NEXUS OF HUMAN FACTOR AND ROAD GEOMETRICS ON TRAFFIC ACCIDENTS ALONG MZUZU-JENDA M1 ROAD STRETCH

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DECLARATION

I, JAPHET KHENDLO, hereby declare that the work presented in this thesis is a result of my own research effort and that to the best of my knowledge it has not been submitted previously to Mzuzu University or any other institution of higher learning for the award of any academic qualification.

Where other sources of information have been used, acknowledgement has been made accordingly by means of references.

Signature………………………... Date………………………...

CERTIFICATE OF APPROVAL

I, the undersigned, certify that this thesis is a result of the authors own work and that to the best of our knowledge, it has not been submitted for any academic qualification within Mzuzu University or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered herein was demonstrated by the candidate through an oral examination held on………...

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Signature: ……………………………………...

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DEDICATION

To God Almighty, thank you for the gift of life, wisdom and determination.

To my Mother and Wife, thank you for your support and prayers.

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ABSTRACT

In Malawi, approximately 20 road traffic accidents occur every day and about 1000 people are killed every year. Mzuzu-Jenda M1 road is one of the accidents prone stretches. Although the road serves as a back-borne route for inputs and exports to and from neighbouring countries, it has had several fatal accidents. This study was conducted to analyse factors leading to accidents in selected hot spots. Specifically, the study looked at the geometric elements of the road, human behaviour leading to accidents, relationship between road geometric elements and human behaviour and its impact on road accidents and modelling alternative road design alignment on accident-prone sections. The methodology included identifying accident-prone areas, conducting topographic surveys to extract geometric elements of road, conducting in-depth interviews with drivers and passengers, and monitoring the speed of the vehicles on those accident-prone areas. Results show Mapanjira, Chilerawalanda, Kasitu, Champhira and Ruviri are the most accident-prone areas. In these areas, geometric elements of super-elevation, sight stopping distance, horizontal clearance, the radius of the curves, lane and shoulder width are less than what is recommended by road design standards of the American Association of State Highway and Transportation Officials and Southern African Transportation and Communications. The geometric elements have made these spots hazardous for drivers even driving at the recommended speed limit. Further, drivers drive at an average high speed of 78 km/hr representing a 30% increase beyond the recommended speed limit of 50 km/hr. The high speed combined with flaws in the geometric elements of the road makes it more likely for drivers to get involved in traffic accidents. The study recommends to properly construct the road sections following the road design standards in the design manuals and widen the shoulder to provide enough horizontal clearance and cushion the sharpens of the curves.

Keywords*:* Road geometrics, Human factors, Road traffic accidents, AASHTO and SATTC

ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
BMJ	British Medical Journal
GoM	Government of Malawi
RTA	Road Traffic Accidents
WHO	World Health Organization
SATCC	Southern Africa Transport and Communications Commission
SD	Sight Distance
SSD	Sight Stopping Distance

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CHAPTER 1. INTRODUCTION

1.1 Background

Road accidents globally claim the lives of about 3,000 people every day (Fshatsyan et al. 2018). In Malawi, approximately about 20 road traffic accidents occur every day, two of which are fatal and two injuries, and about 1000 people are killed every year (WHO, 2018). In 2019, a total of 9326 accidents were registered as compared with 4539 cases in 2018 (GovM, 2019). In the first three months of 2021, road accidents have killed 323 people compared with 248 people who died in the same period in 2020, showing a 37% increase (Kalungwe, 2021). Road traffic accidents occur due to a combination of factors related to elements of the transportation system, road geometrics and road users, with accidents outcomes ranging from property damage to death (Li, 2017). Geometric design elements, such as vertical curves, horizontal curves, lane width and superelevation, and human factors play an important role in defining traffic operational efficiency (Mohammed, 2013).

Road design standards or guidelines specify an appropriate minimum, maximum and desirable values on the visible road geometric elements to which failure to adhere by constructors and road users lead to accidents (Ocinneide, 1997). Many studies have been done on finding the relationship between road geometrics and road safety. Studies by Sayed et al. (2004) and Tawar et al. (2017) in Canada and India respectively, looked at frequency of accidents at some locations without detailing the reasons for such causes. Models have been developed to predict accidents rate and geometric inconsistencies. However, little has been done on linking road geometrics and human behaviours in causing accidents on the accident hot spots. Accident hot spots are sites on the section of roads and highways with higher accident frequency than expected at some threshold level of significance. Hot spots are identified using simple methods such as Accident Frequency (AF), Accident Rate (AR), Accident Density (AD) and Accident Severity Index (ASI) (Chaudhary, 2015). The prime goal of highway safety engineering is to limit the number as well as the severity of traffic accidents by identifying, implementing and evaluating measures to improve highway safety. As the roadway improvements are supposed to be applied to hazardous locations or accident hot spots where they have the most momentous impact, identification of hot spots is a vital step in safety management (Chaudhary, 2015).

The main road in Malawi referred to as “M1” is a conventional road that runs South-North of the country. M1 road plays a vital role in the transportation of goods and services throughout the country. Until the 1920s, Malawi had no roads that were navigable by motorised vehicles. Under British colonial rule, especially during the first few decades, roads remained little more than tracks. The southern part of the country was the first to benefit from road infrastructure development and it was not until the late 1930s that few all-weather roads in the north of Malawi (Atkins, 2016).

The M1 road passes through almost all types of terrain: hilly, valley, plain, swampy, and river. The stretch in the southern and central region is almost plain and this makes travelling very easy and fast while in the northern region most of the places are mountainous and travelling is relatively slow and very difficult. Improvement has been done by adapting conventional designs and making it a bitumen road. The section of the road in the north forms the backbone of transportation of goods and people as most of the imported goods through Dar-es-Salaam, Tanzania comes through this section of M1 road making the road busy and risky.

The stretch under study, from Mzuzu to Jenda, was completed in the 1980s connecting it with the central region (Malawi Roads Authority, 2007). Since its construction, this road section of the M1 has experienced many fatal. According to Northern Region Police personal interview with its spokesperson, the trend of deadly road traffic accidents has always been on a higher level with 2017 registering 23 fatal accidents, 2018 registering 19 fatal accidents, 2019 registering 28 fatal accidents and 2020 registering 20 fatal accidents (GovM, 2020).

1.2 Problem Statement

The cost of fatalities, injuries and death due to road traffic accidents continue to have a tremendous impact on societal wellbeing and social-economic development (Lawrence, 2015). Preventing road traffic accidents requires good methods developed in identifying, analysing and treating accident-prone areas (Cela et al. 2011). Along the M1 road, bush clearing as a method of road safety has been employed to improve road clearance and visibility but accidents are still concentrated on some sections of the road. Major factors causing road accidents including geometric factors (Ocinneide, 1994; Jason et al. 2014; Pranay et al. 2015; Abbas, 2018; Mandefro,2019; Mulugeta,2018; Nyoni,2017; Jayvant et al. 2015) and human factors (Charles et al. 2017; Li, 2010; Oluleye, 2009; Banza et al. 2017; Manong'a, 2015) have been studied in isolation. However, Islam et al. (2017) reported that there is an interplay between geometric and human factors leading to road accidents which need further analysis so that accidents are reduced. Hence, this study was set to analyse the nexus of geometric and human factors leading to road accidents on M1 road in Malawi focusing on the Mzuzu-Jenda M1 stretch.

1.3 Objectives

The study aimed at analysing the nexus of road geometrics and human factor on road accidents on Mzuzu-Jenda M1 road stretch.

1.3.1 Specific objectives

1) To assess geometric elements of the accident-prone areas
2) To analyse human behaviour leading to road accidents on Mzuzu-Jenda M1 road stretch
3) To evaluate the relationship between road geometric elements and human behaviour impact on road accidents
4) To determine the deviations of existing road alignment from standard geometric alignment on accident-prone sections

1.3.2 Research questions

1) What are the geometrics elements present in accident-prone areas?
2) What human behaviours lead to road accidents?
3) What is the impact of geometric elements on human behaviour that lead to accidents?
4) How far is the existing road alignment deviating from the standard geometric parameters on accident-prone areas?

1.4 Significance of the study

The study will assist in assisting in the implementation of the Malawi National Transportation Master Plan which is to improve the safety of transport infrastructure and services. It will also assist engineers in the designing of road geometrics and reduce property damage and loss of life. The research will provide skills and knowledge to the academic world on how to apply different civil engineering techniques in identifying and addressing real-world challenges.

1.5 Ethical Consideration

Ethics is an integral part of the research and its importance varies depending on the methods of inquiry. This study sought ethical clearance from the National Council of Science and Technology (NCST). The NCST approved fieldwork with Protocol Reference number P.07/20/497. Before the interview, the researcher introduced the research context and aims to the participant. The rights of the participants were thoroughly outlined so that the participation was voluntary. Each participant signed a consent form accepting the interview and provision of contact details such as phone or emails.

CHAPTER 2. LITERATURE REVIEW

2.1 Road geometric elements

Road geometrics define the alignment of the road and constitutes cross-sections and longitudinal elements of the road. The relationship between these elements and traffic accidents are classified into two groups: cross-section effects and alignment elements (Mohammed, 2019). Key cross-section elements include lane width and shoulder width while the primary alignment elements include horizontal curve (crest and sag curves), sight distance and gradients (Elvik, 2009; Abebe, 2019).

2.1.1 Cross-section elements

The width of the radius of the various cross-section elements affects the driver's capability to perform evasive manoeuvres. It also determines the lateral clearances both between vehicles and other road users (Pigman, et al. 2009). Figure 1 below shows the cross-section elements; lane and shoulder width of a two lane-road.

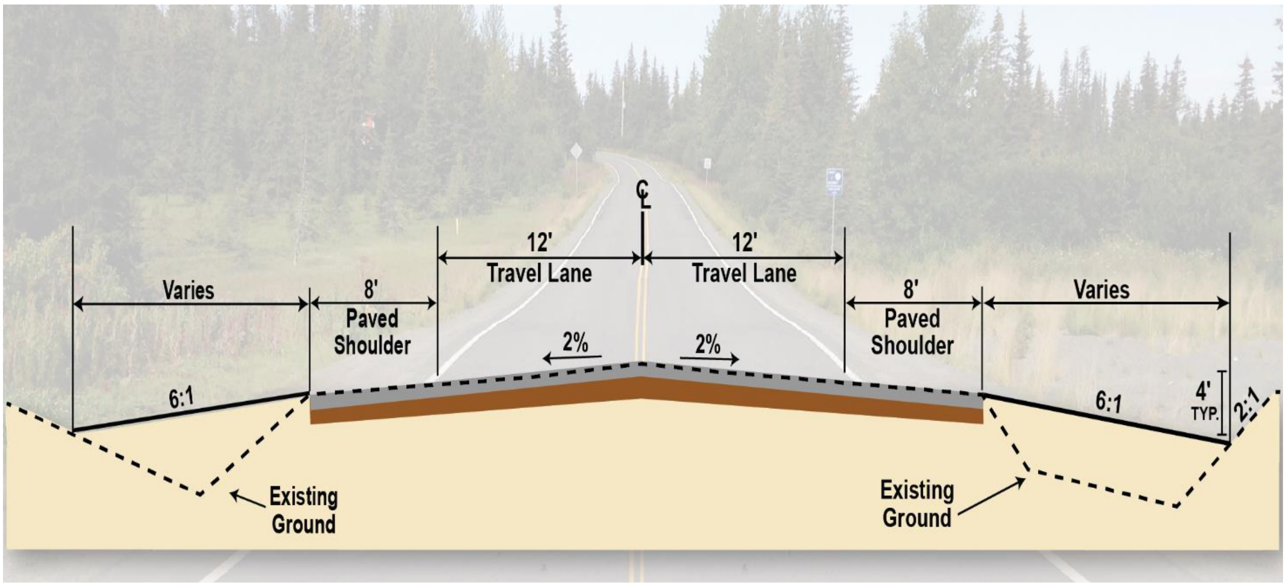


Figure 1. Standard road cross-section showing key elements of the road (Source: AASHTO, 2011)

2.1.2 Lane width

Wider lanes are traditionally associated with higher operating speeds and increased safety (Mohammed, 2019). This is correct to suggest that wider lanes provide enough rooms for the drivers to correct mistakes as they drive. Lane width of 3.4 m as a minimum and 3.7m as maximum have been observed to reduce accidents rates (Zeger et al. 1993). The width of the lane is directly proportional to the cost of construction. Thus, the bigger the lane width the higher the cost of construction.

