulations as clearly defined below.

- **Legal component**: consisting of ***hierarchy*** plans, ***conformity*** *and* ***consistency*** of rules and regulations, including land use zoning of the area.
- **Design component**: consisting of ***integration*** plan, design proposal, perspective plans, 3D and design strategy (image diagram, map).
- **Implementation components**: this component consisting of a strategic action plan, implementation phasing, the volume of public investment, mechanism for financing and stakeholder involvement. Furthermore, the detail description of the components is stated in the proposal part of this project.

Local Development Plan (LDP) implementation is aiming to enable a given neighborhood to be more suitable for living, working, recreation and entertainment. It is an enabler for local communities' to make and activate small scale business enterprise, healthy social environment and community empowerment outputs. [6] During a planning year 2016/7, many LDP plans were prepared for different settlement areas of Mekelle city including other parts of Debri-Dingur area. Some LDPs implemented but many others were outdated. The sites remained under control from any development intervention. In 2017/2018, Mekelle city administration has decided to

prepare and implement Debri-Dingur LDP to solve the problems raised by the community including land ownership issues/tenure, land regularization, land use changes, infrastructure development and socioeconomic benefits.

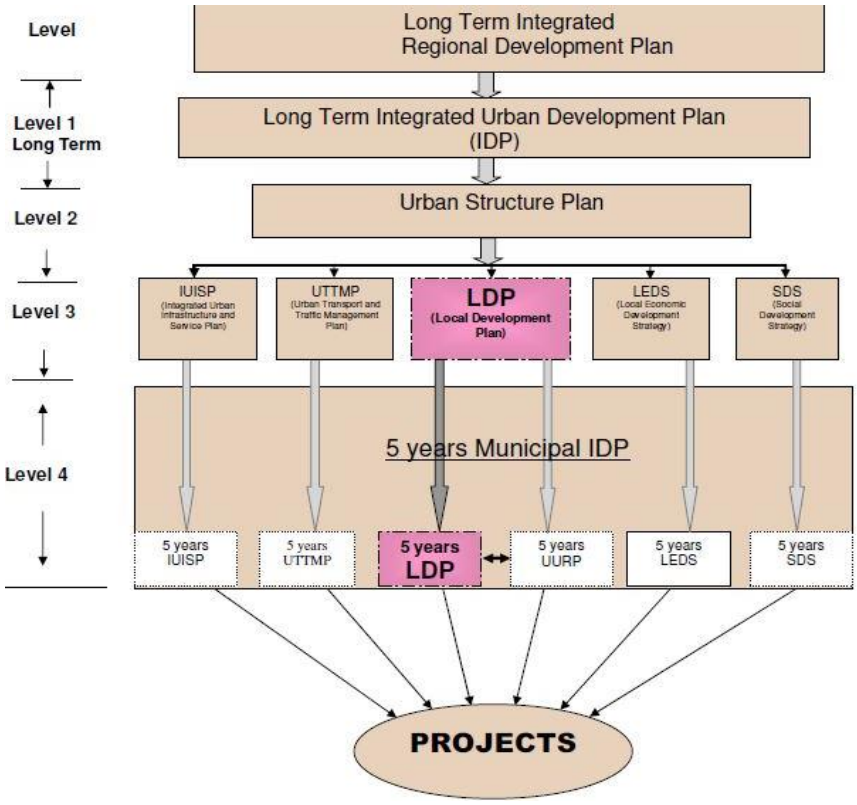

Figure 4: A Framework of the Trend in the Ethiopian Urban Planning System

1.1. Justification of the study

Local Development Plan (LDP) is a lower level urban plan which is prepared within the framework of a structure/master plan. It is detailed and focuses on the specific locality of an urban center for immediate implementation. It is, therefore, an important tool for implementation of structure/master plan proposals. The preparation of LDPs in Ethiopia has a very brief history. Moreover, it is limited to few urban centers mainly central business districts (CBDs). The methodology has been ad-hoc lacking systematized approaches and prepared with lack of expertise knowledge. The approaches pursued by the LDPs prepared for various localities in Mekelle city are not similar due to the fact that there are no locally developed standardized guidelines and well organized consulting firms with different expertise from different field of studies. This has significantly affected the quality of the local development plans so far prepared and impeded their effective execution. Evidently, most of the LDPs prepared for the various localities of Mekelle are either left on shelves or wrongly implemented. [1] Another problem is the knowledge gap in the preparation and implementation of LDPs in Ethiopian urban centers has necessitated for this critical evaluation of the recently implemented Local Development Plan of Debri-Dingur area in Mekelle city with special focus on the spatial analysis.

1.2. Research Objective

1.2.1. General objective

The main purpose of the study is to evaluate the recent implemented local development plan (LDP) of Debri-Dingur area focusing on analysis of spatial changes.

1.2.2. *Specific objective*

- To assess the spatial features with focus on housing, urban morphology, road pattern, built up area and urban density.
- To identify the existing land uses in its composition and dynamics.
- To compare the spatial changes and draw possible recommendation on the land use proposal.

1.3. Scope of the Research

The study of the research covers Debri-Dingur area LDP, which is covering a total area of 1,370,000m2 (137 hectares). The thematic issues in this study are the existing spatial and land utilization. These issues include housing condition, housing facilities, existing land use, physical and social infrastructures.

2. Materials and Methods

2.1 Research study area

Geographical and administration location

Mekelle, the capital city of the Tigrai National Region State, is located in the northern Ethiopia highlands at 783 km drive north of Addis Ababa, the capital city of Ethiopia. Geographically, it is located between $13^0$24'30" to $13^0$36'52" Latitude and $39^0$25'30" to $39^0$38'33" Longitude. It has an average altitude of 2200 meters above sea level with a mean minimum, mean maximum and mean average monthly temperatures of 8.7, 26.8 and 17.6° C, respectively. Amount of rainfall is variable in Mekelle, on average about 600 mm, and more than 70% of it falls between July and August, followed by long dry season [4].

Administratively, Mekelle city is divided into seven sub cities; namely *Hadinet*, *Kedamayweyane*, *Hawelti*, *Semen*, *Ayder*, *Quiha* and *Adihaki*. [5] The study area Debri-Dingur, is administratively found in the fringe of the city in south direction and included in the sub city of *Hadinet* which is recently included in the city administration after the completion of the new LDP. To be more specific on spatial location, the local development plan is in *Hadnet* sub-city near to Debri *tabia* (local administration) in close proximity to Kelamino special high school, *Mizer* low-cost mass housing neighborhood and Meles Zenawi Leadership Academy. The study areas is located in major urban agricultural developments with nearby to major highway Mekelle-Samre and near to the future artificial lake of Mekelle city.

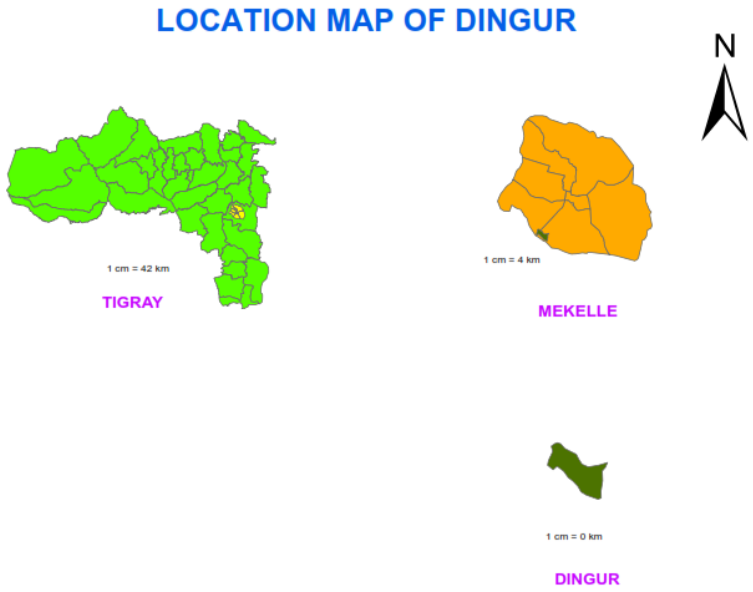

Figure 2: The location map of Debri-Dingur (Source: GIS computation)

Population

Mekelle has an estimated total population of 310,436 [3]. Assessment study indicated (2016) that Debri-Dingur has inhabited with a total number of 458 household heads. In addition, a total number of average persons per household were reported to be 5.6 on the average. To this effect, based on average estimation of persons per household, it is possible to say Debri-Dingur settlement area inhabited with 2,565 population size during LDP preparation period/ 2016/7. [4]

Due to the population increase and new under construction low-cost neighborhood develop, it is important to undertake into consideration to add some number of population size as a contingency at a level of social service requirement planning and land allocation for that purpose. To this end, 7.1% as lower variant, 8.1% medium variant and 9.1% as a higher variant population growth rates are undertaken into consideration to address backlog massive population pressure towards to Debri-Dingur end for the last five years. [4]

Topography and slope analysis

In the administrative boundary of Debri Dingur area which is in the *Hadinet* sub-city of Mekelle city, the slope has classified into five categories that are from 0-2%, 2-5%, 5-7%, 7-10%, and greater than 10%.The slope category from 0-2% is flat area covers 6% of the total LDP site and this creates water inundation which is flood prone with the high cost of construction for drainage lines. The slope category from 2-10% covers 63%, which is a favorable for urban development even though the degree of suitability varies across the slope category. However, the rest 31% is above 10% slope category which is unsuitable for urban development. It is almost one third of the total action area which is 137 hectares.

