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PROPOSING AN EFFECTIVE LASER-BASED ENTRANCE SYSTEM AT FERRY TERMINALS IN TANZANIA

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A B S T R A C T

At one of the famous Tanzanian ferries - Kigamboni ferry terminal, it is common to find a long queue of people at the ticketing window and the entrance waiting for tickets to get into a lounge, respectively. At the tickets' window,one of the main identified problems is difficultness in picking tickets and time wasted during the printing process. Similarly, at the entrance, it takes an average of 12 seconds to scan a ticket due to systems' insensitivity. This study thus introduces a new system that would probably drastically reduce the time spent on two occasions. The system employs laser technology and non-paper-based tickets to save time by simplifying to processtickets, which will also increase the sensitivity of the system for saving time. The impacts of the proposed system will be realisedforthe entire communities by saving their time, government for effective revenue collection as well as a clean and safe environment by getting rid of paper-based tickets.

1. INTRODUCTION

Ferry terminal can be described as "either end of a ferry route, or a station or town at such a point" (Collins English Dictionary, 2019). At the ferry terminal, passengers expect to receive a high service level. Like other products and services, customers always would wish to be satisfied with the service they receive from the service providers (Taifa & Desai, 2017; Taifa & Vhora, 2019). Ferry service level needs to exceed or mirror the passengers' expectations. Tanzania is within the interlacustrine region because her people live between the Great Lakes of East-Central Africa. This makes the region require ferry terminal services at all lakes and the Indian ocean. People expect to receive excellent service. Now, according to Jørgensen & Solvoll (2017, pp.215-216), there are two foremost motives why the service level should require close attention from an economic perspective. First, essential service elements, for example, "the quality of the transport means and the number of departures per day, strongly influence the direct and external costs of operating the services. Second, the service level influences the passengers' generalised travel costs and thereby their welfare." Ferry services require to be more improved as they are much significant in the national transport system of several countries (Jørgensen & Solvoll, 2017), including Tanzania.

Another critical aspect of the ferry terminal is related to time management for the passengers. It is an undisputed fact that business is directly connected to time management (Chawasemerwa et al., 2018). In the

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business perspective, usually, every single minute can be converted into profitability (Sayari et al., 2017). The more an individual is conscious with time, the more he or she will be doing a healthier business that ends up with tremendous profits. Time management is all about how an individual, a company or organisation plans and organises how long they spend on specific activities. Time management is practically attributed to three main factors which are based on the individual, the institution as well as the public. Individually is when a person can control things that might affect his or her effectiveness while undertaking the specific activity. Institutionally and the public, people are bound to follow specific rules and procedures in managing time, though to some factors a person can control them. Conversely, a person's time management trait is affected by individual, public or institutional performance in different aspects such as a transportation system, service provision, feedback provision, and so forth. It is easy to manage time if all factors are mostly under the control of an individual. The problems come when the factors are externally controlled primarily for the case of an institutional and the public. Such a situation can be primarily because they integrate multiple entities, and all the decision has to come from managerial levels within an institution or the public sector. Industrial development, as well as other contributory systems, depend on several factors. That is, there should be an integration of multivariate factors that must be considered collectively (Chawasemerwa et al., 2018). One of the critical factors is technological advancement (Nzumile & Taifa, 2019). Therefore, this studyprimarily focuses on enhancing public time management by re-engineering of the boarding system at Kigamboni ferry through the laser system in Tanzania.

1.1 Problem statement

Dar es Salaam region as the most significant commercial city in Tanzania has one famous Kigamboni ferry terminal (KFT). KFT requires a ferry to operate. A ferry can be described as a merchant vessel deployed to carry passengers, vehicles, loads (cargo) across large water bodies. KFT has two ferries, that is, MV Kigamboni and MV Magogoni. Similar to other ferries worldwide, these two are vehicle and passenger ferries which operate every day between Kigamboni and Kivukoni Front. Both ferries at KFT form a part of the public national transport systems. Since the inception of a new boarding system at Magogoni ferry terminal, it has been repeatedly noticed that time is wasted mostly during the process of issuing tickets, entering a ferry waiting for a place, and while waiting for the ferry. Usually, when the place is congested, especially in the morning and evening, whereby most of the people are going to their working places and returning back,respectively, it is common to witness long queues in both issuing ticket and entrance areas (see Figure 1). Usually, people spend time in these three areas due to the system performance as well as the efficiency of the ferries as explained hereunder.