2.1.3 Shoulder width

A shoulder is the portion of the roadway contiguous with the travelled way that accommodates stopped vehicles, emergency use, and lateral support of subbase, base, and surface courses (AASHTO, 2011). The lack of shoulders on the roads makes the road too dangerous as breakdown vehicles are forced to stop at the centre of the road lane. SATTC provides 1.0 m width as the minimum and 1.5 m as maximum. Headman (1990) indicates that accidents decrease with an increase of shoulder-width from 0 m to 2 m.

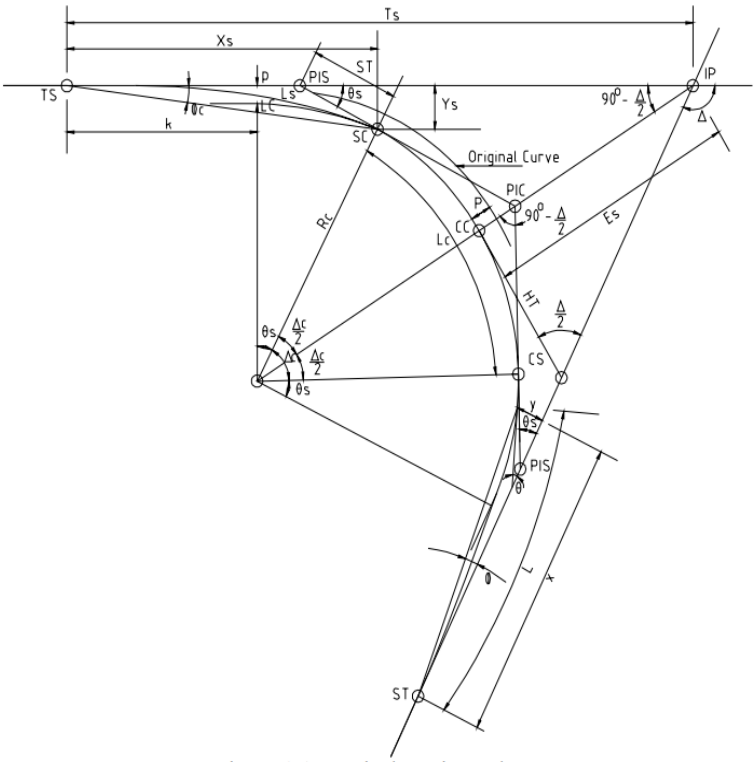
2.1.4 Horizontal curves

The key design parameters of horizontal curves include the radius of curvature, length of a curve, superelevation and transition design (Toole, 2009). A horizontal curve provides a transition between two tangents length of roadway (Deutsch, 2014). Choosing a larger degree of the curve (shorter radius) will make the tangents longer and the curve shorter and sharper (Ghilan et al. 2002). Horizontal curves are identified as the foremost significant geometric factors that affect fatal accidents and injuries on roads (Zhu et.al. 2010). Radius or degree of curvature consistently tops the list of geometry variables that significantly affect operating speeds and crash experience on horizontal curves (Aram, 2010). Accident risks increase with the increase of the degree of curvature (Mathews et al. 1998). The horizontal curve length is given by Equation (1);

$$L = 2\Pi R(\frac{\Delta}{260})$$ ……………………. Equation (1)

Where: **L** is the length of the curve, Δ is the central angle and **r** is the curve radius.

Literature has indicated that the safety of a horizontal curve, its accident frequency and severity, is partly determined by its *internal* features (degree of curve, superelevation, lane width, spiral, etc.) and partly by its *external* features (density of curves upstream, length of the connecting tangent sections, sight distance, etc.) that influence driver expectation and speed in approaching the curve (Hauer, 1999). However, Hauer (1999) did not look into the impact of the entry and exit as factors that also affect the roads accidents on the curve. Superelevation of a road as defined by Abebe (2019) is road traversing incline toward the inside of a horizontal curve to counteract the centrifugal force and increase the safety performance of highway sections also because the riding comfort. Van, (2020) found out the number of accidents on wet pavements to be 6% higher in curves with superelevation of less than 2%. The typical horizontal curve is depicted in Figure 2 as per Indian Road Congress (IRC) guidelines (IRC:38,1988).



Where

A Total deflection angle

IP Intersection point tangents

RC Radius of circular curve

LS Length of Spiral curve

LC Length of circular curve

L Total length

ST Short length

LT Long length

TS Total tangent distance

ES External distance

Figure 2. Typical road horizontal curve (Garnaik, 2014)

2.1.5 Sight distance

Sight distance is that distance along a roadway throughout which an object of specified height is continuously visible to the driving force (Mavromatis, 2013). Stopping sight distance is that the sum of two distances: (1) the space traversed by the vehicle from the moment the driving force sights an object necessitating a stop to the instant the brakes are applied; and (2) the space needed to prevent the vehicle from the moment brake application begins. The two distances are also referred to as brake reaction distance and braking distance, respectively (AASHTO, 2015) The most important component of sight distance on the road is the sight stopping distance (SSD) which affect the feasibility of the road and hence determine how much time the driver can avoid any collision. The sight stopping distance is given by the equation (Institute of Transportation Engineers, 2008);

$$SSD = 1.4Pv + (\frac{V^2}{30(f \pm g)}) \text{ ……………………… Equation (2)}$$

Where: **V** is the initial speed (km/hr), **P** is the perception-reaction time in seconds, **f** is the coefficient of friction and **g** is the percent of grade divided by **100**

This distance is dependent on several variables including (i) height of the driver's eye above the road surface, (ii) the specified object height above the road surface, and (iii) the height and lateral position of sight obstructions like as cut slopes, guardrail, and retaining walls within the driver's line of sight. Sight distance of sufficient length must be provided to allow drivers to avoid striking unexpected objects in the travelled way (Colorado Department of Transportation, 2009). If safety is to be built into highways, the designer must provide a sight distance of sufficient length during which drivers can control the speed of their vehicles to avoid hitting an unexpected obstacle on the travelled way. The minimum sight distance available on a highway should be sufficiently long to enable a vehicle travelling at or near the likely top speed to stop before reaching an object in its path. While greater length is desirable, sight distance at every point along the highway should be at least that required for a below-average operator or vehicle to stop (AASHTO, 2001). Figure 3 is an illustration of sight distance on a horizontal curve.

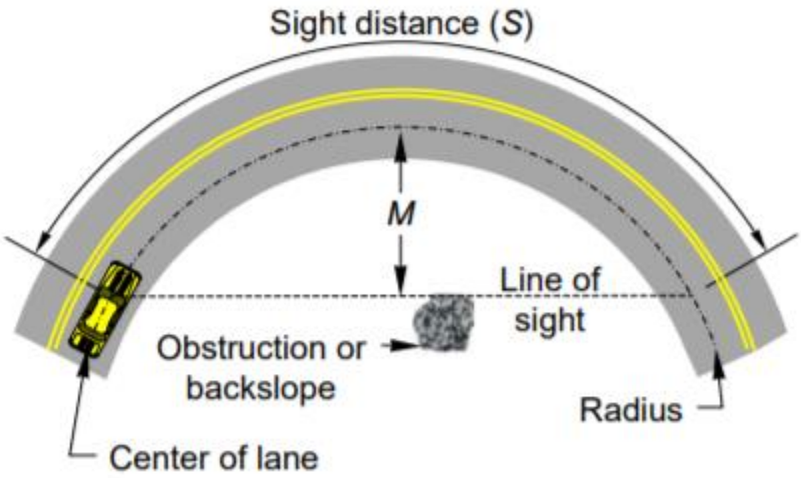


Figure 3. Recommended sight distance on a horizontal curve of the road (Source: MUTCD Design Manual M 22-01.13)

2.1.6 Superelevation

When a vehicle moves in a circular path, it undergoes a centripetal acceleration that acts toward the centre of curvature. This acceleration is sustained by a component of the vehicle's weight related to the roadway superelevation or the side friction developed between the vehicles tires and pavement surface or by a combination of the two (AASHTO, 2011) as illustrated in Figure 4.

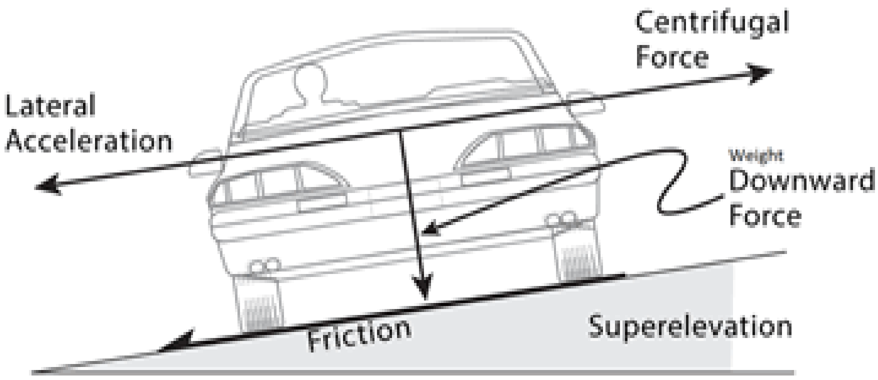


Figure 4. An illustration of a vehicle passing through a super elevated road (extracted from AASHTO, 2011, pg.134).

2.1.7 Horizontal clearance

The roadside clear zone is the distance from the sting of the travel lane which should be freed from any non-traversable hazard like steep slopes or fixed objects. The clear zone distances are targeted towards allowing approximately 80 to 85 percent of all run-off-the-road vehicles to recover or come to a safe stop (Yassin, 2018). The horizontal clearance length provides enough visibility on the horizontal curve that enables the driver to see other objects ahead at the required sight stopping distance. Equation (4) indicates the calculation of horizontal clearance on a road section.

$$C = R - (R + b) * Cos(\frac{31.83 * ASD}{R+b}) \text{........................ Equation (4)}$$

Where: **C** is minimum horizontal offset from the sight obstruction to the inner roadway edge (**m**), **R** is radius of the inner roadway edge (**m**), **b** is offset between the driver and the inner roadway edge (**m**) and ASD is available sight distance (**m**)

2.1.8 Road Curvature

The safety of a horizontal curve- its accident frequency and severity- is partly determined by the *internal* features to it (degree of curve, super-elevation, lane width, spiral, etc.) and partly by the *external* features to it (density of curves upstream, length of the connecting tangent sections, sight distance, etc.) that influence driver expectation and curve approach speed (Hauer, 1999). Further, Hauer (1999) reported that the frequency of road accidents increases with the increase in the degree of the curve. A typical graphical relationship (Figure 5) was also developed by Leisch (1971) describing a direct relationship between accidents and degree of curve. As degree of curve increases so are the number of accidents.

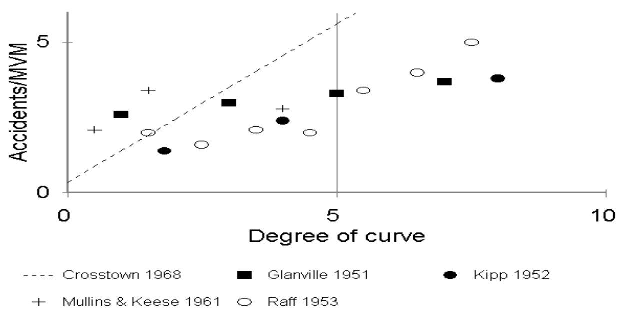


Figure 5. Relationship between degree of the curve and accidents (Source: Leish, 1971)

2.2 Human factors

Driving a vehicle is a constant process of interaction whereby the human in the vehicle takes in sensory perceptions and process them (Cickovic, 2016). Drivers attitude towards the safety of themselves, vehicles and that of other road users contribute to the level of frequency of road accidents.