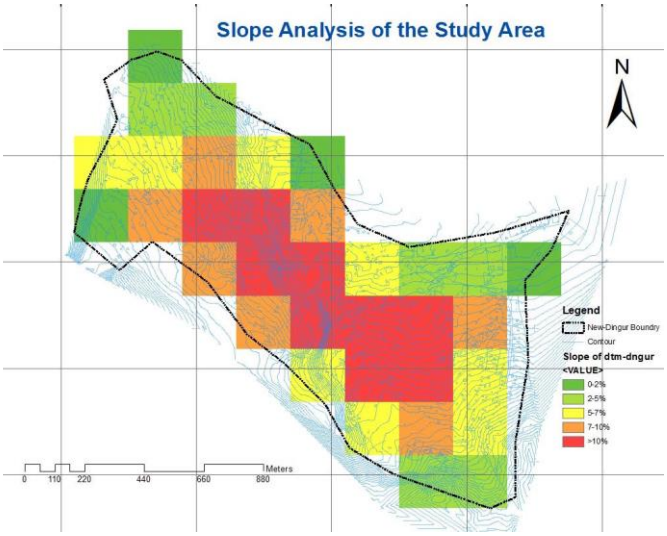

Figure 3: Topography/slope of the study area (Source: Ground Survey, 2016)

2.2 Research Methodology

The detecting spatial or land use change provides a proper background for environmental, planning and urban management analysis. However, examining spatial or land use is not easy due to various factors. To investigate the local development plan mainly the changes on the spatial/land use in the new and first in its kind local development plan (LDP) developed and implemented in the study area, a detail spatial analysis, comparison and categorization was done. The main research method applied here is qualitative and quantitative type of data and analysis was done using categorization, comparison and MS-Excel. Besides, spatial analysis was done using ground survey, aerial photo and GIS computation. Comparative analysis using classification operation enables us to detect trends of land use/cover changes in different times. Thus, map-to-map comparison and post classification comparison were utilized as the main method of analysis.

2.3 Sources and Types of Data

To undertake this study, both primary and secondary data were utilized. The primary data include data gained from randomly selected informants, experts and stakeholder in depth discussion (local administrations and city level administration), analysis, non-structured questionnaire, interviews, ground survey and reconnaissance survey through site visit or observation of the study. Secondary data were taken from relevant literature, review of the previous studies and documents, working manuals, reports and notes by assessing relevant documents from different sources that elucidate the spatial development and changes. Besides, the research mainly utilizes both qualitative and quantitative type of data.

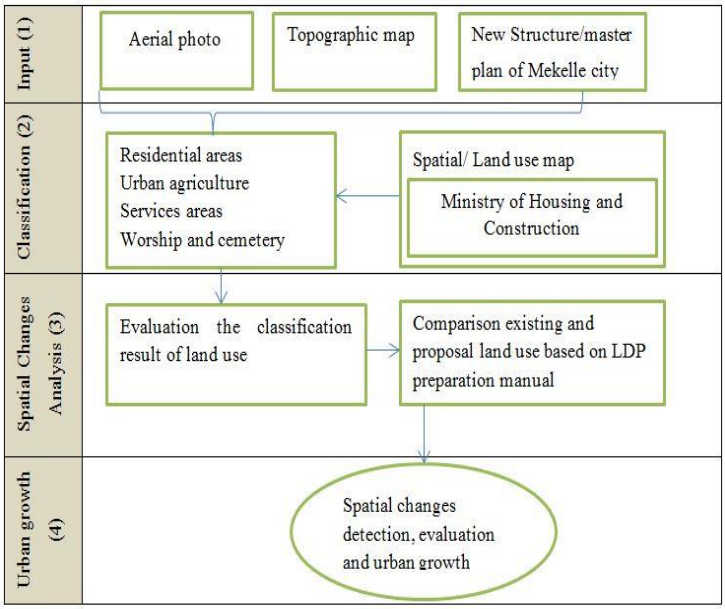

Figure 4: Methodology for evaluation the spatial changes in the LDP of Debri-Dingur area of Mekelle City

3. Situational Spatial Analysis

Introduction

The spatial expansion trend of Mekelle city in the last decade is relatively very fast. It expands towards the four directions of the city by incorporating new rural settlements. In the newly revised structure plan of the city, the Debri–Dingur peri-urban area is proposed as one of the potential growth direction of the city. It was originally restricted around the locality of parts of today's called Debri-Mekayih, where the initial settlement was, and began to expand into the south. The large swampy open area in front of the settlements offers a grazing land for the animals. This area lies in the major urban agricultural land in the city near to Kelamino River, so the re/development of the area is very important in terms of the future development of the city as well as enhances the living environment of the people. Debri-Dingur area is also located in the future center for the entertainment and modern urban agriculture development. In general, the study area is characterized by lack of basic utilities and social services, poor housing condition as well as relatively low income people with small scale agricultural activity, irregular pattern of roads and blocks and rugged topography and swampy areas. [4]

The study area has been considered as one of the Local Development Plan project areas of the structure plan to improve the basic infrastructure provision and improve the accessibility and enables the area to play its future role as part of the mixed use residence. When the asphalt construction from *Mayweini* is completed, the vehicles will prefer to travel via this road and it will become an important commercial development area. Hence the road will be an important infrastructure to attract new development. The study area is also exposed to legal and illegal land occupation by the nearby administration and the residents. [4]

Figure 5: Showing settlement of the study area (Source: Google map 2017)

Spatial Characteristics of the Local Development Plan (LDP)

Debri-Dingur area land use cover is mainly characterized by housing and also important functions like a market place, service sector area and road. The Debri-Dingur area LDP is characterized by a different plot and block layouts. Irregular plot and block arrangements of the old settlement of the area is characterized by inaccessible settlements, poor basic infrastructure facilities (water, power and telephone), poor to fair housing condition, irregular parcel layout with large plot size, irregular block layout arrangement, lack legal land ownerships (land tenure problems),swamps or wetlands and social infrastructure problem.

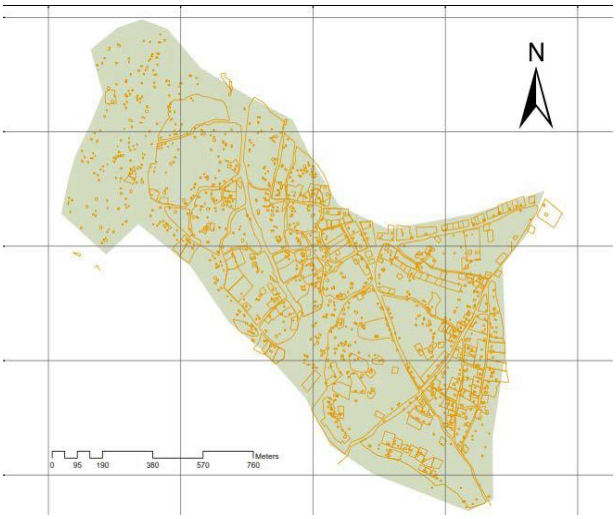

Figure 6: Map showing the spatial characteristics of the area (Source: Ground Survey)

The assessment of the land use shows that the study area lacks basic social services like a Kindergarten (There is only one KG available), health center, farmer's training center, playground and public facilities (toilet, garbage collection). The LDP area is dominantly occupied by residential land uses which are dispersed all over the site without following the standard planning and some of them are mixed-use with other urban agricultural activities, notably fattening and dairy farms.

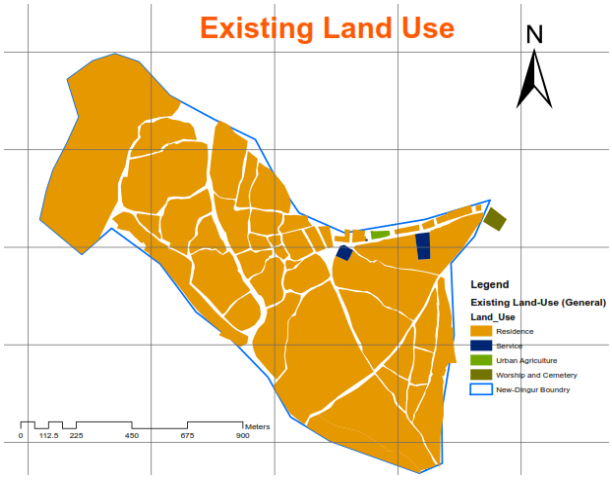

Figure 7: Existing land use (Computed by author)

In the new structure plan the study area has mainly mixed development which includes housing and commercial function and there is a proposed an artificial lake.

Figure 8: Structure plan land use cover of the study area (Source new structure plan of Mekelle city)

Urban Density

As shown in the figure 9 below, the action area of Debri-Dingur area covers 137 hectares of land and there are about 458 inhabitants in the area. The gross population density of the LDP site is 3.34 residents per hectare. When comparing the density of the site with that of other parts of the city, it is sparsely scattered.

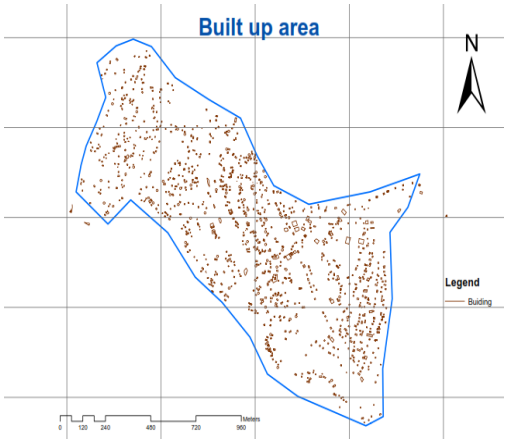

Figure 9: Built up area of the study area

Existing Morphology and Block Arrangement

The LDP site has an irregular arrangement of blocks since the area is dominated by old settlements of dwellers. The irregular block arrangements have caused the site not to easily get links well with the rest parts of the city. It has also made the local roads narrower and some of them are even dead ends. Generally the unplanned block arrangement and haphazard development has left the area with poor road hierarchy.

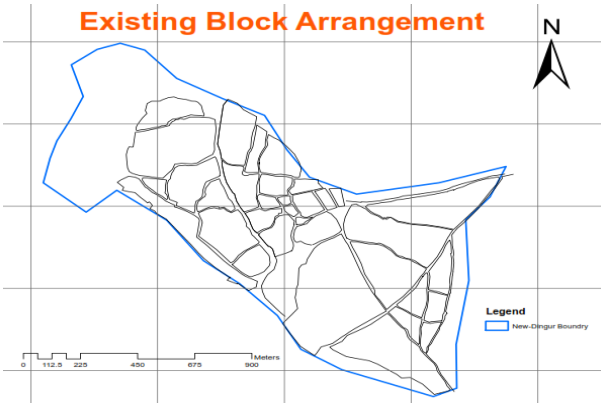

Figure 10: Existing Morphology and Block Arrangement (Computed by author)

Based on household non-structured assessment results and ground surveying and field observation made the following possible: concluding strategic actions have been made to address LDP assessment results of Debri-Dingur area.