Figure 1. The captured long queue at both issuing ticket and entrance areas (Kigamboni ferry terminal) – early in the morning time.

a) Issuing tickets processes

Since the tickets are paper-based, they are to be printed by using the computer after the previous batch has been finished. The printing process itself consumes time that results in increased waiting time, and sometimes the system fails to print due to a network problem. Likewise, the piles of tickets obstructing individuals from being efficient and effective as it might take him or her more than five seconds to provide a ticket to a customer at the window.

b) Entrance

At the entrance, tickets are scanned to get into the waiting area. During the scanning process, the system takes much time to recognise the printed code on the tickets following different circumstances, such as poor printing quality, contaminants from person's hands when touching the coded area and also the inefficiency of detection light from the source.

c) Ferries

Considering ferries, this is the most devastating point where lots of time is wasted compared to the fore mentioned areas. It is brought by the fact that; the number of people keeps on increasing day by day, which surpasses the ability of the available ferries to serve efficiently. The solutions for this are readily available, though a huge investment is required to undertake the tasks. However, this part will not be the case for this study; only the first two areas will be taken into consideration. Additionally, Kigambon ferry terminal handles both passengers and vehicles. For the vehicles, the terminal necessitates having suitable facilities, including proper markings on the ground, so that to facilitate vehicles to line up systematically.

1.2 Purpose (objective) of the study

Following the two key areas where time is mostly wasted with the exclusion of time spent during waiting for the ferry, the proposed system purposely aims at reducing time on both ticket issuing as well as at the entrance gate where customers have to get into the designated area waiting for the ferry. Additionally, it also aims at enhancing the effectiveness in revenue collection, as discussed in the subsequent sections.

The remaining parts of this imperative study are as follows. The theoretical orientation regarding laser and available related systems is discussed in Section 2. Afterwards is Section 3, which gives the details of the proposed laser-based entrance system at Kigamboni ferry station. The entrance system encompasses emitter, receiver, electromagnet, lock, coin and counter. Section 4 discusses the system mechanism. Furthermore, the impact of the proposed system is discussed in Section 5, that is, the impact on the government, community and environment. Finally, the paper highlights the concluding remarks, together with recommendations, forfuture research in Section 6.

2. THEORETICAL BACKGROUND

In this section, we generally provided a brief about the laser itself since its discovery and its capability are to be integrated into the proposed system. We also figure out its performance in some systems where the laser is an integral part of them.

2.1 Laser

According to NASA (2019), a laser "produces a very narrow beam of light [which] is useful in many technologies and instruments. The letters in the word laser stand for light amplificationby stimulated emission of radiation." According to Jelínková & Šulc (2013, p.17), the "generation of laser radiation is based on the stimulated emission of light in an active material which is in an excited state caused by a pumping source. The first laser radiation was generated in May 1960 by T. Maiman, but the history of the laser goes back much further." The principle of a laser is centred on three distinct characteristics: a) optical resonator, b) population inversion of electronics, and c) stimulated emission within an amplifying medium (MSE 5317, n.d.).

Currently, the readily available laser devices are capable of emitting radiations ranging from infrared rays (700 nm – 1 mm), visible rays (400 nm – 700 nm) and ultraviolet rays (180nm – 400 nm) (Gill, 2017). Laser light is generated by exciting an atom to a high energy level followed by emission of light with the same wavelength as the incident radiation during its decay (Gould, 1959; Kogelnik & Li, 1966; Chu & Townes, 2003; Stern et al., 2016). The choice of laser wavelength is one of the essential considerations that should be made (Veitch et al., 1995; Abbott et al., 2017). Multiple light rays are generated by amplifying the emitted rays of light through a pumping mechanism which differ from device to device. Figure 2 depicts laser light generation through the excitation of an atom to a higher energy level.

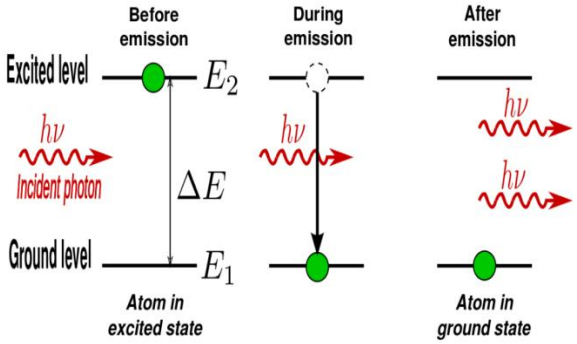


Figure 2. Laser generation, specifically the stimulated emission (Wikipedia, 2018).