Manong'a (2015) reported that over speeding caused more fatal road traffic accidents in the whole world than any other attribute on road accidents. The study found out that 461 fatal road traffic accidents were caused due to over-speeding and 92 fatal accidents occurred as a result of drivers overtaking carelessly and failure to keep to the near side of their lane. Over speeding makes drivers lose reacting time to control the vehicle in stable condition and fail to brake when they encounter an emergency leading to a vehicle crush (Pikunas, 2004). Charles (2017) found out that in Malawi over speeding by drivers is a result of various factors but mainly hinging on the quest to make a profit in the face of rising fuel costs. Most drivers overload their vehicles so that they can carry more people translating to more money through their transport fares. Further, drivers strive to make several trips in the designated routes they travel and to do so they often over speed. This behaviour has led to inability to control the vehicle when passing through sections that have complex road alignment.

Driving under the influence of alcohol is another human behaviour that has a high probability to lead serious accidents. Even with a little amount of alcohol consumption, drivers are twice likely to be involved in traffic accidents than sober drivers (Zhao, 2014). Wang et.al. (2011) found out that alcohol changes the attitude, driving ability and driving performance of drivers towards safety on the roads.

2.3 Road geometric elements impact on human behaviour

Design consistency is the conformance of geometric elements of the road with driver's expectancy, and its importance and significant contribution to road safety are justified by understanding the driver's vehicle interaction. The inconsistencies that exist on a roadway can produce a sudden change in the characteristics of the roadway which can surprise motorists and lead to speed errors (Shashidher, 2018). In contrast, when design consistency is ensured, all abrupt changes in geometric features for contagious highway elements are eliminated, preventing critical driving manoeuvres and minimizing accidents (Koeckner, 1980).

Lamn et al. (1987) (as cited in Shashidher, 2018) reported that half the vehicle accidents are attributed to inappropriate speed adoption in rural highways which design consistency is said to affect safety. Yet, the importance of geometric design consistency to road safety is not always maintained within current design approach.

An inefficient combination of horizontal and vertical alignment may cause road safety challenges, even when the horizontal and vertical alignment are separately consistent with the design standards. Such poor synchronization of horizontal and vertical alignment can create locations where the available sight distance drops below the required sight distance (Hassan, 2001).

2.4 Designing road alignment

The position or the layout of the centre line of the road on the ground is called the alignment and takes into consideration different factors including construction cost, maintenance cost, vehicle operation cost, and accident rate (Namitha, 2017). Traditionally, alignment is performed manually using drawing tools and mathematical techniques. When performed manually, geometric design is extremely cumbersome, time-consuming and vulnerable to very costly errors (Ananya, 2016; Chen-fu,2013). The traditional approach is also based mainly on a two-dimensional (2-D) analysis which does not guarantee a satisfactory good design (Yesser et.al. 1998).

Road designing in Malawi was done using local methods of walking to see the best route and using aerial photographic which could be analysed and interpreted using stereoscopes machine which could allow engineers to view in 3 dimensions (3D) (Kulemeka, 2020). The best route was defined focusing on drainage and making the road alignment routed along the ridge. Bearings, distances, sight and prominent natural features were guide-lines in determining road layout plan (Chikhwenda, 2019).

2.5 Nexus of human factor and road geometrics on road accidents

Road traffic accidents (RTA) are approaching epidemic proportions in low- and middle-income countries (Nantulya, 2002). RTA and their human casualties are a major scourge in both developed and developing countries (Whitegg, 1987). Accidents are not usually caused by one variable but by a mixture of variables (Oluleye, 2009). Human error is generally agreed to play some part in a large proportion of road accidents which constitutes human, vehicle and road infrastructure (BMJ, 1978). Even though a third of the accidents are caused by human behaviour related factors, road safety engineering also contributes to traffic accidents (Saupe, 2010). The interaction of vehicle and road geometrics ensures safe travelling on the roads.

A study by Othman et al. (2009) quoting (Fink, 1995) has shown that the degree of curvature is a good predictor of crash rate on horizontal curves. Although the effect of approaching tangent length and sight distance was as clear, the results suggest that the diverse safety effects of long approach tangent length and short approach sight distances became more pronounced on sharp curves. A study by CTE (1995) revealed that superelevation, together with sharp curves, is the main factor of crashes on motorway access ramps.

Studies on road traffic accidents have been done in isolation, focusing on either the contributions of human factors or road geometrics. Road safety engineers are faced with the challenge of addressing safety issues within the three major traffic pillars: human, vehicle and infrastructure (Othman, 2009). Petridou & Moustaki (2000) in their research on human factors in the causation of road traffic crashes, found out that human behaviour contributes to three of five traffic accidents.

CHAPTER 3. MATERIALS AND METHODS

3.1 Study Area

The research was conducted on the Mzuzu-Jenda M1 road section in areas prone to road accidents. The road meanders along the Chikangawa forest and provides a direct reliable route for both international and local freight from Tanzania. It crosses a geographical area dominated by mountains and valleys. The road has a number of bridges and also evades many mountains and valleys. The stretch has registered more than 100 fatal accidents for the past five years, making it one of the deadliest road stretches in Malawi. Data from Mzuzu Road Traffic Police archive reveal that areas of Champhira, Mapanjira, Luviri trading centre, Wateleka, Kathundu, Kasitu Lodge, Chilera-walanda, Mzimba bridge, Zimwanda and Luwafwa are prone to road a ccidents (GovM, 2019).

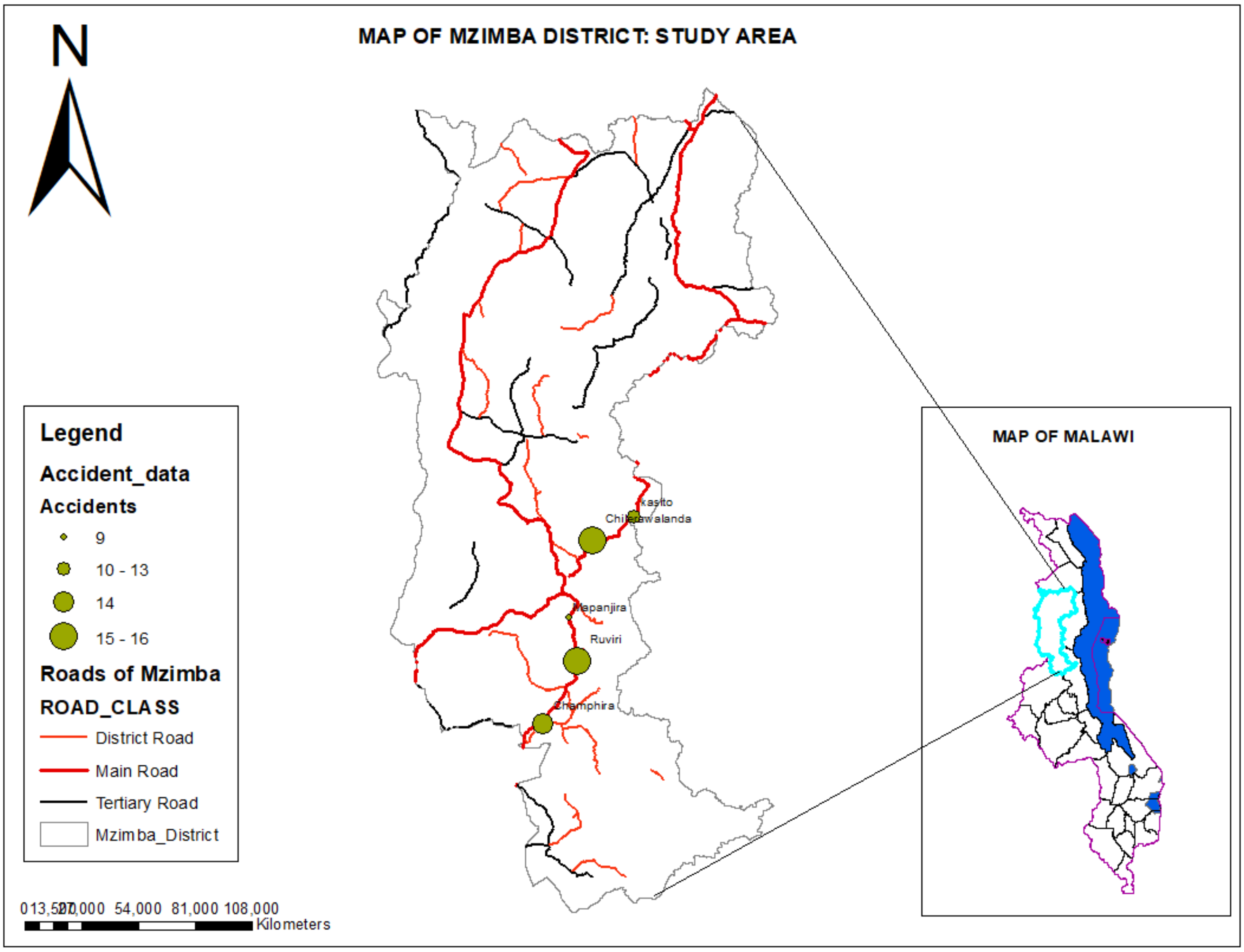


Figure 6. Map of Mzimba District showing sections of M1 road under study

3.2 Accident hot spots identification

Accident data in areas where accidents frequently happen was obtained from Mzuzu Road Traffic office. Based on records of a four-year period through 2020 has an exponential increase in road accidents along the road section under study as shown in Table 1.

Table 1. Number of accidents that occurred in different hot spots on the Mzuzu-Jenda M1 stretch (Source: Malawi Northern Traffic Police)

Location	**Easting**	**Northing**	**2020**	**2019**	**2018**	**2017**	**Total**
Kasitu	586073.362	8686082.979	4	2	4	3	13
Mapanjira	570545.462	8661969.966	3	5	1	-	9
Ruviri	572328.853	8651663.766	3	4	5	4	16
Mzozoma	570968.000	8654641.000	1	-	3	-	4
Champhira	564302.393	8636730.750	2	7	3	2	14
Chilerawalanda	575978.026	8680312.812	4	6	-	6	16
Mzimba Junction	569284.000	8671229.000	1	-	-	2	3
Elephant rock	585755.000	8704014.000	-		-	1	1
Watereka	574946.000	8678638.000	1	2	-	-	3
Kasangadzi	586708.725	8689050.356	1	2	3	2	8
Total			**20**	**28**	**19**	**23**	**91**

The identification of the hotspot areas was done using the accident frequency method, of which areas that had more accidents than others were considered as high risks areas and were selected for further investigation. Clustering method of spatial analysis was used in the ArcGIS Software to map those areas which were indicating high rates of accidents.

3.3 Research design

The research implored a mixed method. A road survey questionnaire was used to gather qualitative data from drivers and passengers who were involved in car accidents and Survey equipment was used to capture topographic data of the existing road sections in accident hot spot areas.

3.4 Sampling frame and methods

3.4.1 Sampling frame

A traffic count was done using a formula developed by Cornell University to determine the daily traffic volume on the road section. The development of the formula states that during the busiest day 15% of the traffic occurs during the busiest hour in rural areas, 11% of the traffic occurs during the busiest day in urban and 12% of the traffic occurs during the busiest hour of the day in Suburban. Take a count for 15 minutes, convert this value to a full one-hour count by multiplying by 4. Divide this number by the estimated percentage of traffic for the busiest hour: 15% in rural areas and 11% in urban areas. Suburban areas are going to be somewhere in between, usually on the brink of 12%. The traffic count was done for 15minutes during the busiest hour of the road. According to the information obtained from Raiply Road Block Police officers, 8 vehicles pass through the road on the busiest hour.

Count for 15 Minutes: T=8 Vehicles

One-hour count: T*4=32

Dividing by 15% (15% of traffic occurs on busiest day in local areas)

32/0.15= 214 vehicles each day

3.4.2 Sampling method

Purposive and randomly sampling techniques were utilized in the study. Purpose sampling was used in selecting accidents blackspots with data from Road Traffic Authorities confirming most prone spots in the Mzuzu-Jenda M1 road stretch as the main inclusion criterion. The same method was also used to get drivers who were involved in car accidents as respondents to the survey questionnaire that was distributed to gather human factor details for road accidents.