Plot size and BAR (Built up Area Ratio):

The LDP residence acquired large plot areas compared with the main urban areas standard (140m^2 and above) however, with very small built up areas in proportion to the total area, this implies that the study area is not well developed yet and sparsely scattered development, vacant spaces and underutilized plots are common. Houses within the range of 300-600m^2 plot sizes are common; thus, plots below the minimum standard and excessive plot areas need planning intervention to be regularized the tenure system.

Land acquisition and tenure:

It is only 43.2% the residences acquired their land from local administration/municipality. This implies that there is another way of land acquisition means and need to follow legal framework for land administration; hence, illegal housing construction and squatter settlements is vivid.

Housing Ownership:

In the Debri-Dingur area, 88% of the housing units are privately owned and this indicates the housing provision and development is dominated by the private or self-financed land developers.

Housing function:

The houses mainly function as a living area and 95.2% of those are used as a residence or living. Hence, this makes the LDP area economically inactive.

Housing Typology and condition:

The common housing typology is the row house which accounts for 46.9% of the total housing typology and the rest is detached and other housing typology. The physical housing conditions in the Debri-Dingur LDP is 56.1% which accounts for the medium housing condition since 45.7% of the housing are constructed before 10-20 years ago.

(a)

(b)

Figure 11: The housing condition of the study area

Building materials and housing construction:

The majority of the materials of the houses for wall, ceiling, roof and floor are made of local abundant construction materials. Mud and stone are the widely used local materials for floor and wall with 77.3% and 78.2% respectively, and the most common roofing material is CGIS which accounts for 85.6%. Some flat *hidmo* house (vernacular housing style) are still available.

Housing facilities and utilities:

Traditional kitchens accounts for 69.2% and most of them are in poor quality. There are also 98.5% of the houses without toilet and shower and existing toilets and showers are also in poor physical condition.

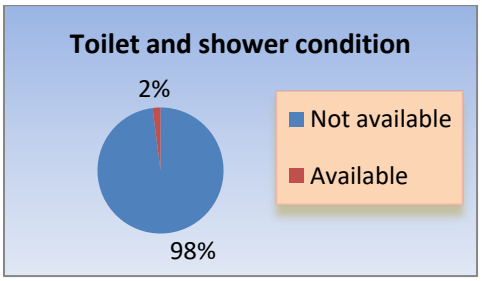

Figure 12: Toilet and shower in the study area

From the existing unplanned road 53.1% are in a poor condition and also there is lack of access and connectivity, no drainage and water supply systems, insufficient of access and supply to electric and telecommunication networks. In the entire existing housing unit, there is no septic tank and the solid waste is dumped on various open spaces. Therefore, special emphasis should be given to the design, construction of housing, and provision of infrastructure in accordance with planning rules and regulation during the proposed LDP implementation period.

(a)

(b)

Figure 13: Access road to the study area

4. Conclusions

Before going to the spatial comparison (existing land use, gap analysis and the proposal) it is very important to see the concept plan and the general framework of development which helps to solve problems mentioned in the situational analysis and it includes:

General framework of the concept plan development:

- Upgrading the old neighborhood by providing suitable access and efficient road linkage
- Providing basic infrastructures and utilities
- Improve the security of tenure
- Provide sufficient social and municipal services.
- Improve the residential with various dwelling densities and types of housing.
- Ensure efficient use of land for different uses.
- Provide a good quality of public spaces and enhance the quality of the environment

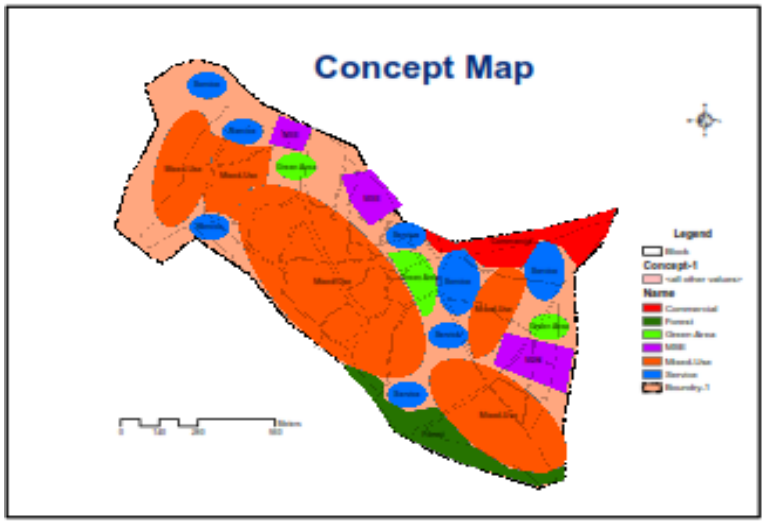

Figure 14: Concept map of land use proposal

The planning area for the LDP includes proposed potential area for park, river for urban agriculture, connectivity, social services, churches, recently on going and under construction of good quality residential neighborhoods. The action area for the LDP includes health center, some micro and small industries. However, it lacks open space and greenery, poor quality infrastructures and residences. The area covers a total of 137 hectares.

Existing Land use, Gap Analysis & Proposed LDP

The evaluation of the existing spatial cover and the new developed LDP proposed and currently implemented has been compared based on the Federal LDP manual or standard as stated in the table 2.

Table 1: Existing Land use, Gap Analysis & Proposed LDP

No.	Land use components/elements	Standard	Existing (ha)	Gap in %	Proposed in %
1	Housing (Residence)	40-50%	121ha (88%)	38%	58%
2	Business and commerce	7-20%	-	8%	8%
3	Services (special functions)	10-20%	0.96ha (0.7%)	10%	6%
4	Green, recreation, sports and environmental sensitive area	15-20%	4.1ha (3%)	11%	11%
5	Administration	3-7%	0.023ha(0.02)	1.5%	1.5%
6.	Manufacturing and storage	10-15%	0.5ha (0.37%)	2.5%	2.5 %
7.	Utilities and infrastructures	15-25%	10.4ha (7.6%)	13%	13%
	Total	**100%**	**100%**		**100%**

Proposed Land Use Allocation

The study area is found on the fringe of the peri-urban area and the LDP is newly developed to include the study area in the rapidly urbanizing Mekelle city administration. Hence, based on the population growth and LDP manual prepared by Ministry of Works and Urban Development, Federal Urban Planning Institute, in order to propose the land use zoning for newly developed LDP the following land allocation have done and based on the land requirement, the total action area, population and standard the spatial allocation is stated in the table 1.

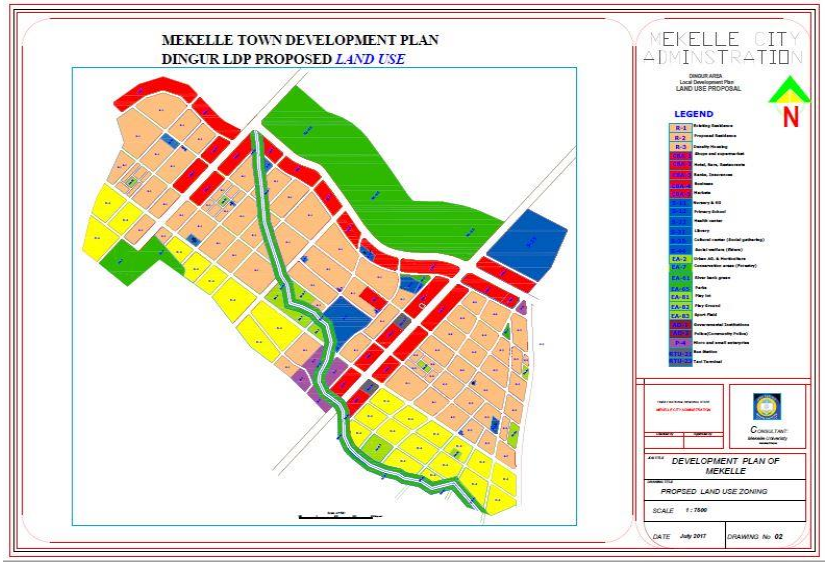

Figure 15: Proposed land use of Dingur-Debri area

Figure 16: LDP land use proposal

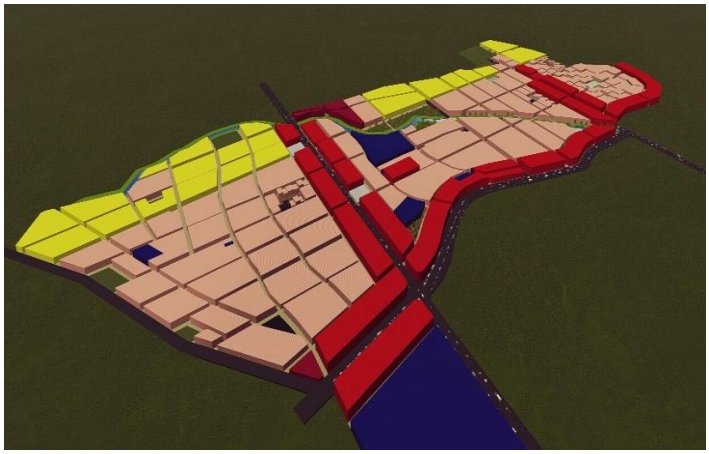

Figure 17: 3D of the land use proposal

Table 2: Existing land use, gap Analysis & proposed use allocation

No.	Spatial Services	Proposed No.	Area (msq)	Total area (msq)	Remark	Existing No.
1.	Nursery	3	175	525		0
2.	KG	2	1500	3000		1
3.	Primary school	1	18,000	18,000	Maximum population of 25,000	0
4.	Health center	1	2000	2054	2054	1
5.	Model Cemetery	1	50000	50,000	Out of the LDP area	0
6.	Elders recreation area	1	500	500		0
7.	Social gathering /festival places	1	25000	25000	18,175.5	0
8.	Market center	1	2500	2500	2550 Small scale	0
9.	Community empowerment center	1	500	500	635	0
10.	Housing	1080 (HU)	140	151,200		
11.	Urban agriculture Poultry and livestock production			10,657		1
12.	Manufacturing			8117	Garage also	0
13.	Carwash		1500		1000	0
14.	Garage & parking			Manufacturing		0
15.	Retail				CBA	0
16.	a)Play lot	5	1066	2000	1000-2000 standard	0
	b) Play ground	1	3456	3000	3000-4200	0
17.	Kebele Level Football field	1	7676	7676	8064	0
18.	Administration					0
19.	Community police	5	175	875		1
20.	Public Water Tap	5	25	125		-
21.	Mobile Toilet with Landscape	1	300			