From Figure 2, equation 1 depicts how to compute E2.

$$E_2 - E_1 = \Delta E = h\nu \quad (1)$$

Since it was designedover 30 years ago, the laser is currently used in many fields (Jelínek, 1991; Tajima & Mourou, 2002; Yogo et al., 2008; Akar & Aşkin, 2015), including medicine, metrology, engineering, agriculture and many more. Contrast to the conventional light source; the laseris distinguished by the ability to deliver power in a narrow direction beam, monochromaticity, coherence and collimation which make it superior with more significant impact than any other light source (Jelínková & Kluiber, n.d.). Likewise, according to Akar & Aşkin (2015, p.19), "laser communications systems work similar to fibre-optic links, except that the beam is transmitted through free space, requiring line-of-sight conditions. They can be easily deployed, as they are naturally inexpensive, small, and low power. The carrier transmission signal is usually produced by a laser diode, where 2 parallel beams are needed for transmission and reception."

2.2 Related systems

Different security systems are currently employing lasers in their obstacle detection mechanism. Human Counter using Laser Beam with Door Alarm (Das et al., 2016) is one of the systems that employ a laser beam in its operations. The system was designed to monitor the entrance of a building, ensuring that any movement within protected areas is detected with an alarm. Counting starts when the laser beam is blocked by an obstacle (human) at the entrance where the discontinuity is detected. The flowchart of the operation is shown in Figure 3.

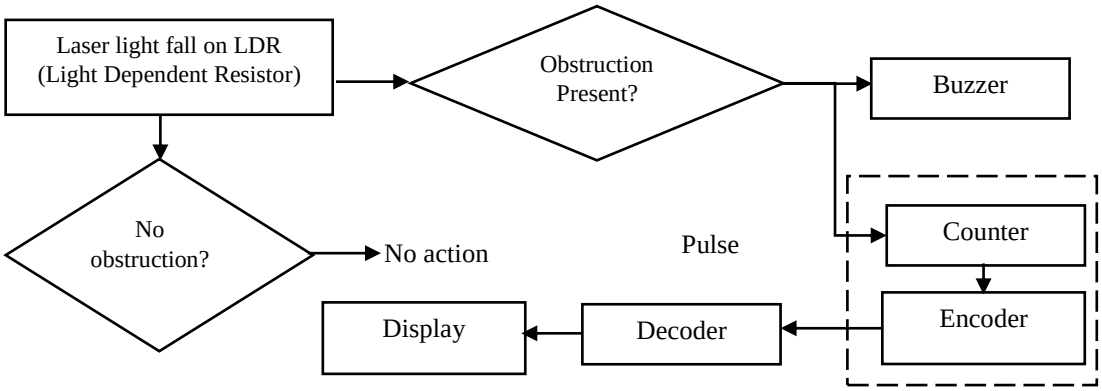
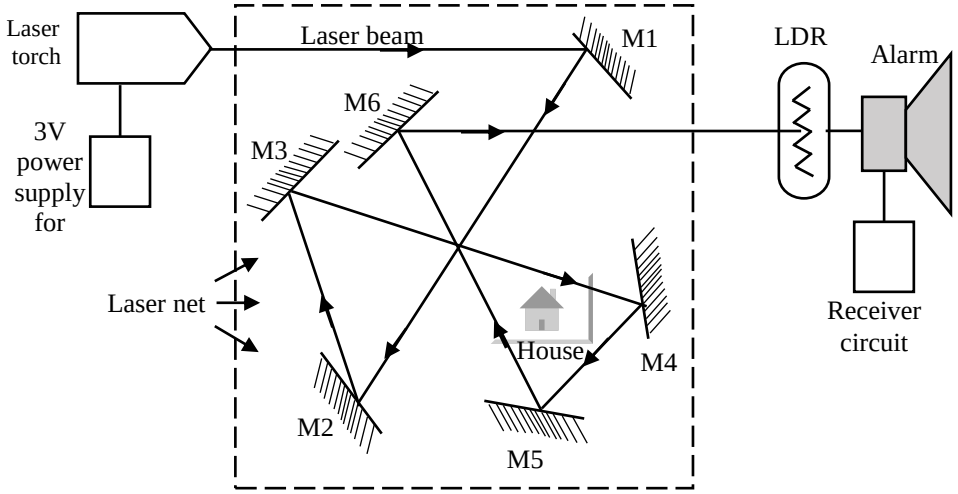