There are numerous approaches in calculating sample sizes and this study utilized an equation developed by Bartlett *et al*., (2001) as follows;

$$n = \frac{P(100-p)Z^2}{E^2} \text{..............................Equation (5)}$$

Where: **n** is the sample size, **p** is the percentage occurrence of a state or conditions, **E** is the percentage maximum error required and **Z** is the value corresponds to level of confidence required. Having 214 vehicles as the daily traffic volume with a margin error of +/-2% at 95% confidence level, the sample size used for the research was 197.

3.5 Software and Equipment

This study made use of software and equipment to successfully conduct data collection and analysis as outlined in Table 2.

Table 2. List of software and equipment used during data collection and analysis

Specific Objective	**Data Required**	**Data Collection Method**	**Analysis Method**	**Software**
To identify road geometric elements of accidents prone areas	Accident data Coordinates and elevation of accidents spots (XYZ)	Archival of road traffic accidents reports at Regional Traffic Police Office Differential GPS	Mapping hotspot areas (Kernel density Estimation) $f(x, y) = \frac{1}{nh^2} \sum_{i=1}^{n} K\left(\frac{d_i}{h}\right)$	ArcGIS10.6
To evaluate human factor leading to road accidents on Mzuzu-Jenda M1 road stretch	Vehicle speed data Age Gender Experience Type of Vehicle Vehicle condition	Speed radar gun Road survey questionnaire	Pearson correlation coefficient Logistic regression $\boldsymbol{log\frac{p}{1-p} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_2 + \cdots \beta_k x_{ki}} + \mathcal{E}$ **SATCC**	STATA
To analyse relationship between road geometric elements and human factor impact on road accidents	Topographic data of existing road alignment Road cross section dimensions	Differential GPS Total Station Measuring Tape	Logistic regression $\boldsymbol{log\frac{p}{1-p} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_2 + \cdots \beta_k x_{ki}} + \mathcal{E}$ SATCC	STATA AutoCAD 3D
To model alternative road design alignment on accident-prone sections	Topographic data of existing road alignment Road dimensions	Differential GPS Total Station Measuring Tape	SATCC (Southern Africa Transport and Communications Commission)	AutoCAD Civil 3D

3.6 Data analysis

3.6.1 Assessment of geometric elements of the Mzuzu-Jenda M1 Stretch in accident-prone areas

Super-elevation analysis on a Horizontal Curve

Super-elevation analysis has been done using the law of mechanics that governs vehicles operations on a curve. The formula below indicates force that balances or is at equilibrium when a vehicle is passing through a horizontal curve. When a vehicle is passing through a horizontal curve, the forces are supposed to equate to zero indicating the balance as stipulated in AASHTO (2011) shown in the formula below.

$$\frac{0.01e+f}{1-0.01ef} = \frac{v^2}{gR} = \frac{0.0079V^2}{R} = \frac{V^2}{127R} \text{.................Equation (6)}$$

Where: **e** is rate of roadway superelevation (**%**), **f** is side friction (demand) factor (**v**) is vehicle speed (**m/s**), **g** is gravitational constant (**9.8/s^2**), **V** is vehicle speed (**km/h**) and **R** is radius of curve (**m**)

Sight stopping distance analysis (SSD)

The analysis of SSD has been based on the existing ground measurements and designing standards using the existing parameters. Using equation (7) as provided by AASHTO (2011), calculations were done using the existing horizontal radius obtained from the plotted topographic survey data and speed limit as indicated on the speed road signs. The differential Global Position system was used to collect topographic survey data of the existing road alignment. On each location of the study area, controls (Easting, northing and elevation) was established to act as a base for all survey measurements which were connected to a national coordinate network system.

$$\text{ASSD} = \frac{R}{28.65}\left[cos^{-1}\left(\frac{R-M}{R}\right) \text{.......................Equation (7)}\right.$$

Where: A**SSD** is the available sight stopping distance (**m**), **R** is the radius of the curve (**m**) and **M** is the mid-ordinate of the curve (**m**)

The calculations of the required SSD of the road section from the design manual AASHTO (2011) recommends the use of the existing speed limits on that road horizontal curve section and corresponding the side friction coefficient.

$$\text{RSSD} = 0.694V + \left(\frac{V^2}{254f}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation (8)}$$

Where: **S** is required sight stopping distance (**m**), **V** is Designated speed limit (**Km/hr**) and **f** is friction coefficient

Analysing whether the present SSD is sufficient or not is based on the comparison of the existing SSD and what is required or recommended. The measure of the different significance in causing road accidents is based on the reaction time.

Limit state function for the stopping sight distance

The calculation of the limit function for the sight stopping distance has been based by using the formula below as discussed by Porter (2015). The analysis of the significance of the limit function for the sight stopping distance was done by the use of the standards provided by AASHTO for the speed limit vs the required sight distance.

$$\boldsymbol{Z_{SSD}} = (\boldsymbol{ASSD}) - (\boldsymbol{RSSD}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation (9).}$$

Where: $\mathbf{Z_{ss}}$ is the limit function for the sight stopping distance, **ASSD** is the available sight stopping distance and **RSSD** is the required sight stopping distance

Horizontal clearance

The required clearance by the inner roadside of a curve has been analysed using equation (10) provided by AASHTO (2011) below. The value of *b* was obtained from the ground measurement while the ASD was obtained after the topographic survey data was plotted on AutoCAD Civil 3D.

$$C = R - (R + b) * Cos\left(\frac{31.83 * ASD}{R+b}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation (10)}$$

Where **C** is minimum horizontal offset from the sight obstruction to the inner roadway edge (**m**), **R** is radius of the inner roadway edge (**m**), **b** is offset between the driver and the inner roadway edge (**m**) and **ASD** is available sight distance (**m**)

Curvature of the horizontal curves

The impact of the curvature on road accidents has been done by the impact of deflection angle on the frequency of road accidents. Figure 7 is a graph developed by Hauer (1993) and summarises the impact of an increase in the deflection angle on the frequency of accidents.

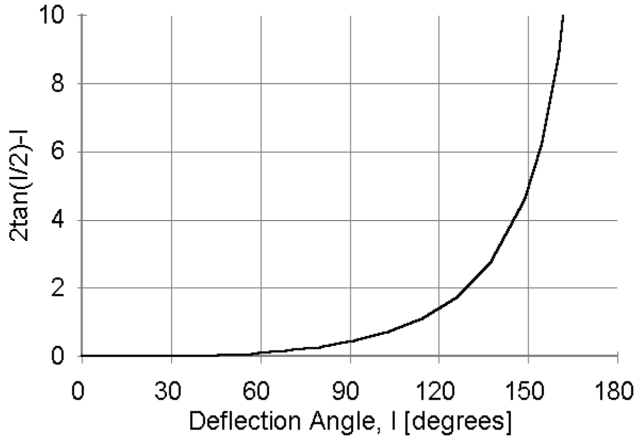


Figure 7. The relationship between deflection angle and frequency of accidents

Topographic Survey data

The equipment used in this study included Single Leica GS15 GPS System, Leica Total Station and Leica Dumpy level each with its own accompanying accessories. The Leica GS 15 GPS System is a Global Positioning System that makes use of a system of satellites to accurately determine the position of features relative to a chosen datum by means of coordinates. It gives the real time X, Y and Z coordinates of features thereby making it possible for the feature to be located on the earth's surface. This was used to establish a horizontal control network in Post Processing mode. Its main strength is in its ability to pick data for surveying at highly impressive speeds and the ability to cover a large distance from a single setting. When capturing horizontal data (XY), it covers a distance of 6 Kilometres with accuracy of +/-20mm while with vertical control it varies hence not ideal for precise Engineering work.

Dumpy level was used to establish vertical control network. This is a highly accurate level that can transfer or determine precise height differences between surveying legs of up to 50 meters.

3.6.2 Analysis of human behaviour leading to road accidents on Mzuzu-Jenda M1 road stretch

Logistic Regression model was used instead of Linear Regression because the dependent variable is categorical and not continuous.

$$\log \frac{p}{1-p} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_2 + \cdots \beta_{ki} x_{ki} + \mathcal{E} \text{……………………formula (1)}$$

The Logistic Regression model determines the probability of a particular categorical outcome (an accident) given a set of independent variables. In this case, the dependent variable was “were you the driver at the time of the accident?” while age, gender, marital status, experience and other factors were used as independent variables. The probable answers being binary the responses were either 0 or 1 (0=No and 1=yes), analysis of such variables follows Logit or Probit analysis hence the model used is fit for this survey.

3.6.3 Evaluation of the relationship between road geometric elements and human behaviour impact on road accidents

The road geometric elements and human behaviour factors were analysed using graphs in Microsoft excel to check their relation to causation of road accidents. A speed radar gun was used to capture vehicle speed tracking it on two locations. In the research done by (Natalia, 2016), they used different methods to track the speed base-ball and found that the speed radar gun app was very effective. This was used instead of the Police traffic speed radar detector because at the time of the data collection, their equipment were in South Africa for calibration.

3.6.4 Modelling alternative road design alignment on accident-prone sections

The following design criteria based on the geometric design standards manual of Southern Africa Transport and Communications Commission (SATCC) 2001 were assigned to the horizontal geometry of the centre line, profile and cross-section of the roadway. The design criteria on sections differ depending on the cross section and alignment existing information of that location under study.

The general areas of focus include design speed, superelevation rate, coefficient of friction, minimum K for crest curves, roadway width, carriageway width and shoulder width. The following general procedure in the designing process of the road using AutoCAD Civil 3D as presented in Autodesk, 2020 was employed.

i. Prepare point file (comprising of easting, Northing and elevation saved in Excel CSV format
ii. Create a new job in AutoCAD Civil 3D
iii. Import the point file into the AutoCAD Civil 3D environment
iv. Create a road alignment using alignment creation tool
v. Create a surface profile
vi. Create a grade line (proposed road design alignment) and vertical curves using the profile creation tools
vii. Create assembly. The assembly is constructed by adding individual sub assembly which consists of the road lane, width and daylight that has specifications based on the design criteria
viii. Create a corridor, 3D model representation that consists of a combination of vertical, horizontal and cross section elements. Corridors are also used to calculate earth work perform sight distance analysis and find data for construction purposes.
ix. Generate the volume report which also shows among others the fill and cut data
x. Produce the perspective view

CHAPTER 4: RESULTS

4.1 Road geometric elements of the Mzuzu-Jenda M1 Road stretch in accident-prone areas

4.1.1 Mapanjira

The general alignment of the road section at Mapanjira constitute a reverse curve with radii; 78.461m and 103.891m with deflection angles of 73° 01′ 28″ and 55° 06′ 00″ respectively. The vertical profile of the road section indicated no presence of sag or vertical curves as the overall grade was -0.01%.

The operating speed indicated on the sign post approaching the curve shows 60 km per hour speed limit. Rumble strips had been installed 150m away from the curve in both directions. Along the right side of the curve, guardrails have been placed to protect vehicles that may skid off. Using the topographic survey data of the existing road and the cross section elements were plotted in AutoCAD Civil 3D as shown in Figure 8.