5. Recommendations

The newly developed LDP, which is a fancy neighborhood spatial proposal includes all the spatial elements and with its building height regulation has tried to follow the standard land use allocation according to the Federal LDP preparation manual, but it needs strategic approach how to implement the proposal, including the time framework or phasing based development. It should indicate the community and stakeholders' engagement during

the actual implementation. The proposed LDP also needs to recommend higher land use coverage of mixed residence, excluding pure residence areas which make it uneconomical to the local administration and the dwellers unless its implementation is in phase based approach with pure residence as an alternative land use. The LDP's spatial proposal has discrepancy with the main structure plan of Mekelle city. Based on the findings, discussions and conclusions, the following recommendations are also forwarded:

- The local administration shall provide and regulate the land according the standards and regulations of the Federal urban planning manual and the newly developed LDP. The existing land ownership issues and illegal land acquisitions should also need legalization and standardization.
- Most of the local residence areas support the local development plan since they are looking forward to a better urban area with ample infrastructure and facilities, but a continuous awareness creation programme is very important to continue such participatory approach.
- Before desiring to give land for other new dwellers, it is necessary to empower/secure residents' livelihood & wellbeing using urban agriculture, small and medium enterprises, business centers, indigenous recreation center, etc.
- Landfill site and the solid waste collection and disposal of the site should be improved and integrated with the main city, Mekelle.
- Better to use rehabilitation rather than to use compensation approach during a time of LDP implementation practice to help the original dwellers.
- Provision of infrastructure that enables residents to run business and access social services should be prior to give land for new residence.
- All the development should consider increasing the creation of job opportunities by SME (small and medium enterprises) for unemployed youth community.

Acknowledgements

The author wishes to express his gratitude to all people who have participated directly and indirectly during the research work and special thanks goes to my spouse Feven Tekeste.

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Impact of Road Improvement for Non-Motorized Transport Viability (A Case Study on Shashemene- Halaba Kulito Road)

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Abstract

This research aims to assess the impact of road improvements on the viability of NMT in rural Ethiopia. This case study is conducted on the road from Shashemene to Halaba Kulito town with total of 64km asphalt road. The research describes methods of road improvement by evaluating costs (vehicle operating costs, travel time costs and accident costs savings) and benefits of non-motorized transport. This case study dealt with primary and secondary data which included field surveys and document reviews. Primary and Secondary data were collected through visual field observations of the study area by including existing types of non-motorized and motorized vehicles through traffic count survey and current road condition. The raw data were acquired by contacting the Operators, Traffic Polices, Transport Ministry and Roads Authority. The types of road improvements considered in the research were widening by 3m with Single Surface Treatment (SST) and Lane Addition with Double Surface Treatment (DST) for NMV. Based on the acquired data, HDM-4 analyses were performed to generate the required economic parameters for two alternatives that are Net Present Values (NPVs), Economic Internal Rate of Return (EIRR) and Benefit-Cost Ratios (B-CRS). As a result of this, alternative-2 (NMV lane addition) project can be taken as feasible. This improvements highly impact on the viability of NMT in the project area. Out of the total benefits, a minimum of 63.7% were generated from NMT operations, 36.2% from MT, and the remaining 0.13% from accident reduction. This confirms that NMT operations on the Shashemene-Halaba Kulito road is strongly viable and this road improvement can be replicated to other rural areas of Ethiopia.

Keywords: *Non-motorized transport, vehicle operating costs, travel time costs, accident costs, economic parameters, and HDM-4.*

1. Introduction

1.1 Background

Non-motorized transportation (NMT) is the primary means of transportation for people in many developing countries and it is essential to consider the design and modernization of its transportation system. The common form of NMT include: bicycles/tricycles, human porter-age, pack animals, handcarts/wheelbarrows, animal drawn carts, and other human powered vehicles. NMT includes any form of transportation that provides personal or goods mobility by methods other than the combustion motor. NMT provides a very flexible solution to accessibility, especially where resources are scarce (Replogle, 2009). In many developing countries, rural transport infrastructure used to access farms, markets, water supplies, schools, and clinics is often in poor condition for some or all of the year. Improving rural transportation to reduce poverty thus requires a combination of appropriate transport infrastructure and affordable transport services. This research focuses on non-motorized transport services by exploring transport infrastructure. The use of NMT is increasing in some regions mainly because of their affordability, flexibility and cost-effectiveness in providing low cost transportation. This has led to the recognition that the full range of transport needs in many countries would not be adequately catered by MT alone. Therefore, it is emphasized that investment policy in the road transport sector should include NMT issue. A formal method has been developed for calculating the operating costs incurred by NMT on roads and thereby for estimating the benefit derived by NMT from road improvements. The presence of NMT can influence the speed of motorized transport, thereby affecting the operating costs of motorized vehicles. In addition, a policy such as road improvements influences the costs and benefits of both motorized and non-motorized road users.

1.2 Project evaluation criteria based on literature

According to the Ghana Project Evaluation Criteria Manual (2009), the evaluation of projects should be undertaken using a multi criteria analysis approach integrating, in particular, economic, social, and environmental aspects.

Simmons et al. (2015), stated that there are many individual and societal economic impacts in investing on NMT in consideration with the potential economic impact of NMT projects at the time of planning and decision making. These potential benefits include: conventional economic benefits related to infrastructure, travel time savings, reduced transportation operating expenses, and safety improvements.

Ethiopian Roads Authority, Country Report 4, (2009) indicates that breaking down the rural isolation can enhance the local income-generating opportunities as well as open access to markets and social services. The findings of the study have not only presented a situation analysis on rural transport and use of animal drawn carts, but the study has also suggested guidelines for implementation and monitoring of a project to increase the use of the IMT.

The Highway Design and Maintenance Standards Model (HDM 4) developed by the World Bank has been widely used to analyze the economic consequences of road projects. This tool is a model used to conduct economic and financial analysis of road projects. The Model performs strategy, program and project analysis. This HDM-4 will help decision makers to justify the cost of implementation of non-motorized transport interventions. All costs and benefits are valued in monetary terms. The costs are expressed in economic prices to reflect the true resource cost to the economy. Benefits to NMT users accrue when dedicated infrastructure is created for NMT. Provision of appropriate infrastructure for NMT has different benefit. The most significant benefits are the reduction vehicle operating cost, time savings to NMT/MT user due to improvement in NMV/MV speeds and reduced fatal / serious injury accident.

1.3 Study Area and Population

The selected case study area is located between two cities of Ethiopia, Shashemene to Halaba Kulito town. Totally, the study project covers a length of 64 km of asphalt road. So, the non-motorized vehicles, especially animal-drawn carts are the major transportation service providers in this area for movement of passengers and agricultural inputs and outputs from home to the fields and harvested crops from the fields to the storages. They are also used to transport commodities to markets.

In this research, the Population surveys were carried out in Shashemene, Aje and Halaba towns. However, depending on the homogeneity of the data separately gained from the three Woredas, the total road sections were aggregated into different sections: Shashemene-Abuara section with 20 km which includes 0.3 km of gravel road; the Abuara-Yayi section with 31km and the Yayi – Halaba Kulito section with 13 km which is located in the three woredas of Shashemene, Shalla and Halaba. In this regard, the following data were collected: traffic data comprising the type of non-motorized vehicles, and motorized vehicles with respective percentage compositions, in both cases, road data, and accident data.

1.4 Statement of the Problem

The existing Shashemene – Halaba Kulito asphalt road is 64 km in length. This roadway is crowded by animal drawn carts, which is one of the major NMT services in the study area. The carriageway of the road is insufficient to sustain both motorized and non-motorized vehicular transportation demand. It is a major factor that affects the performance characteristics of NMT and MT; thereby it affects users' costs and benefits by increasing the cost of travel time, wear and tear of NMT vehicles and components, and fares/user charges. It also increases the degree of conflicts with MT traffic (accident rates) resulting in reduction of economic importance for the road users both as a mode of transportation and as a source of income and reduction of social benefits.

Currently, the Shashemene – Halaba Kulito road provides services for various slow and fast moving vehicles as well as for mixed motorized and non-motorized means of transport. However, according to the ERA (2016) condition survey result, the existing road condition is very bad that the pavement surface has almost deteriorated and is with insufficient width to cope up the operations of both motorized and non-motorized traffic volume. Therefore, the road must be improved (up graded) to increase the benefits of non-motorized vehicles through less operating costs which will not only benefit non-motorized vehicles but also motorized vehicles with better performance characteristics concurrently reducing accidents.

1.5 Objective

1.5.1. General objective

The general objective of this study is to evaluate the impact of road improvement for NMT operational viability on Shashemene – Halaba Kulito road after analyzing the effects.

1.5.2. Specific objectives

The specific objectives of the study are to:

- Assess the current levels of NMT operations on Shashemene-Halaba Kulito road compared to MT.
- Assess the existing road condition and propose improvement alternatives for viable NMT operations;
- Determine the financial and economic viability of NMT operations on the study road compared to MT, as result of road improvement.

2. Research Data

2.1 Traffic data

Traffic data were required to undertake the required analysis to test the viability of NMV. The traffic counts were conducted at three woreda locations. The first location was taken at Alilu Eilu kebele. The second traffic counts were conducted 2km before the exit to Aje village towards Halaba Kulito. The third traffic counts were

carried out at the entrance of the Halaba Kulito town at Gadaba kebele. These locations were selected based on the NMV high activities. The counts were carried out on two directions at each location.

2.2 Road Data

The existing road condition data were acquired from the ERA document, "Detailed Paved Road Condition Survey Report of 2016" and these were substantiated through visual inspection. The data gathered consisted of geometric characteristic of the existing road, surface conditions of road facilities, and the roughness of the road surface and deterioration of road surface (distress type).