Figure 3. Flowchart of the system (Das et al., 2016)

Laser-Based Security for Home (Hemane & Sen, 2018) also employs a laser beam in its operation. In this system, the laser beam is made invisible. In case of an intruder in the protected area, the main circuit senses the beam discontinuity and turns on the alarm circuit. The system uses multiple mirrors to cover the whole sensitive area with the laser beam by reflecting it to the mirrors in each corner, as shown in Figure 4. Suman and Debasis also developed another system called Laser Security System (Ambroziak, 1970a) which employsa laser beam as well. The system works in such a way that when a person or an obstacle blocks the laser beam from striking the detector, the alarming circuit is activated. When activation is done, the notification in the form of sound or light is released to alert the presence of the intruder. The system is schematically presented in Figure 5.



Note: M1 to M6 are mirrors; LDR = Light Dependent Resistor; V = volts.

Figure 4. Block diagram of the home security system (Banerjee, 2017).

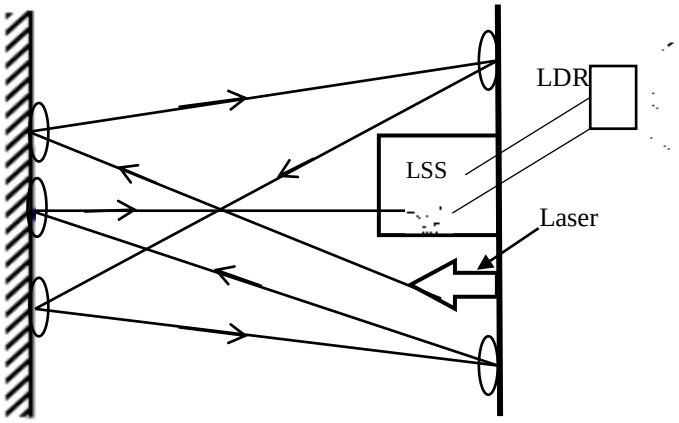


Figure 5. Laser security system (LSS). Note: LDR = Light Dependent Resistor.

Moreover, Iwasawa et al. (2017, p.85) created a "laser-based scanning angle-resolved photoemission spectroscopy system (μ-ARPES) equipped with a high precision 6-axis control system, realising not only high-resolution photoemission spectroscopy in energy and momentum but also the spatial resolution of a μm scale. This enables our μ- ARPES system to probe fine details of intrinsic electronic states near the Fermi level such as the superconducting." Another study by Stern (2016) also developed a "laser-based alignment system" for the compact linear collider. Stern (2016) discussed a calibration protocol, a sensor design, as well as estimations concerning the uncertainty of the measurement.

3. PROPOSED SYSTEM

The proposed laser-based system in the station is generally aiming at reducing waiting time, especially when an individual is about to get into the waiting area through the gate. The reduction of time will be achieveddue to the increased sensitivity of the system in detecting discontinuity of a light beam when interrupted. The complete system shall have the following main parts during the operation.

a) Emitter

A laser pointer which is readily available nowadays with low price will be used as an emitter. The laser pointer will be enclosed inside the casing and thus no direct contact with customers. Following that, there will notbe any effect of the laser light. Also,the beam power is within the safe range in case of any contact with it, especially when there is a need to open the casing. Therefore, the pointer will be emitting visible light with any of the wavelengths found in the visible range of 400 nm – 700 nm as they are easily available. Figure 6 illustrates a laser pointer.

Figure 6. Laser pointer.

b) Receiver

By taking into account high reliability, sensitivity and temporal stability of the phototransistor (Ambroziak, 1970a), the receiver will be used as a receiver. It has a unique property of luminous sensitivity, spectral response and time constant compared to another photodetector such as photodiodes and photocells (Ambroziak, 1970b). The fact that a phototransistor is capable of converting light to an electrical signal and amplifies it, enhances the system to use the amplified signal to actuate a relay switch.

c) Electromagnet

An electromagnet is a form of a magnet in which an electric current produces its magnetic field. One way of making it is by rounding a wire on a ferromagnetic material such as iron (see Figure 7). The strength of the field is proportional to the number of turns around the material. The magnetic field in the electromagnet can be induced and disappear depending on whether the electromagnet is connected to an electric current or not, respectively. In this study, the electromagnet in the system will be used in the closing and opening of the entrance in combination with the lock. This will take place just after the beam discontinuity has been detected when an intruder interrupts along a beam path.