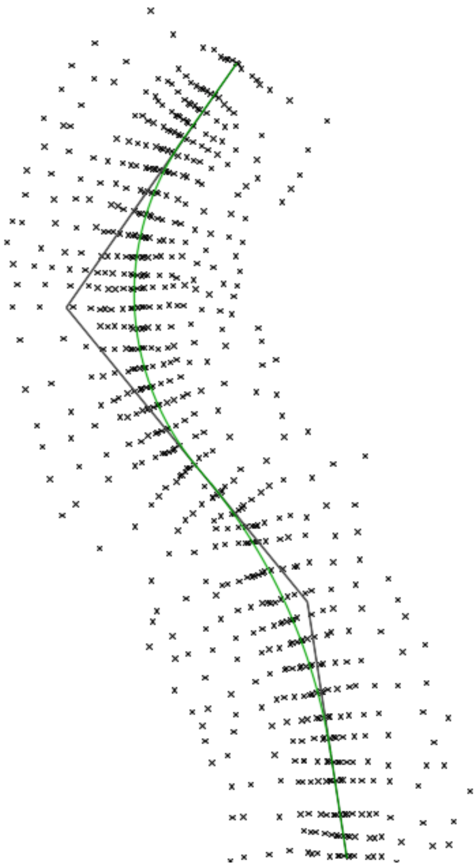


Figure 8. Horizontal profile of the road section at Mapanjira

Evaluating Superelevation on First Horizontal curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01 * 0.04 + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{277.778}{78.461 * 9.8} = \frac{0.0079 * (60)2}{78.461} = \frac{(60\ )2}{127(78.461)}$$

$$\frac{0.1804}{0.99928} = \frac{277.778}{78.461 * 9.8} = \frac{24.440}{78.461} = \frac{3600}{127 * 78.461}$$

$$0.181 = 0.361 = 0.362 = 0.361$$

Available sight stopping distance (ASSD) for the first curve

Available sight stopping distance was calculated using Equation (7) as follows;

Where b is 9.166m and R is 78.461m

The sight stopping distance will be;

$$\text{ASSD}= \frac{R}{28.65}\left[cos^{-1}\left(\frac{R-M}{R}\right)\right.$$

76.405m

The required sight stopping distance for the first curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

From the ground observation and brake force coefficient used;

Speed=60km/hr and f=0.18

$$RSSD = 0.694(60) + (60)^2/254(0.18)$$

120.652m

The limit function of sight stopping distance (Z_{SSD})

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$Z_{SSD}=76.405-120.652$$

$$-44.247m$$

Horizontal clearance for the first curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=horizontal clearance (m), R=78.461m, ASD=76.405 and b=3.4m

$$C = 78.461 - (78.461 + 3.4) * Cos(\frac{31.83 * 76.405}{78.461 + 3.4})$$

$$=7.359m$$

Curvature of the first simple horizontal curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer (1993). The deflection angle of the first curve is 73° 01′ 28″.

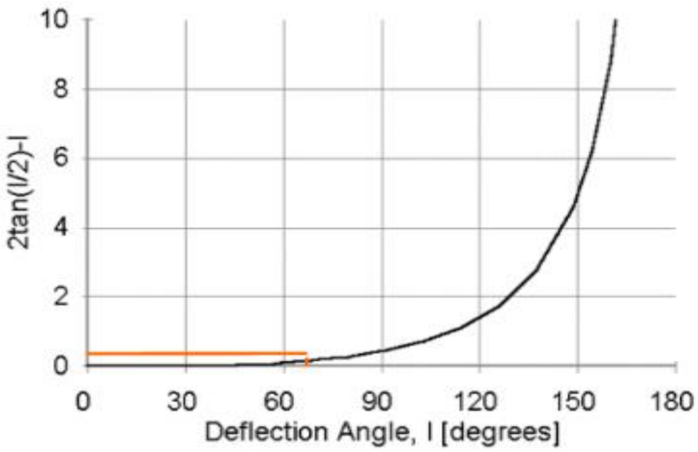


Figure 9. First Mapanjira simple deflection angle

Evaluating Superelevation on the Second Horizontal Curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01 * 0.04 + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{277.778}{103.891 * 9.8} = \frac{0.0079 * (60)2}{103.891} = \frac{(60\ )2}{127(103.891)}$$

$$\frac{0.1804}{0.99928} = \frac{277.778}{103.891 * 9.8} = \frac{28.440}{103.891} = \frac{3600}{127 * 103.891}$$

$$0.181 = 0.273 = 0.273 = 0.273$$

Available sight stopping distance (ASSD) for the Second curve

Available sight stopping distance was calculated using Equation (7) as follows;

Where is 12.137m is Mid ordinate and R is 103.891m

The sight stopping distance is;

$$ASSD = \frac{258.373}{28.65}\left[cos^{-1}\left(\frac{258.373 - 10.058}{258.373}\right)\right]$$

=101.433m

The required sight stopping distance for the second curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Vehicle speed =60km/hr and brake coefficient=0.18

$$RSSD = 0.694(60) + (60)^2/254(0.18)$$

RSSD=120.652m

The limit function of sight stopping distance (Z_{SSD}

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

Z_{SSD}=101.433-120.652

-19.219m

Horizontal clearance for the second Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=103.891m, ASD=101.433m, b=3.4m

$$C = 103.891 - (103.891 + 3.4) * Cos(\frac{31.83 * 101.433}{103.891 + 3.4})$$

=11.074m

Curvature of the horizontal curves on the second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 55° 06′ 00″

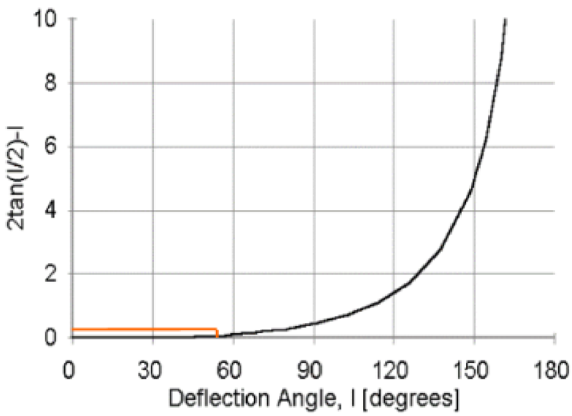


Figure 10. Second Mapanjira simple deflection angle

Lane width on the whole road section

The road section has a lane width of 3.4m.

Shoulder width on the whole road section

The ground observations and measurements indicated there is no shoulder on this road section.

4.1.2 Champhira

The ground measurements on this road section indicates a lane width of the road 3.5m and a shoulder width of an average 0.5m. A road sign indicates speed limit of 80km per hour. The general alignment of the road section at Champhira consists of a compound Horizontal curve with a radius of 209.914m with a deflection angle of 27° 17′ 42″. The vertical profile of the road section indicates no presence of sag or crest curves as the overall grade is -0.03%.

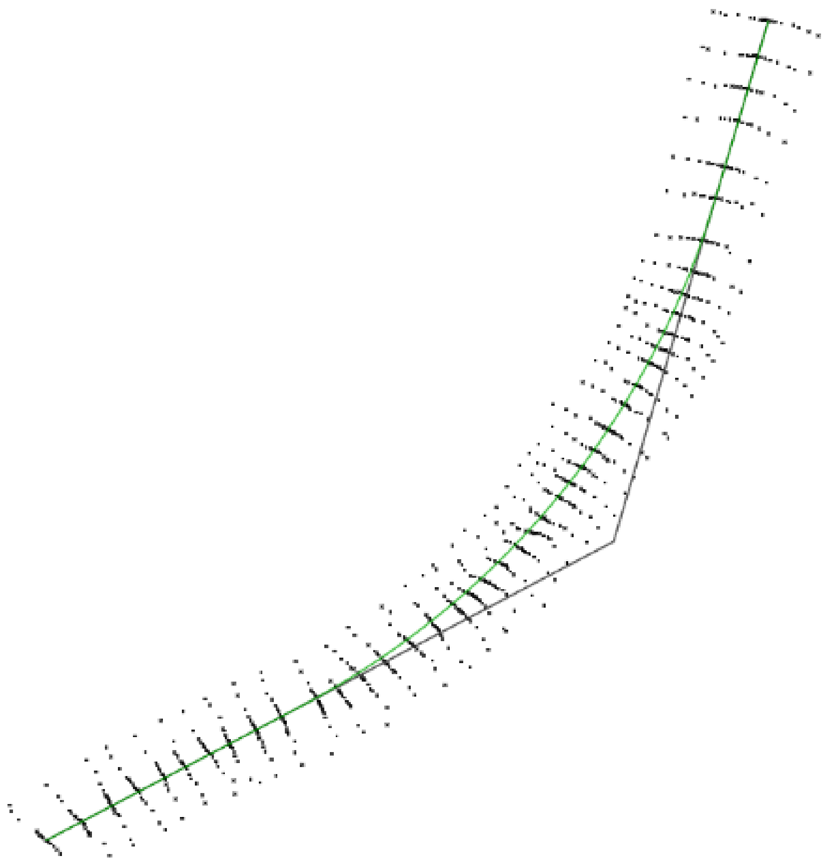


Figure 11. The longitudinal presentation of the road at Champhira

Superelevation on the Horizontal curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01 * 0.04 + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{(17.7)^2}{209.914 * (9.8)} = \frac{0.0079 * (80)^2}{209.914} = \frac{(80)^2}{127(209.914)}$$

$$\frac{0.1804}{0.99928} = \frac{493.827}{9.8 * 209.914} = \frac{113.76}{209.914} = \frac{14400}{127 * 209.914}$$

$$0.118053 = 0.240 = 0.241 = 0.240$$

Available sight stopping distance of the Horizontal Curve (ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;
Where b is 24.523m and R is 209.914m;

$$\boldsymbol{ASSD} = \frac{209.914}{28.65}\left[cos^{-1}\left(\frac{209.914 - 24.523}{209.914}\right)\right]$$

=204.926m

Required sight stopping distance of the Horizontal Curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Vehicle speed =80km/hr and brake coefficient=0.18

$$\boldsymbol{RSSD} = 0.694(80) + (80)^2/254(0.18)$$

S=195.502

The limit function of sight stopping distance (Z_{SSD})

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

Z_{SSD}=204.926-195.502

9.424m

Horizontal clearance for the Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=209.914m, ASD=204.926m, b=3.5m

$$C = 209.914 - (209.914 + 3.5) * Cos(\frac{31.83 * 204.926}{209.914 + 3.5})$$

=26.151m

Curvature of the horizontal curves on the curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 27° 17′ 42″

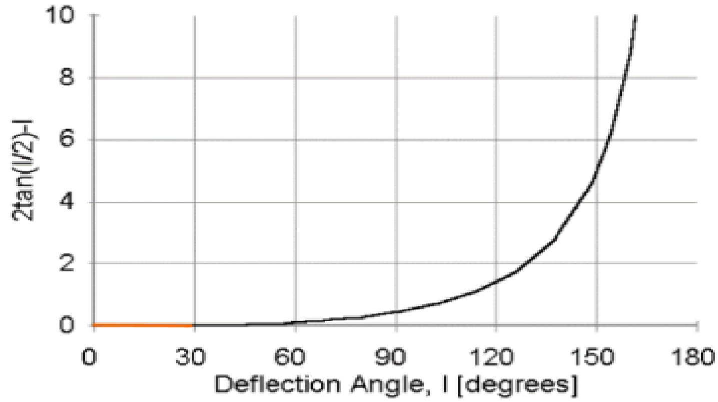


Figure 12. Compound Curve deflection angle

Lane Width of the whole road section

The road section has a lane width of 3.5m.

Shoulder width of the whole road section

The shoulder of the road is 0.5m.

4.1.3 Chilerawalanda

The ground measurements on this 1.9 km road section shows lane width of 3.5 m and a shoulder width of an average 0.2 m. The road signs as we approach the curve indicates a speed limit of 60 km per hour. The general alignment of the road section at Chilerawalanda consists of a broken-back horizontal curve with radii of 104.643 m and 75.853 m with deflection angles of 54° 45′ 09″ and 75° 32′ 07″ respectively. The vertical profile of the road section indicates a slope of -7.46% as shown in the Figure 13 below.