2.3 Traffic Accident Data

Road traffic accident data were collected from three traffic police stations. The data base consists of three-year accidents which were collected from the three woredas police stations. Then, costs by accident types (fatal, injury and property damage) were collected from Medhin Insurance plc.

2.4 Data Needed for HDM-4 Project Analysis

2.4.1 Network Data

This study uses HDM-4 software packages to show the impact of road improvement on the viability of NMT on Shashemene – Halaba Kulito road. The HDM software packages require different sets of data inputs. On the study road, condition surveys were conducted by the ERA in 2016. Relevant data from the survey results were considered as input data. In addition, subjective measurement (visual inspection) data were also included as input data. Similarly, data acquired from the South District ERA Authority through interviews were comprised in the analyses together with the existing road condition and defect values. Each road section is defined based on length, carriageway width, traffic flow, shoulder width, and surface class. The geometry of each road section includes rise + fall, super elevation, average horizontal curvature, acceleration noise due to driver, road alignment, posted speed limit, speed limit enforcement, and altitude.

The default values of geometric classes by each road class are defined and presented in the HDM-4 Manual, Volume-2. Table 1 below presents the values utilized in this research.

Table 1: Definition of geometric class by geometric parameter

No.	Geometry Class	Rise + Fall (m/km)	Number of rises and falls per km	Horizontal curvature (deg/km)	Super-elevation (%)	Speed limit (km/h)
1	Straight and level	1	1	3	2	110
2	Mostly straight and gently undulating	10	2	15	2.5	100

Table 2: Speed limit and speed reduction factor for improved road

Alternative	Widening	Speed limit	Speed reduction factors		
		km/h	NMT	MT	Roadside friction
1	None	100	0.7	0.9	0.7
2	+1 m	100	0.75	0.9	0.7
3	+3 m	100	0.9	1	0.8
4	+2 lanes	120	1	1	1

The geometry of the Shashemene – HalabaKulito road is mostly straight and gently undulating. The default values of geometric parameter are used from Table 2. The altitude is also included in the geometric characteristics. The posted speed limit needs to be specified; in this case 70 km/hr was used. In the case of speed enforcement, the default value of 1.1 was not used since this value indicates that the traffic will travel up to 10 percent above the posted speed limit. However, in this case study, there is no posted speed enforcement and thus one was used to indicate that the posted is the enforced speed with no added provision.

The default value of 1 was used for roadside friction since no side friction occurs. However, on the study road, there is huge NMV activity, especially animal drawn carts, so both MV and NMV interfere each other. Because of this, values of 0.5 and 0.7 have considered in the case of XMT and XNMT respectively under the base case alternative (before improvement) of the study road.

2.4.2 Traffic flow periods

Default flow periods were used for Shashemene - HalabaKulito road. This flow period is inter-urban and data provides the results regarding volume per capacity. Table 5.3 below presents the hourly traffic flow distribution data as provided in HDM-4 Manual, Volume -2. The climate zone along the Shashemena and Halaba Kulito road is sub-humid. To identify the environment applicable to the immediate vicinity of the road project is located in tropical zone with temperature range of 20–30˚c.

This temperature class was adopted in the research. The average annual rainfall of the three towns: Shashemene, Aje and Halaba Kulito amounts to 813 mm. Thus, the moisture classification of the road is sub–humid. In order to conduct the economic analysis, a discount rate of 10.23% was adopted in the research since it is commonly applied in Ethiopia. Accordingly, both costs and benefits were discounted at 10.23% to convert their future values to present year and judge the viability of the project based on the net present worth (total discounted benefits minus total discounted costs). Similarly, both IRR and B-CR were calculated using the same discount rate.

2.4.3. Vehicle fleets data

In addition to the ERA vehicle classification of car, land rover, small bus, large bus, small truck, medium truck, heavy truck and truck trailer; NMV mainly: rickshaw, motorcycle, animal drawn cart, bicycle and pedestrian were included in the study since they were the focus of the research. The default values in HDM-4 (tire type, number of wheel, operating weight, annual kilometers driven, annual working hours, service life of the vehicle and loading amount) were used in the case of motor vehicles because these values appropriately represent the characteristics of the study area but not in the case of NMV. NMV fleet characteristic and utilization characteristic in the study area not the same as HDM-4 NMV fleet characteristics. For example, annual kilometers coverage, annual working hours, service life of the vehicle, percent of time a vehicle is driven for private use, average number of passengers per vehicle are not similar. Financial costs of new vehicle, tire, fuel lubricating oil, and working hours of labor were collected from the report of the Ethiopian Trade Commission, 2016/2017. The financial costs were converted into economic costs multiplying by 0.85, indicating that 15% of the costs are transfer payments mainly taxes.

2.4.4. Functional characteristics of NMV in the study area

The data about the performance characteristics of NMT on the study roads were collected through interviews of operators in the towns of three woredas and these are the following: Travel distance, and time, Wear and tear of vehicles, and Fares/user charges.

2.4.5 NMT operating cost

The operating costs of NMVs were estimated for the study area. The basic information for the cost components listed below was obtained primarily from interviews of manufacturers/NMV traders, owners, operators, pullers and passengers. Generally, the cost comprised of fodder of cart puller animals, tires, maintenance cost, crew costs (including food), annual taxes, overhead, and passenger time. The total time and operating costs of each NMT type were calculated separately and aggregated using the following formula as used in HDM-4 manual on volume-4.

TOCk = TMCk + VOCk

Where:

TOCk: total time and operating cost of NMT type k per vehicle km;

TMCk = travel time cost of NMT type k (cost/km); and

VOCk = operating cost of NMT type k (excluding pedestrians) (cost/km).

The cost of travel time is directly related to average speeds. The time cost comprises: passenger time value and cargo holding cost that are calculated using the following formula as suggested in HDM-4 manual volume-4.

TMCk = PAXCk + CARGCk …… Eq 4.5

PAXCk = passenger time value for NMT type k per veh-km.

CARGCk = cargo holding cost for NMT type k (cost/km)

The value of passenger time is calculated using the following formula: indicated involume-4 HDM-4 manual.

$\ldots PAXCk = PAXVk/Sk$……Eq 4.6

where; Sk = Average annual speed of NMT of type k (km/hr)

Physical characteristics of NMT encompasses operating weight and type of wheels; NMT utilization comprises: average service life, annual number of km travelled and annual number of working hours; unit costs comprise: purchase costs, interest rate, hourly crew wages, and passenger and freight value of time, energy; road characteristics comprise: length, vertical alignment and surface condition). Similarly, model calibration parameters and NMT traffic data are included.

The annual kilometers travelled (AKM) are calculated using the following formula shown in volume-4 HDM-4 manual.

$AKMK = Sk * HRWKOk$…… Eq 4.7

where:

HRWKOk = baseline average no. of NMT working hours per year

HRWKOk = 2522.16 hr/year

The crew cost per km, CRWC of each NMT type k calculated by

$CRWC = CRWVk/Sk$……..……Eq4.8

Where:

Average crew wage per hr, for NMT type k (cost/km) then change birr/hr

The repair and maintenance cost per km RMC includes costs of replacing tires, breaking devices and other components, lubricant oil and the cost of maintenance labor. This can be calculated using the formulae stated below comprising two equations used in volume-4, HDM-4 manual.

Average Road roughness (RIav)

NMV vehicle age measured in terms of cumulative km travelled (CKM)

RMCK= (a_rmc+b_rmc*RIav)*CKMk*PCHCk*10-3…….Eq4.9

CKMk= 0.5*AKMOk*LIFEOk……... Eq4.10

CKMk=average km travelled by NMT type k (km)

AKMOK=baseline average annual km travelled by NMV type k (km/year)

PCHCK=average purchase cost of NMV type k.

There are 5 types of animal-drawn carts operating on the study road and the types depend on materials used in their manufacturing and these include Sodo cart, 45, 40, 36 and 32-Symiyaz. Each has its own physical characteristics. For bicycles and pedestrians, the default values have been used since they are similar to those operating on the study road.

Table 3 below presents sample examples of NMV fleet data which were entered the HDM4. The data were collected through interviews with the operators. Other types of NMV fleet data are presented in appendix II.

Table 3: Sample example the NMV fleet data that is input into HDM-4.

Item	NMV vehicle fleet data	
	Animal drawn cart	
	Sodo cart with 2 hourse	45 symyaz cart with 3 donkey
Type of wheel	Penumatic	Penumatic
Operating weight of passanger	20-30	10 to 15
Pay load(kg)	1,500-1,700	1,000-1,200
Number of wheel(No)	2	2
Operating weight of fright(kg)	1,900-2,100	1,300-1,500
Wheel diameter(m)	1	1
Service year	8	6
Annual number of km travelled	20,177.28	15,763.50
Annual number of working hours	2,522.16	2,522.16
Purchase cost (ETbirr)	23,600	14,600
Interest	0.00	0.00
Hourly crew wage (ETbirr/km)	7.66	6.39
Passanger value of time (ETbirr/km)	1.22	1.45
Cargo value of time	0	0
Energy(kJ/km)	2293	2340
Energy used (birr/mJ)	0.55	0.69

2.4.6 Work Standards Data

The target standard depends on level of the road condition aimed to achieve. Regarding this project, different standard were set up that can be applied in order to meet the specific objectives related to functional characteristics of the road system.

A. Type of standards

According to the surface of the existing road, the characteristic of traffic on the section, and the general operational practice were based on engineering and economic considerations. Accordingly, the standards are grouped in to two as follows:

- Routine Maintenance and
- Road improvement

On the study road, the required maintenance was considered to be routine every year up to the end of analysis period. This was a base case alternative for specific maintenance works. The presumed maintenance works were: Patching, Crack sealing, Edge-repair and Drainage works.

Generally, two improvement alternatives were selected for the study road and these were:

- Partial widening by 3m with single surface treatment and re-surface of existing pavement;
- NMV lanes (NMV lanes addition)

B. Estimated financial cost for improvement and maintenance of the road

In respect to agency costs, infrastructure costs for improvement (considering the NMT) and maintenance costs of the Shashemene-Halaba-Kulito road were estimated based on information from relevant sources. The unit rates were established based on available resources such as prevalent market rates, data from recently awarded projects, quotations from vendors, etc.