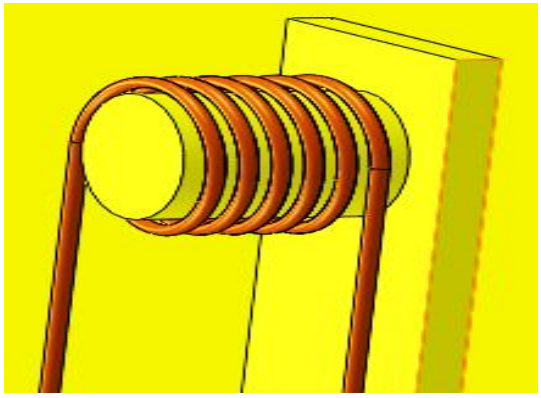


Figure 7. Electromagnet.

d) Lock

The locking part consists of two main parts, such as rod and spring, as in Figure 8. Both the rod and spring should be aligned with the electromagnet so as to be attracted just after a sensor has detected the beam discontinuity. The restoring force of the spring will return the rod to its original position when the intruder no longer blocks the beam. This will happen when the electromagnet has been demagnetised due to the absence of an electric current flowing through the coil.

Figure 8. Lock.

e) Coin

Coin or an intruder is a rounded, small in size and light steel object. It is designedto block a beam from reaching a phototransistor after a person dropped it in a small slit. As the object descends along the guided path, at one point nearly the end, it will pass between a transmitter and receiver and block the laser beam. This will cause the discontinuity of the beam and activate the sensor for the rest of the system's operation to occur. After that, the coin will be reserved in the shell at the bottom of the casing. When the shellis filled with coins, it has to be emptied by taking all the coins and selling them again in the designed areas contrast to the status quo of the system where the tickets are to be dumped.

f) Counter

A counter is supplemented in the system to count the number of coins (intruder) each time a customer drops it. This will enable the effectiveness in revenue collection by ensuring that the number of coins displayed on the counter matches the amount of money collected. The counting starts instantly after the coin leaves the beam path where it meets with a counter as it descends the shell.

4. MECHANISM FOR THE PROPOSED SYSTEM

By considering the main parts of the system in Section 3, there are other parts which also have to be integrated into the system to work it out. Figure 9 presents a block diagram of the system.

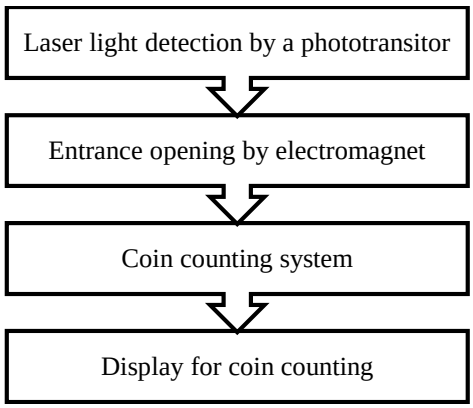


Figure 9. Block diagram of the system.

The laser light is made to strike a phototransistor in a continuous manner enabling a relay switch to be in an open condition. Once a coin interrupts the beam in its path, the discontinuity of the laser light is sensed followed by activation of a relay switch. The switch allows an electric current to start flowing in the coil within which a magnetic material is fixed. Once the materialis magnetised, a lock is attracted towards the electromagnet and the entrance opens to allow a person to get into a waiting area. After the coin crosses a beam, the lock is getting back to its original position due to demagnetisation of the armature. Thishappens due to the opening of a relay switch as once it was. On its way down to the shell, the coin is detected by a counter sensor which counts the number of coins continuously and displays. A complete flow diagram of the operation is presented in Figure 10.

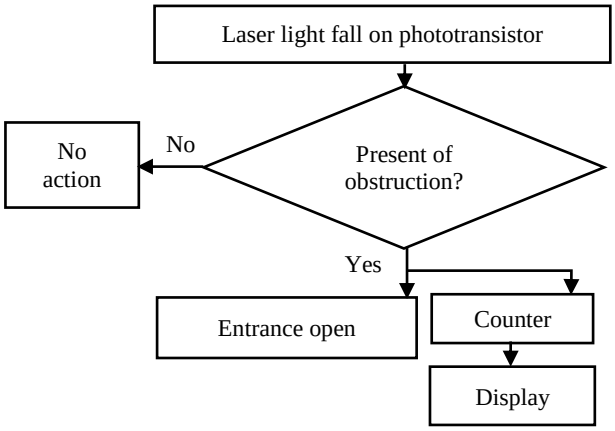


Figure 10. System's operation flowchart.