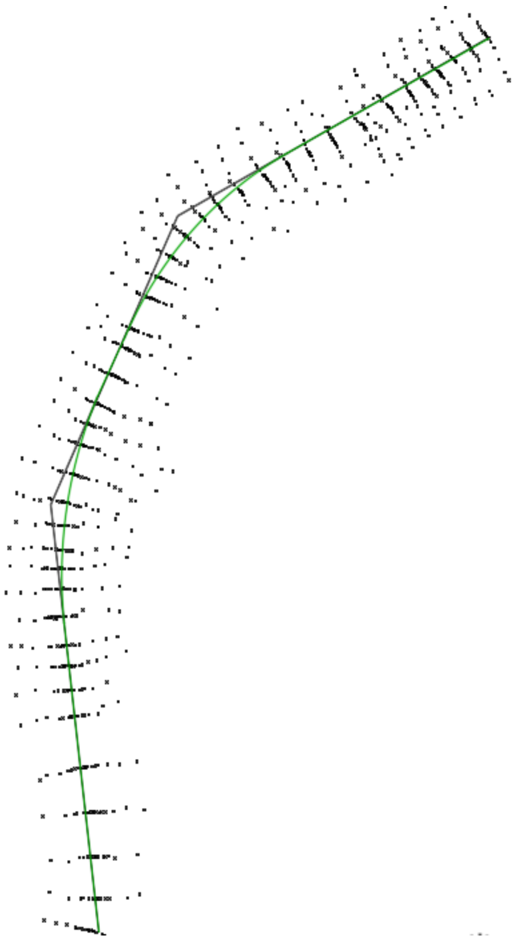


Figure 13. The horizontal alignment of the road section at Chilerawalanda

Superelevation of the first Curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01*0.04+0.18}{1-0.01*0.04*0.18}=\frac{(16.667)^2}{104.643*(9.8)}=\frac{0.0079*(60)^2}{104.643}=\frac{(60)^2}{127(104.643)}$$

$$\frac{0.1804}{0.99928} = \frac{277.778}{1025.501} = \frac{28.444}{104.643} = \frac{3600}{13289.661}$$

$$0.118053 = 0.271 = 0.273 = 0.271$$

Available sight stopping distance of the simple horizontal curve(ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;

Where R is 104.643 m and M is 12.225m

$$ASSD = \frac{104.643}{28.65}\left[cos^{-1}\left(\frac{104.643 - 12.225}{104.643}\right)\right]$$

=102.136m

Required sight stopping distance of the simple horizontal curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Vehicle speed =50km/hr and brake coefficient=0.18

$$RSSD = 0.694(60) + (60)^2/254(0.18)$$

=120.38m

Limit state function for the stopping sight distance of the first curve

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$\boldsymbol{Z_{SSD}} = 102.136 - 120.383$$

-18.247m

Horizontal clearance for the first Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=104.643m, ASD=102.136m, b=3.4m

$$C = 104.643 - (104.643 + 3.4) * Cos(\frac{31.83 * 102.136}{104.643 + 3.4})$$

11.160m

Curvature of the horizontal curves on the Second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 54° 45′ 09″ as shown in Figure14.

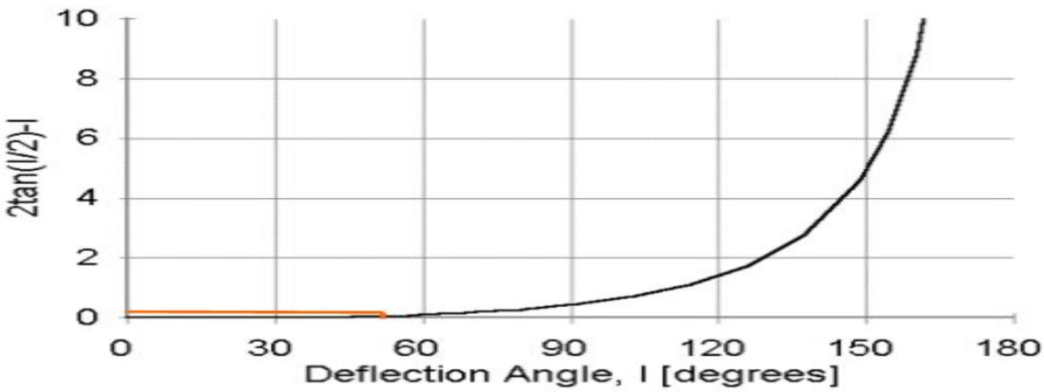


Figure 14. Deflection angle of the first curve

Superelevation of the second Curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01 * 0.04 + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{(16.667)^2}{75.853 * (9.8)} = \frac{0.0079 * (60)^2}{75.853} = \frac{(60)^2}{127(75.853)}$$

$$\frac{0.1804}{0.99928} = \frac{277.778}{743.359} = \frac{28.444}{75.853} = \frac{3600}{9633.331}$$

$$0.118053 = 0.374 = 0.375 = 0.374$$

Available sight stopping distance of the first horizontal curve(ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;

Where R is 75.853m and M is 8.861m

$$ASSD = \frac{75.853}{28.65}[cos^{-1}\left(\frac{75.853 - 8.861}{75.853}\right)]$$

74.057m

Required Sight Stopping distance on the second curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Vehicle speed =60km/hr and brake coefficient=0.18

$$RSSD = 0.694(60) + (60)^2/254(0.18)$$

120.38m

Limit state function for the stopping sight distance

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$\boldsymbol{Z_{SSD}} = 74.057 - 120.383$$

-46.326m

Horizontal clearance for the first Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=75.853m, ASD=74.057m, b=3.4m

$$C = 75.853 - (75.853 + 3.4) * Cos(\frac{31.83 * 74.057}{75.853 + 3.4})$$

7.041m

Curvature of the horizontal curves on the Second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 75° 32′ 07″

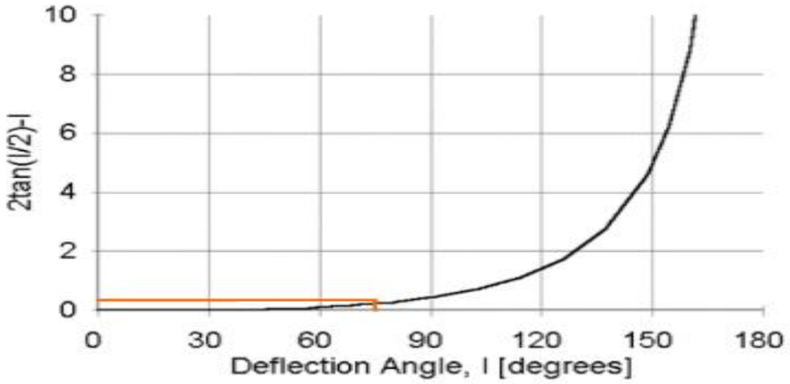


Figure 15. Deflection angle of the second curve

Lane Width

The road section has a lane width of 3.4m

Shoulder width

The shoulder of the road is 0.2m

4.1.4 Ruviri

The ground measurements on this road section shows width of the road 3.5m and there was no shoulder on the right hand side of the road, while the left side has a shoulder width of 0.45m. The road sign indicated a speed limit of 50km per hour. The general alignment of the road section at Ruviri consists of a broken-back curve with a radius of 89.276m and

104.248m with deflection angles of 64° 10′ 42″ and 54° 57′ 40″ respectively. The vertical profile of the road section indicates a gentle moderate slope.

Rumble stripes have been installed 150m away from the beginning of the curve.

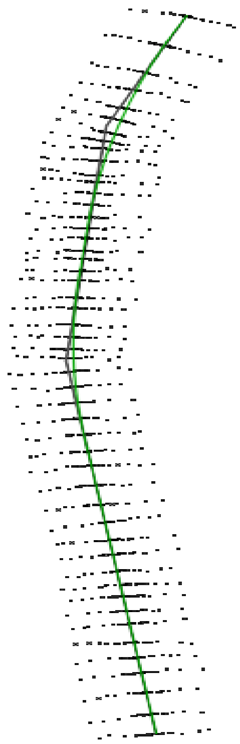


Figure 16. The horizontal alignment of the road section at Ruviri

Superelevation of the first curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01 * 0.04 + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{(13.889)^2}{89.276 * (9.8)} = \frac{0.0079 * (50)^2}{89.276} = \frac{(50)^2}{127 * 89.276)}$$

$$\frac{0.1804}{0.99928} = \frac{192.904}{874.905} = \frac{19.75}{890276} = \frac{2500}{11338.052}$$

$$0.118053 = 0.220 = 0.221 = 0.22$$

Available Sight distance of the first Curve (ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;

Where M is Mid ordinate 10.429m and R is 89.276m

$$ASSD = \frac{89.276}{28.65}[cos^{-1}\left(\frac{89.276 - 10.429}{89.276}\right)]$$

87.162m

Required Sight Stopping distance of the first curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Vehicle speed =50km/hr and brake coefficient=0.18

$$RSSD = 0.694(50) + (50)^2/254(0.18)$$

S=89.381m

Limit state function for the stopping sight distance

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$\boldsymbol{Z_{SSD}} = 87.162 - 89.381$$

-2.219m

Horizontal clearance for the first Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=89.276m, ASD=87.162m, b=3.4m

$$C = 89.276 - (89.276 + 3.4) * Cos(\frac{31.83 * 87.162}{89.276 + 3.4})$$

8.965m

Curvature of the horizontal curves on the Second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 64° 10′ 42″ as shown in Figure17.

Figure 17. Deflection angle of the first curve

Superelevation of the second curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{0.01 * 0.04 + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{(13.889)^2}{104.248 * (9.8)} = \frac{0.0079 * (50)^2}{104.248} = \frac{(50)^2}{127 * 104.248)}$$

$$\frac{0.1804}{0.99928} = \frac{192.904}{104.248} = \frac{19.75}{104.248} = \frac{2500}{13239.496}$$

$$0.118053 = 0.189 = 0.189 = 0.18$$

Available Sight distance of the first Curve (ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;

Where M is Mid ordinate 12.200m and R is 104.248m

$$ASSD = \frac{104.248}{28.65}\,[cos^{-1}\left(\frac{104.248 - 12.200}{104.248}\right)]$$

101.873m

Required Sight Stopping distance of the first curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows; Vehicle speed =50km/hr and brake coefficient=0.18

$$RSSD = 0.694(50) + (50)^2/254(0.18)$$

S=89.381m

Limit state function for the stopping sight distance

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$\boldsymbol{Z_{SSD}} = 101.873 - 89.381$$

12.492m

Horizontal clearance for the first Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=104.248m, ASD=101.873m, b=3.4m

$$C = 104.248 - (104.248 + 3.4) * Cos(\frac{31.83 * 101.873}{104.248 + 3.4})$$

11.136m

Curvature of the horizontal curves on the Second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 54° 57′ 40″ as shown in Figure18.

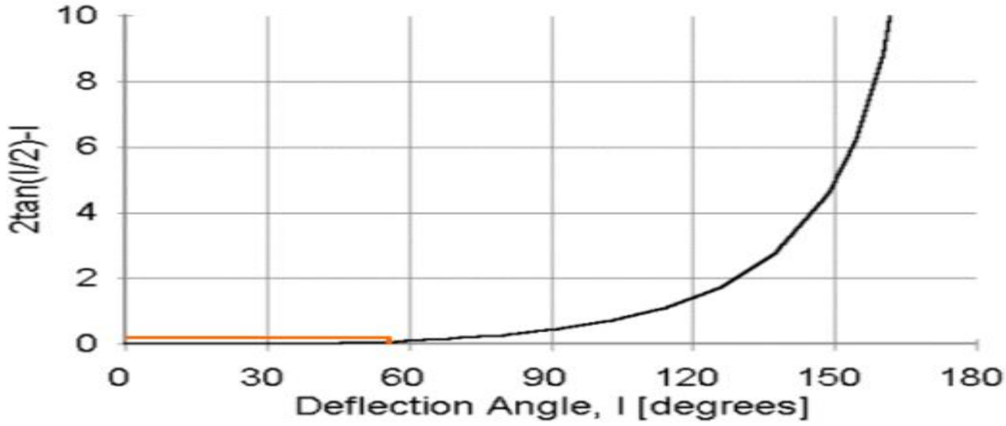


Figure 18. Deflection angle of the second curve

Lane Width

The road section has a lane width of 3.5m

Shoulder width

The shoulder on the left side of the road is 0.45m and 0.000m on the right hand side.

4.1.5 Kasitu

The ground measurements on this road section shows width of the road 3.5m with a shoulder width of 0.5m on the right and 1.0m shoulder on the left.

The general alignment of the road section at Kasitu a reverse curve with radii of 324.093m and 309.605 with deflection angles of $52° 09' 57''$ and $42° 22' 06''$ respectively. The vertical profile of the road section indicates a gentle moderate slope. The road sign indicates a speed limit of 50km/hr and rumble stripes have been installed 84m away from the beginning of the curve.

Rumble surfaces have been installed at the beginning of the curve as a safety measures to alert the traffic of the curves ahead.