ERA Cost Estimates

Routine Maintenance -- Unpaved = Birr 150,000 per km

Paved = Birr 200,000 per km

Improvement = Between Birr 1, 000,000 and Birr 10,000,000 per km.

The following economics costs were estimated:

- Routine Maintenance for paved (RM) = Birr 533 per m^3;
- Routine Maintenance for gravel road (G-RM) = Birr 400 per m^3;
- Miscellanies: - Birr 50,000 per km = Birr 339 per m^3;
- Partial widening by 3m with single surface treatment = Birr 2,000,000 per km
- One way NMV lanes = Birr 5,000,000 per km

Accidents data in the study were accounted for and done by collecting the necessary costs from insurance companies in Shashemene. Accordingly, fatality, injury and property damage costs were collected as 42,000, 70,000 and 200,000 ETB respectively.

2.4.7 Estimation of traffic growth rates

One way of forecasting traffic by assessing correlation between traffic and gross domestic product (GDP) or GDP per capita and calculate related elasticity is to use fuel sale statistics (i.e. petrol for private car traffic, diesel for bus and truck traffic).(Trisha Sen2013). According to IMF (International Monetary Fund) world economy outlook data base in April 2015, gross domestic product based on purchasing power party (PPP) per capital show high increase in the years to come. However, world population perspective (2017 Revision)data show the population growth in Ethiopia in the future year tend to decrease. Depending on the past 10 years GDP, the population growth rate, future economic condition of Ethiopia (forecast GDP and population growth rate) and traffic growth rate were established. The average Traffic growth rate for five years equals to the average growth rate of both GDP and population (the sum of the GDP and population growth rate within 5 years divided by two). Then, the estimate traffic growth rate of all vehicle types equates to 6%, in 2018 to 2022, 7.1% in 2023-2027, 7.32% in 2028-2032, 8% in 2033-2037, and 6% after 2038 because at the end of the analysis year, it is assumed that the road almost tend to be old .The users are also going to decrease as the GDP of Ethiopia increases.

3. Analysis and Results

The project analysis steps are the following:

A. Configure the HDM-4 workspace

Configure the HDM-4 workspace with proper default values for the country. The process of configuration for a network is the same as for a project-level evaluation.

B. Define Vehicle Fleet

Define the vehicle fleet in terms of motorized and non-motorized vehicles that are the most common vehicle types in the road area and different traffic growth scenarios. In this project, a total of nine (9) motorized and three (3) non-motorized vehicle types were defined under the vehicle fleet.

C. Define Road Network Classes

Define the road network that contains the road classes that will be evaluated. Five (5) possible road classes were defined in terms of surface type, traffic load and condition. Each road class is identified by an ID code and a description.

In this case, the first letter of the ID code refers to the surface type (G for Gravel and P for Paved Surface roads. Finally, define work standards and project.

- Define Project detail

On this window general, select section, select vehicle and define normal traffic tab page is displayed:

- ✓ General

Under general, data are entered in respect to description of the project, analysis type whether by section or by the whole project, project start year, project life period, road network, vehicle fleet, and currency required in outputs Select section.

- ✓ Select vehicle

The vehicles selected from the pre-defined Shashemene-HalabaKulito vehicle fleet included both MT and NMT in the analysis; then there was a verification of each vehicle type.

- ✓ Define normal traffic

This confirms the volume of traffic using the selected road section in the given year. The initial traffic composition and growth rates (by vehicle category and type) define for all section for both MT and NMT.

Alternatives:

Three (3) alternatives are defined including the base case for the five (5) sections:

- Project Analysis

The set up run screen confirms the selection of the base alternative without widening and the selection of the discount rate of 10.23% which is commonly used on road projects in Ethiopia. In this study, accident costs were included; however, energy balance emission and acceleration effect were not included due to unavailability of data.

- ✓ Run the analysis

This starts the analysis and produces the output necessary for report generation.

- Generate report

The outputs reports from the HDM-4 analysis are produced under generate report/select report. The types of outputs for Non-Motorized transport were similar to motorized transport and the outputs include: NMV speeds, NMV traffic flows, time and operating costs, and accident costs.

3.1 Current NMT and MT Traffic Levels

Animal drawn carts are of high volume out of the total NMT and MT vehicle volume mentioned in Fig 3.1, Fig 3.2 and Fig 3. In Halaba Special Woreda, animal drawn carts are highly used compared to Shashemene and Shalla woredas. Next to Halaba woreda, the communities heavily use animal drawn carts in Shashemene woreda for passenger and freight transportation.

Generally, on Shashemena - HalabaKulito road, animal drawn carts are the most usable mode of transportation. The services are highly available, flexible and give door-to-door services. Therefore, NMT is a highly beneficial means of transport in the study area compared to MT.

3.2. Existing road condition evaluation

In order to measure the condition of the pavement, different testing techniques were used by ERA. These tests help to identify distresses, degree of cracking, as well as the roughness of the surface to determine the IRI rating for each section of the roadway. The pavement design and condition percentages in terms of ‘Good’ or 'Poor' condition helped to determine the future pavement preservation needs.

Overall, the results show that the condition of the Shashemene – Halaba-Kulito road is bad; so, the existing road need maintenance and improvement to justify viability, especially for non-motorized transportation services.

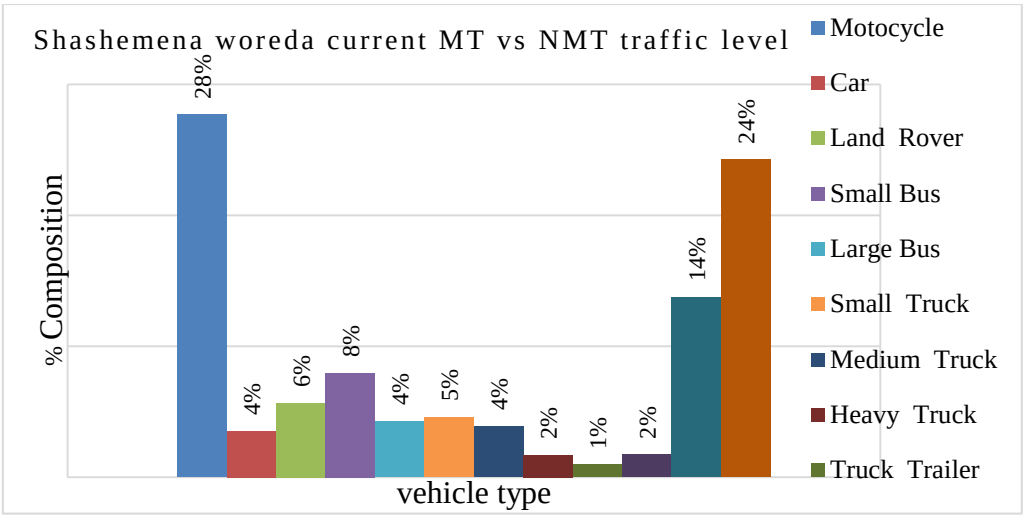

Figure 1: Existing NMT level compared to MT with in Shashemene woreda

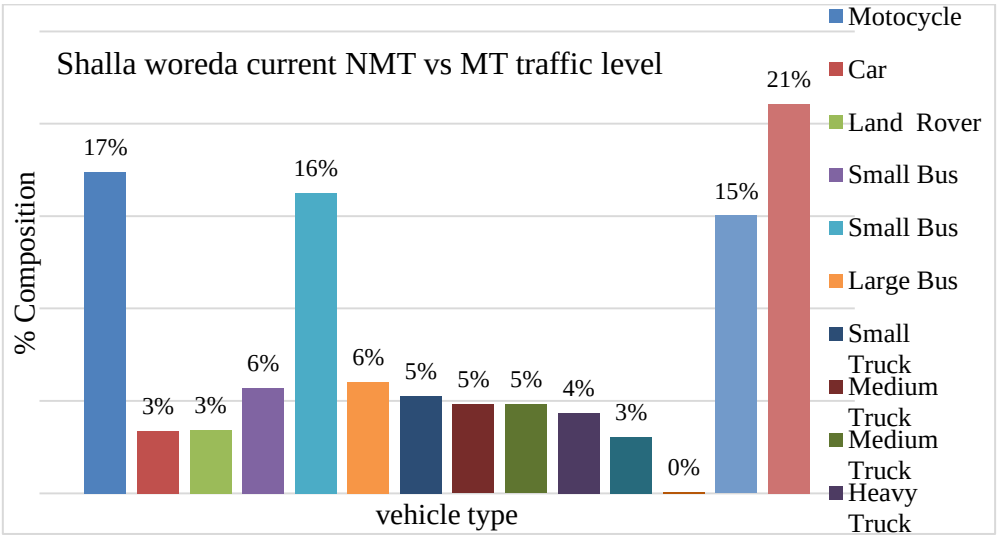

Figure 2: Existing NMT compared to MT within Shallaworeda

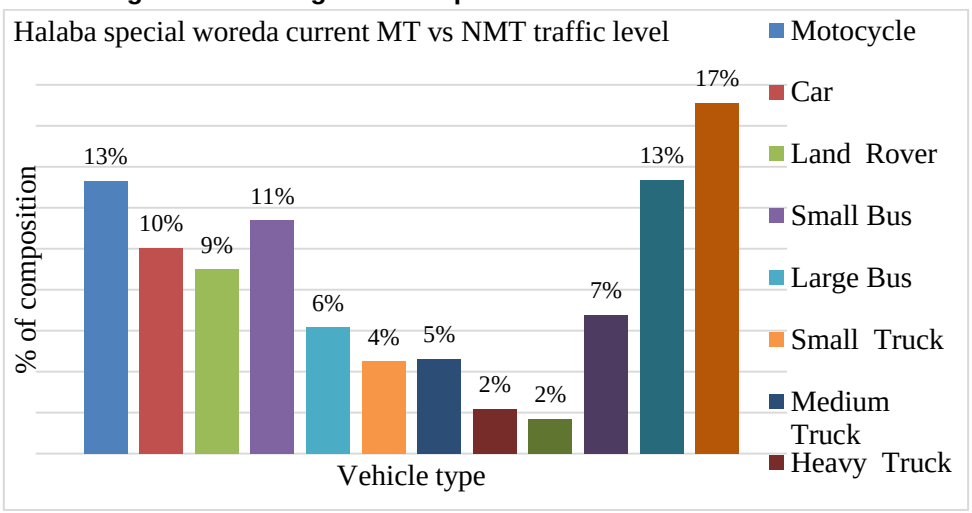

Figure 3: Existing NMT volume compared to MT in Halaba Special woreda.