5. THE POTENTIAL IMPACTS OF THE PROPOSED SYSTEM

While operating, the system is going to have diverse effects as compared to the current one. Following the improvements in the critical areas, the system will have an impacton the community, government as well as the environment.

a)Community

Considering the sensitivity of the system through laser application, certainly, the time taken by a customer to get into a waiting area will be reduced. A customer is only required to purchase a coin and drop it in the slit for it to descend and block the laser beam. This will definitely shorten the processing time as compared to the former one where the tickets need to be printed first. The ticket also must be scanned, andit normally takes some time to be recognised by the system. In the new system, all these bottlenecks will no longer be there as only the coin will be reused and drastically, the time will be reduced.

b) Government

The system is supplemented with a counter which will be used in counting. The counter will count each time a customer drops a coin and displaysit on the system operator's screen. The number of coins counted will indirectly indicate the amount of money collected throughout the day. This will definitely increase the efficiency in revenue collection by ensuring that the number of coins is equivalent to what has been collected.

c) Environment

The current system utilises paper for printing tickets. Despite the bins that havebeen positioned inside the waiting area, still, customers are not dumping their tickets into bins after crossing the entrance. This increases pollution as more ticketsare dumped on the ground, and as a result cleaning activities becomes a bit difficult. Replacing the paper-basedtickets with the coin will drastically eradicate completelysuch waste due tickets which usuallyare currently dumped on the ground. Nevertheless, this will also reduce deforestation as paper, which is one of the forest products will no longer be used. Figure 11 shows the scattered tickets at the Kigamboni ferry terminal.

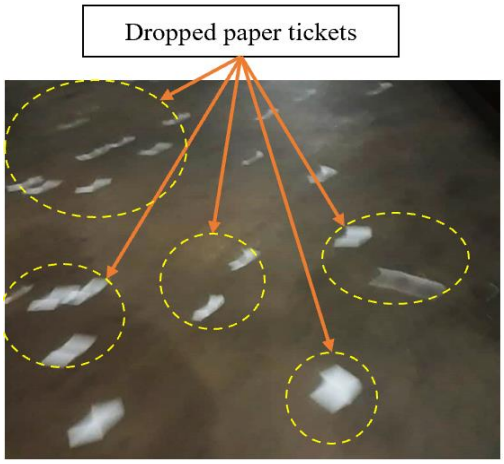


Figure 11. Dumped tickets on the ground at Kigamboni ferry terminal.

6. CONCLUSION AND FUTURE WORK

6.1 Concluding remarks

Most of the laser systems already developed are generally less expensive in comparison with their counterparts. This is backed up by the fact that the system's parts are readily available at a low price, and it is simple to design and install. Following this, the proposed system is also simple to design and fabricate as most of its parts are available locally. Installation and maintenance are also easy to undertake with minimum cost as possible, mainly because the system itself is not so complicated. Of course, this study does not give a fully assembled and tested laser-based entrance system; nevertheless, this provides the first step towards the development stage of this imperative system. It is thus expected that the management of the Kigamboni ferry terminal should be able to set well their areas of operations with clear guidance of the major five performance objectives. These include quality of their service level, speed including ticket printing processes, flexibility, dependability (being on time and reliable one) and being productive in the essence of cost performance objective. In addition, the issue of sustainability – environmental values - as it previously mentioned how the paper tickets are scattered around the whole area of Kigambon ferry terminal.

6.2 Potential future research

Currently, people in Tanzania are witnessing significant improvements in the public transport systems across Dar es Salaam though it is at some parts. Such considerable improvement is due to the commencement of 'Rapid Transit Buses (RTB)' operation. The proposed system will also be viable to be used for effective collection of revenues from selling the coins instead of a paper-based ticket, hence will notably save time during purchasing and getting into the waiting area. Its viability is justified by the fact that both the two parts, that is, ferry and rapid transit buses projectsuse the same systems of issuing tickets. Thus, the system will not only save time but also there will be maximum utilisation of resources such as installed system and personnel.

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