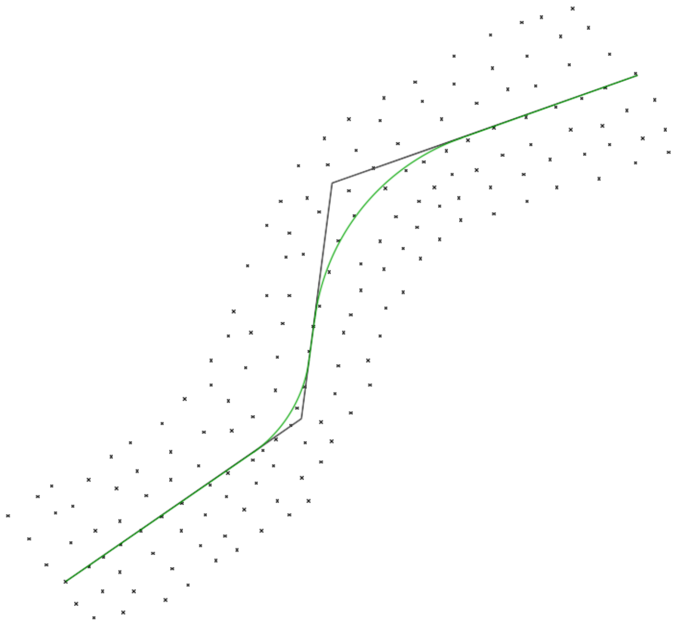


Figure 19. The horizontal alignment of road the section at Kasitu

Superelevation of the first curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{(0.01 * 0.04) + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{192.904}{71.649 * (9.8)} = \frac{0.0079 * (50)^2}{71.649} = \frac{(50)^2}{127(71.649)}$$

$$\frac{0.1804}{0.99928} = \frac{192.904}{702.160} = \frac{19.75}{71.649} = \frac{2500}{9099.423}$$

$$0.118053 = 0.275 = 0.276 = 0.275$$

Available Sight stopping distance on the first Curve (ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;

Where R is 71.649m and M is 8.370m

$$ASSD = \frac{71.649}{28.65}\left[cos^{-1}\left(\frac{71.649 - 8.370}{71.649}\right)\right]$$

69.977m

Required Sight Stopping distance on the first curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Where V=50km/hr and the breaking coefficient (*f*) is 0.18

$$RSSD \ = 0.694(50) + (50)^2/254(0.18)$$

89.381m

Limit state function for the stopping sight distance

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$\boldsymbol{Z_{SSD}} \ = 69.977 - 89.381$$

-19.404m

Horizontal clearance for the first Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=71.649m, ASD=69.977m, b=3.4m

$$C = 71.649 - (71.649 + 3.4) * Cos(\frac{31.83 * 69.977}{71.649 + 3.4})$$

7.378m

Curvature of the horizontal curves on the Second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 79° 58′ 02″ as shown in Figure 20.

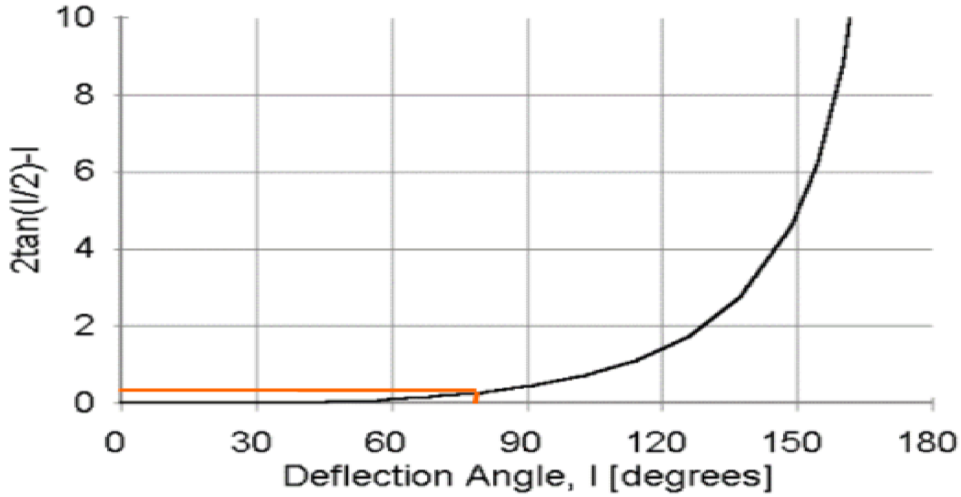


Figure 20. Deflection angle of the first curve

Superelevation on the second Horizontal Curve

Superelevation of the road section was calculated using Equation (6) as follows;

$$\frac{(0.01 * 0.04) + 0.18}{1 - 0.01 * 0.04 * 0.18} = \frac{192.904}{96.413 * (9.8)} = \frac{0.0079 * (50)^2}{96.413} = \frac{(50)^2}{127(96.413)}$$

$$\frac{0.1804}{0.99928} = \frac{192.904}{944.847} = \frac{19.75}{96.413} = \frac{2500}{12244.451}$$

$$0.118053 = 0.204 = 0.205 = 0.204$$

Available Sight stopping distance on the second Curve (ASSD)

Available sight stopping distance was calculated using Equation (7) as follows;

Where R is 96.413 and M is 11.263

$$ASSD = \frac{96.413}{28.65}[cos^{-1}\left(\frac{96.413 - 11.263}{96.413}\right)]$$

94.130m

Required Sight Stopping distance using the second curve (RSSD)

The required sight stopping distance has been calculated using Equation (8) as follows;

Where V=50km/hr and the breaking coefficient (*f*) is 0.18

$$RSSD = 0.694(50) + (50)^2/254(0.18)$$

S=89.381m

Limit state function for the stopping sight distance

The limit function of the sight stopping distance was calculated using Equation (9) as follows;

$$\boldsymbol{Z_{SSD}} = 94.130 - 89.381$$

4.749m

Horizontal clearance for the first Curve

The clearance for the horizontal obstruction has been calculated using the available sight distance, the radius of the inner roadway and the offset below driver and the inner roadway edge. The calculation was done using Equation (10) as follows;

Where C=Horizontal clearance (m), R=96.413m, ASD=94.130m, b=3.4m

$$C = 96.413 - (96.413 + 3.4) * Cos(\frac{31.83 * 94.130}{96.413 + 3.4})$$

10.127m

Curvature of the horizontal curves on the Second curve

The analysis of curvature of the road which measures the impact deflection angle on road accidents has been done by the use of accident-deflection angle graph developed by Hauer, 1993. The deflection angle for the second curve is 59° 25′ 39″ as shown in Figure21.

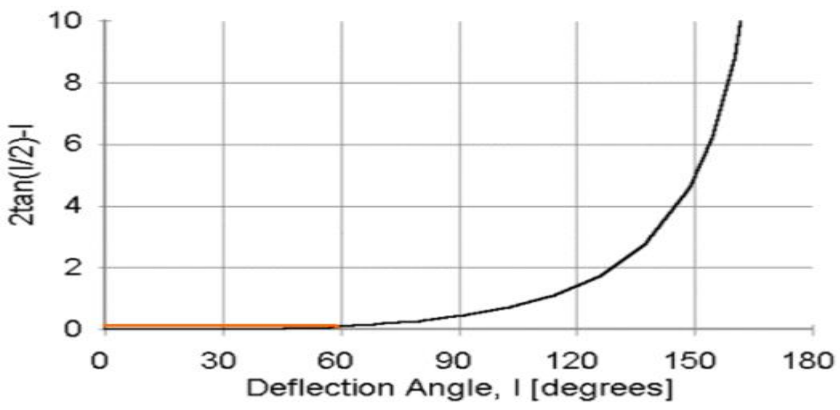


Figure 21. Deflection angle of the second curve

Lane width

The cross-section measurements on this road section indicated that the lane width is 3.5m

Shoulder of the road

The cross-section measurements on this road section indicated that there is a 0.4m shoulder width.

4.2 Human behaviour leading to road accidents on Mzuzu-Jenda M1 road stretch

4.2.1 Respondents demography

The demographic of the respondents indicated that 71% were male and 29% female of which 48.9% were married and 51.1% were unmarried. 61.7% of the respondents driving was their occupation while 37.8% were not.

Among the 181 respondents, 43 indicated that they were driving at the time of the car accident of which 67.6% are male drivers and 32.4% were female drivers. Responding to the question of road signs visibility, 55.9 % indicated that road signs are not visible and 44.1%

indicated that they are visible. On whether they drive at high speed on the rumble strips along the road stretch, 52% responded yes, 29.4% indicated no while 17.6% responded not. 52,9% of the respondents said they drive at high speed of the rumble strips because they are familiar with the road section, 20.6% they get irritated, 8.8% said the car jerks a lot while 17.6% did not respond. Figure 22 and 23 below summarises the respondent's demography and Human character.