3.3. Proposed road improvement alternative

The project analysis was then conducted using HDM-4 for 23 years including the implementation period. Five (5) sections were selected to demonstrate these results. Inserting all the necessary data into HDM4, the analyses were performed. By using the Economic Analysis Summary, benefits to costs ratios were taken to prioritization of the alternative road sections. Tables 4 and 5 present the results of the Economic Analysis Summary and Benefit-Cost Ratios respectively.

Table 4: Sample results of HDM-4 regarding the Economic Analysis Summary for Aje-Yayi road section

HDM-4 HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: Shashemena-Halaba-Kulito improvement road project
Run Date: 13-01-2018

This report shows total economic benefits using the following:
Currency: Ethiopian birr (millions).
Discount rate: 10.23%.
Analysis Mode: Analysis-by-Section

Section: Ajia-Yayi
Alternative: Alternative-3 vs Base Alternative

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	440.30	7.60	0.00	21,175.75	4,127.91	48,704.36	59.80	0.00	73,619.91
Discounted	232.10	3.26	0.00	5,740.99	870.85	10,732.23	16.49	0.00	17,125.20

Table 5: Benefits to cost Ratios results of the five sections within two alternatives

HDM-4 HIGHWAY DEVELOPMENT & MANAGEMENT

Benefit Cost Ratios

Study Name: Shashemena-Halaba-Kulito improvement road project
Run Date: 13-01-2018
Currency: Ethiopian birr (millions)
Discount Rate: 10.23%.

Section Ajia-Yayi						
Alternative	**Increased in Agency cost**	**Decrease in User cost (B)**	**Net Exogenous Benefits**	**Net Present Value NPV=B+E-C**	**NPV/Cost Ratio (NPV/C)**	**Internal Rate of Return (IRR)**
Base Option	0	0	0	0	0	0
Alternative-2	37.042	4,096.37	0	4,059.32	109.58706	0.80
Alternative-3	235.354	17,360.56	0	17,125.20	72.76359	67.00

Section Abuara-Ajia						
Alternative	**Increased in Agency cost**	**Decrease in User cost (B)**	**Net Exogenous Benefits**	**Net Present Value NPV=B+E-C**	**NPV/Cost Ratio (NPV/C)**	**Internal Rate of Return (IRR)**
Base Option	0	0	0	0	0	0
Alternative-2	34.03	5,529.71	0	5,495.68	161.49509	1.17
Alternative-3	320.624	19,564.44	0	19,243.82	66.26	75.29

Section Yayi-Halaba-Kulito						
Alternative	**Increased in Agency cost**	**Decrease in User cost (B)**	**Net Exogenous Benefits**	**Net Present Value NPV=B+E-C**	**NPV/Cost Ratio (NPV/C)**	**Internal Rate of Return (IRR)**
Base Option	0	0	0	0	0	0
Alternative-2	20.775	2,738.94	0	2,718.16	130.83817	0.95
Alternative-3	217.117	12,195.96	0	11,978.84	55.17228	69.20

Section Shashemena-Abuara						
Alternative	**Increased in Agency cost**	**Decrease in User cost (B)**	**Net Exogenous Benefits**	**Net Present Value NPV=B+E-C**	**NPV/Cost Ratio (NPV/C)**	**Internal Rate of Return (IRR)**
Base Option	0	0	0	0	0	0
Alternative-2	47.805	4,667.49	0	4,619.68	96.636	1.61
Alternative-3	300.349	19,058.72	0	18,758.37	62.455257	78.33

Section Shashemena-Abuara 300m gravel						
Alternative	**Increased in Agency cost**	**Decrease in User cost (B)**	**Net Exogenous Benefits**	**Net Present Value NPV=B+E-C**	**NPV/Cost Ratio (NPV/C)**	**Internal Rate of Return (IRR)**
Base Option	0	0	0	0	0	0
Alternative-2	0.55	267.37	0	266.82	485.12	8.08
Alternative-3	1.264	404.57	0	403.31	319.07278	54.40

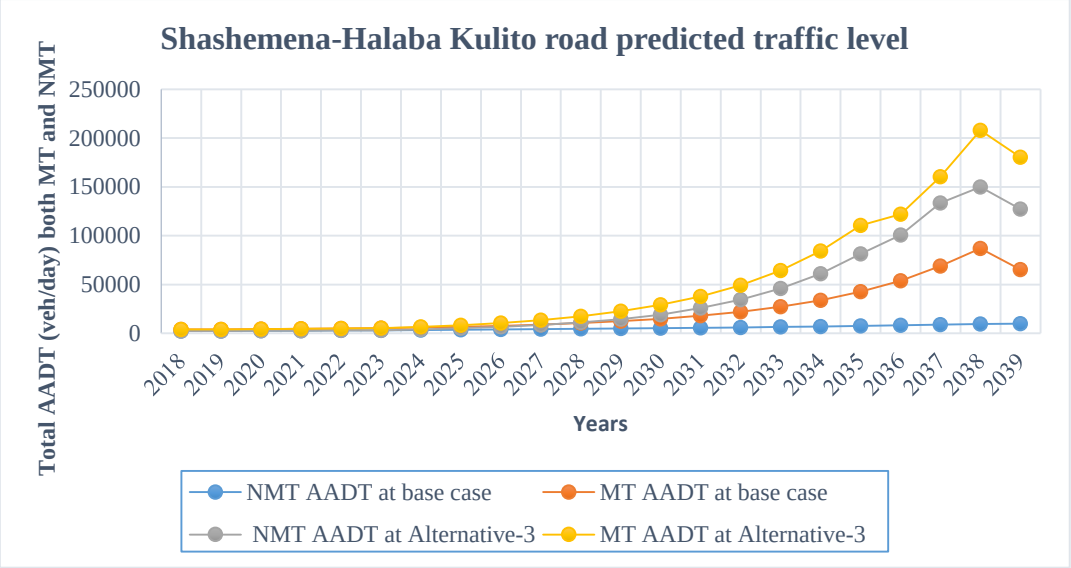

Figure 4: Forecast NMT compared to MT on Shashemene-HalabaKulito area

3.4 Viability of NMT operations compared to MT as result of road improvement (NMT lane addition)

The impact of NMT lane addition road improvement project can be measured in terms of Quantified (Direct) benefits and Unquantified (Indirect& Induced) benefit (Vehicle operating costs and travel time cost savings from both MT and NMT on the five road sections as shown in Figure 5, Figure 6, Figure 7).

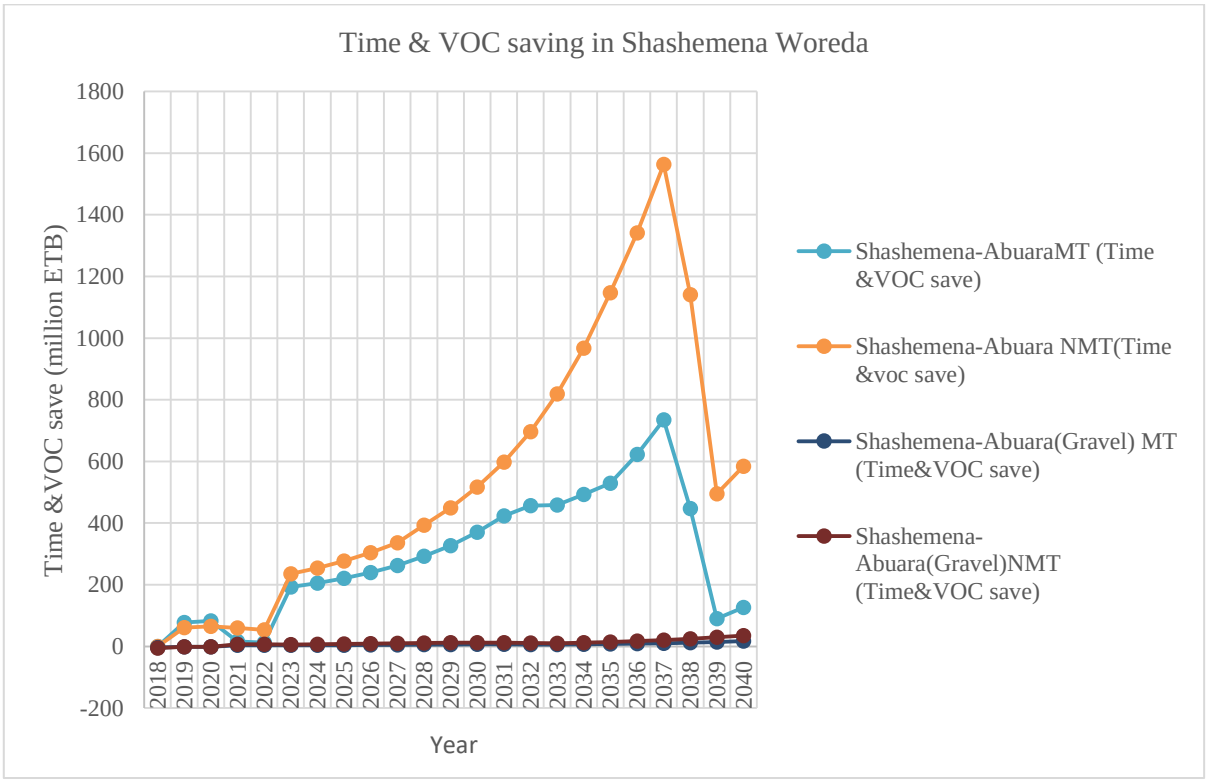

Figure 5: Shashemena woreda Time & VOC saving of both MT and NMT

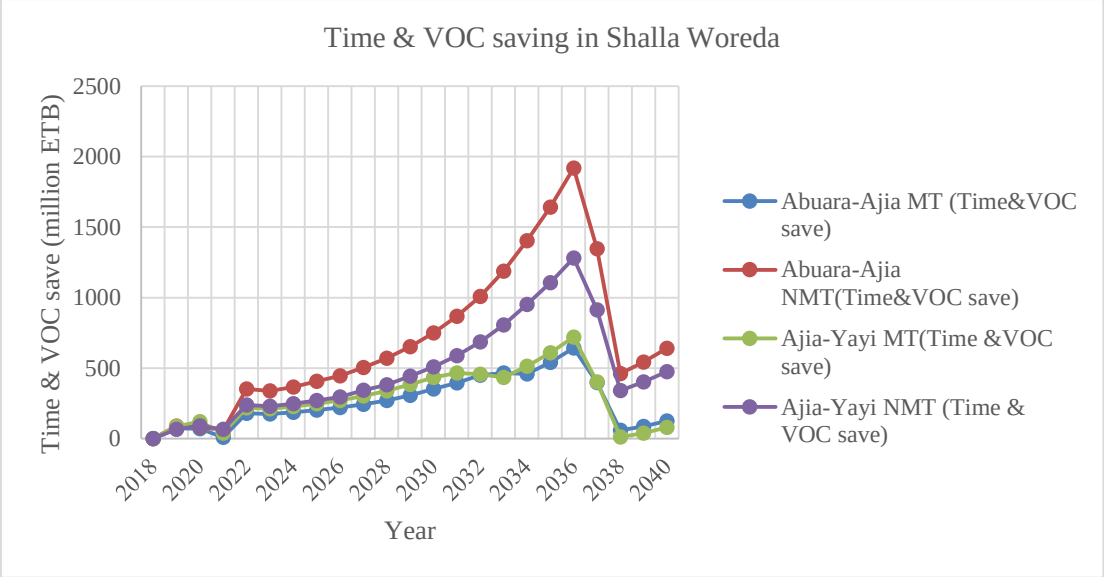

Figure 6: VOC and Time savings of both MT and NMT on ShallaWoreda road section.

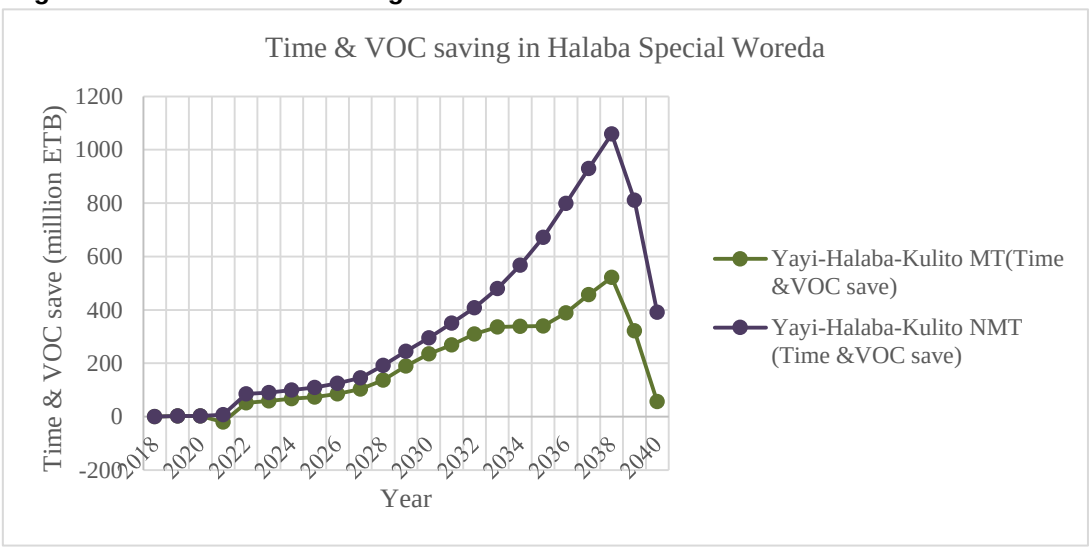

Figure 7: Halaba Special woreda VOCs and Time savings for both MT and NMT vehicles.

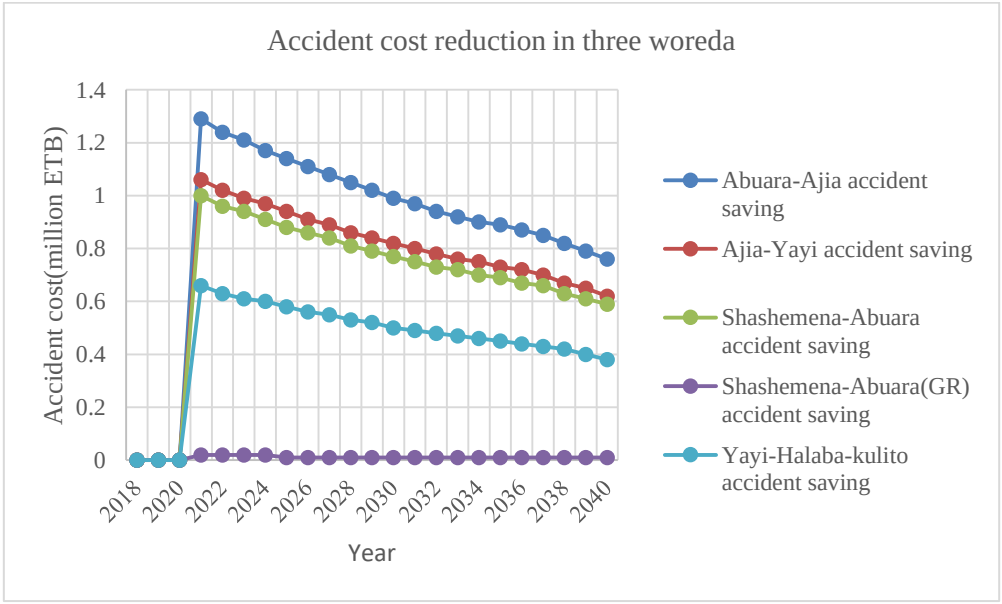

Figure 8: Accident cost savings from both MT and NMT in the three woredas along the Shashemene – Halaba-Kulito road.

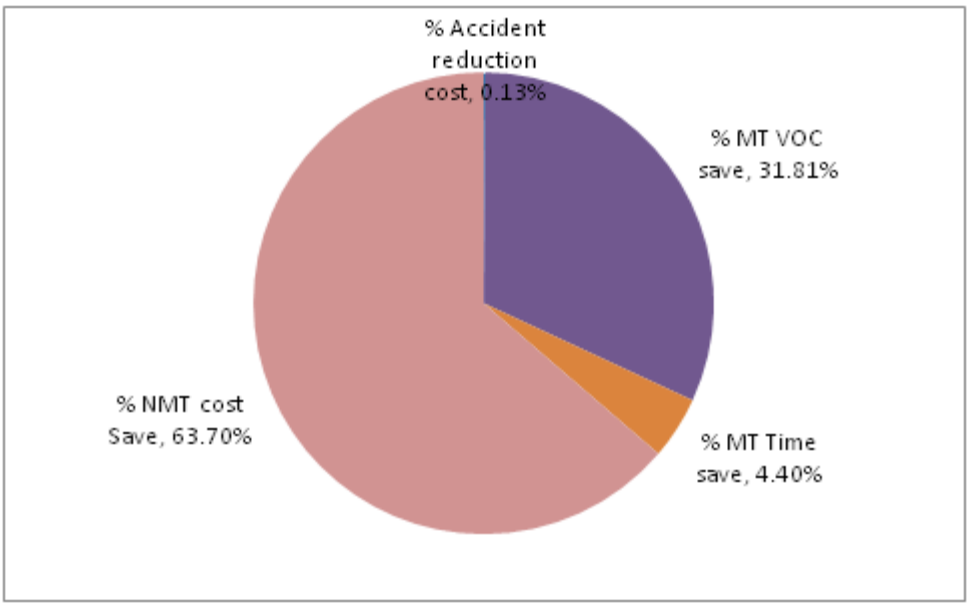

Figure 9: Percentages (%) of benefit over 23 year's analysis period as a result of NMT lane addition (Alt-3) + DST of existing pavement

4. Conclusions

Generally, the subject of the study is the Shashemene-Halaba Kulito road with a total length of 64 km. The road accommodates a significant volume of non-motorized transport vehicles. The study considered the betterment of the road for sustainable operations of NMT in fulfilling the requirements of the users. The Highway Design and Management (HDM-4) tool was utilized for the study to find the impact of road improvement on the viability of NMT operations by considering two road improvement alternatives versus the respective base case scenarios. This was done with the purpose of prioritization of the alternatives to recommend the optimum option for implementation. During the analysis of the field data, the Microsoft excel software was utilized.

Then, the proposed road improvement alternatives that can be intervened to increase the viability of NMT operations were examined. They were examined utilizing HDM-4. The examination included comparison of the results of the two (2) improvement alternatives against the base case in all five (5) sections. The viable alternatives were selected using the maximum NPV, IRR and B-CR (using NPV/cost) with proper allocation of the available budget for each improvement alternative. Therefore, in this case, alternative-2 (NMT lane addition and DST with the help of routine maintenance) was found to be the most cost-effective alternative in all five (5) sections.

The viability of NMT compared to MT was justified through the results of 63.7% and 36.21% of MT cost savings and 0.13% reduction of accident costs. These benefits are from quantifiable components of VOC and travel time costs. The intangible benefits from environment, health, education and community services will surely be generated but could not be quantified. Therefore, improvement of the Shashemene-Halaba Kulito road will have a high positive impact on maximizing the viability of NMT. This can be replicated to other areas in Ethiopia where rural roads mostly serve NMT.

On the basis of this study, an important issue that should be considered is that the existing NMV (animal drawn cart) can be improved for sustainable development. This is because the prevalent NMVs are not comfortable for transporting passengers to protect the animals. Therefore, the existing NMVs can be replaced by other new NMV types such as new rickshaw vehicles that are effectively utilized in Asian countries. Their advantages were confirmed by the data collected through questionnaires and processed using Excel. It was found that 91.24% of the current users are interested to change the animal drawn carts to new Asian rickshaws though 8.76 % of them disagreed.

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