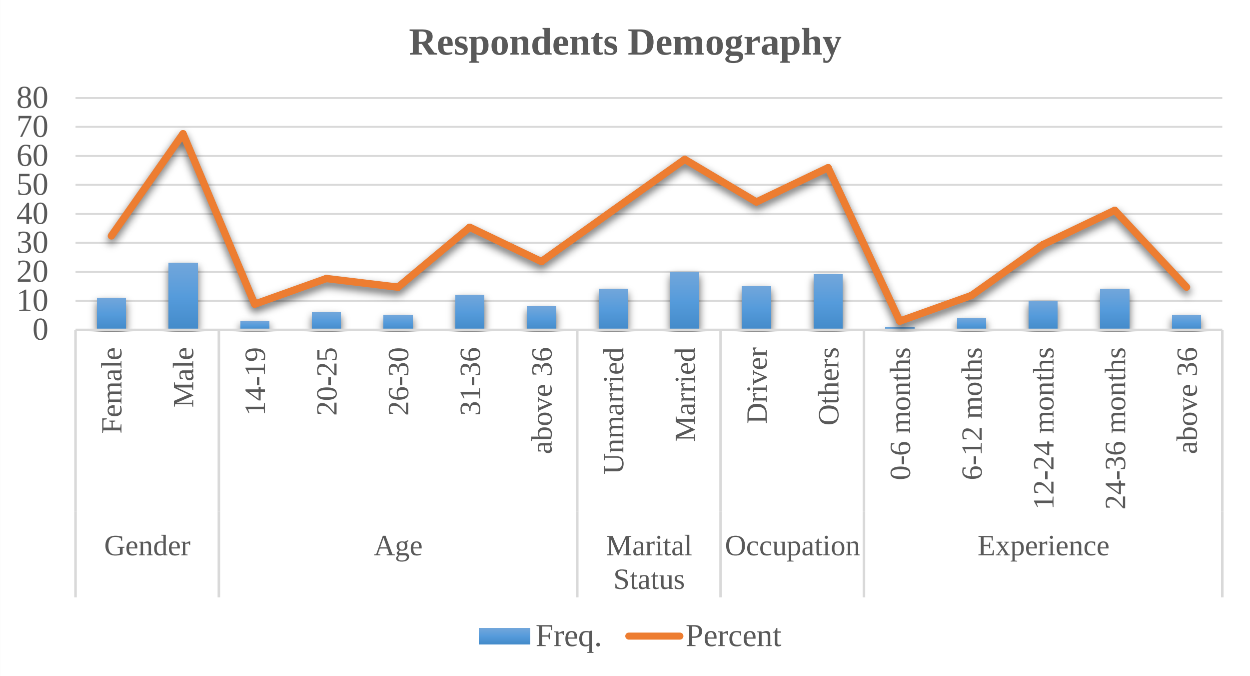


Figure 22. Respondents' demography

4.2.2 Respondents human factors

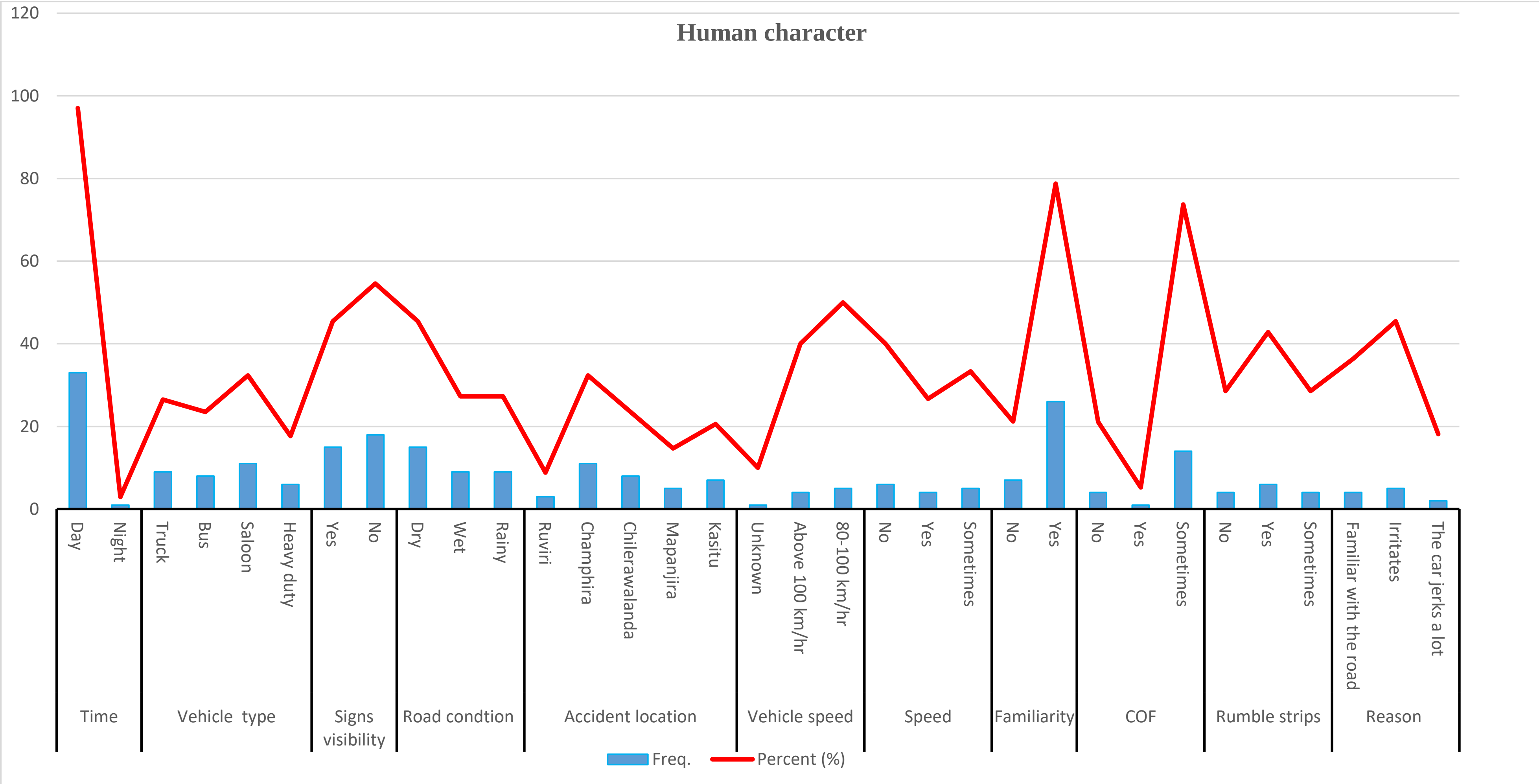


Figure 23. Respondents human factors

4.2.3 Logistic output for drivers involved in an accident

Table 3 below shows the Logistic Output for Respondents that were driving at the time of an

Dependent Variable: Being involved in a car accident	

accident.

Number of Observation (N) = 64,

Probability > chi2 = 0.0862

Independent Variables	Coefficients	Standard Error	P>|z|	95% Conf. Interval
Gender				
	3.216089	1.491682	0.031**	.2924463
Age			6.139732	
20-25 Years				
26-30 Years	3.124504	1.837464		
31--36 Years	.7644907	1.715323	0.089***	4768592
Above 36 years	2.177914	1.502505	6.725866	
	1.77555	1.602606	0.656	-2.59748 4.126461
			0.147	-.7669417 5.122769
Time of the Accident			0.268	-1.3655 4.916601
PM				
	-1.843949	2.025937		
Road signs availability				
Yes (Available)			0.363	-5.814713
	-1.010871	.973362	2.126815	
Road condition				
Wet			0.299	-2.918626 .8968832
Rainy	1.159463	1.230163		
	2.296169	1.286181		
Traffic condition				
Moderate			0.346	-1.251612 3.570538
	-.0604932	.9597358	0.074***	-.2246991
Road Visibility			4.817036	
Adequate				
Fair	-3.858737	1.913356		
Poor	-1.25322	1.921465	0.950	-1.941541 1.820554
	-4.337662	1.984789		
Vehicle COF condition				
Yes			0.044**	-7.608846 -
Not Sure	1.151229	1.829899	.1086285	
	1.754325	1.868076	0.514	-5.019222 2.512783
Rumble stripes			0.029**	-8.227777 -
Yes			.4475476	
Sometimes	-1.010408	1.526692		
	-1.512046	1.601785		
Constant			0.529	-2.435307 4.737765
	.4539411	2.917626	0.348	-1.907036 5.415686
			0.508	-4.002669 1.981853
			0.345	-4.651488 1.627396
			0.876	-5.2645 6.172383

Table 3. Logistic output for the respondents

Log likelihood = -23.292096

* Significance at = 1%, ** Significance at = 5 %, *** Significance at = 10%

Pearson Chi2 Goodness of Fit Test for the model:

The goodness of Fit model shows the validity of the model used. In this case the calculated Chi-square (Model) is 86.54 with a p-value of 0.0001, which is less than 1% (0.01) hence highly significant at 1%. Therefore, the model is valid. This is the only reliable overall test of validity for logit models.

The positive coefficients show that those variables increase the likelihood (Probability) of an accident happening while negative coefficients show that those variables decrease the likelihood of an accident happening. However in explaining the variable output concentration is drawn at the variables which are significant at any level i.e at 1%, 5% and 10% p>0.01, p>0.05 and p>0.1 respectively.

Table 4. Goodness of fit test.

Logistic model for being involved in accident1, goodness-of-fit test	
Number of observations	64
Number of covariate patterns	62
Pearson $Chi^2(44)$	86.54
Prob $>Chi^2$	0.0001

Source: Road Survey data Logistic model

Gender

From the above output, gender was found to be significant at p>0.031 hence significant at 5%. The positive coefficient implies that gender of the driver increased the likelihood of an accident happening. From the results, male drivers were the ones who were involved in traffic accidents as compared to their female driver's counterparts.

Age

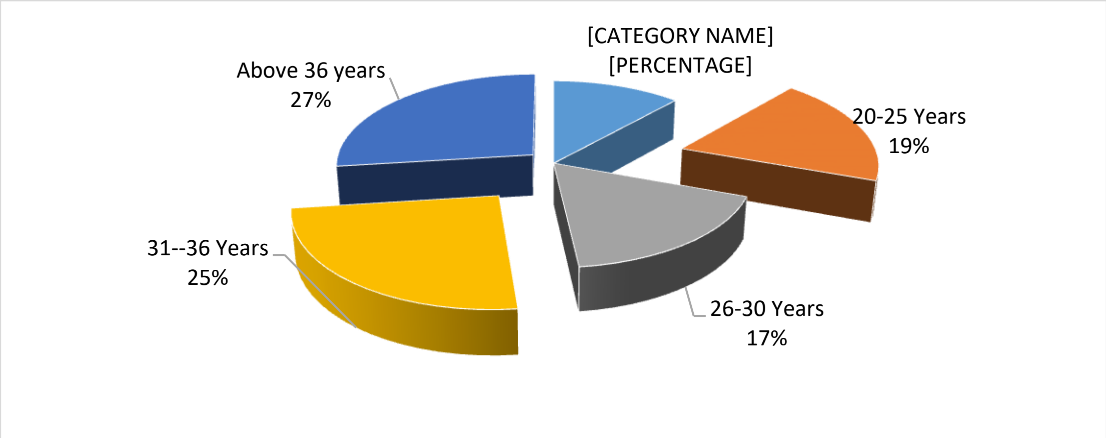


Figure 24. Age of the respondents

Results show that more than half (52%) of the accidents involved drivers at least 30 years of age. Based on **Figure 24** drivers over 36 years represented 27% of those involved in accidents and while those with ages between 31 and 36 years represented 25%. Fewer accidents involved drivers with 14-19 years of age which represented 12 %.

Road condition at the time of the accident

From Table 3 above it can be observed that most drivers (47%) had accidents while the road was dry. Drivers experienced accident along the Jenda road stretch while the road condition was either wet or dry had an equal percentage of about 26.5% respectively. The road surface condition whether dry or wet, accidents were still happening along the road stretch.

Visibility of the road at the time of the accident

The probability/likelihood of an accident happening decreases when the visibility is adequate. When visibility is adequate drivers are in control of the vehicle such that they can easily see what is happening in their environment. The likelihood of an accident happening decreases by -3.858737.

Vehicle type versus involvement in an accident

The results show that vehicles that are most likely to involve in an accident are taxis representing 37.2 percent followed by trucks representing 26.4 percent as detailed in Table 5.

Table 5. Vehicles which frequently uses the road and were used for study

Vehicle	Frequency	Percent (%)
Truck	32	26.4
Bus	24	19.8
Taxi	45	37.2
Heavy duty vehicles	20	16.5
TOTAL	121	100

Vehicle Certificate of Fitness at the time of an accident

The survey revealed that 70.2 percent of the vehicles involved in accidents had valid Certificate of Fitness (COF), this implied that most vehicles involved in accidents were road worth. The relationship between COF and being involved in an accident was statistically insignificant in terms of increasing the likelihood of an accident happening.

Table 6. Status of Vehicle Certificate of Fitness (COF)

COF Condition	Frequency	Percent (%)
Not Valid	11	9.1
Valid	85	70.2
Not Sure	25	20.7
Total	121	100

Driving at high speed on the rumble strips

Data from the survey has revealed that many drivers drive at high speed on rumble road sections with 52% saying they travel at high speed, while 38% responded that they do travel at high speed sometimes while 10% responded that they don’t travel at high speed.

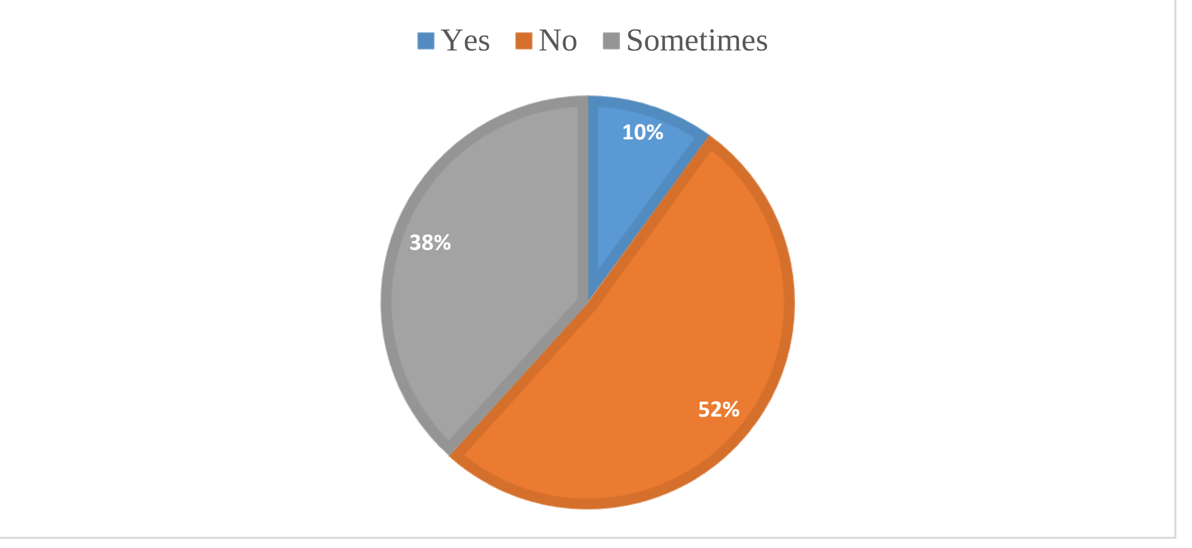


Figure 25. Driving at high Speed

Reasons for driving at high speed on the road rumble strips

Results presented in Figure 26 below show reasons for driving at high speed on the rumble strips installed on specific road stretches. 56% of the respondents indicated familiarity with the road for driving at high speed on rumble strips, 27% indicated that they do so to avoid being irritated as they pass through while 9% said the car jerks a lot. Some drivers (9%) said it is not applicable to them which meant that they do not drive at high speed on the road rumble strips.

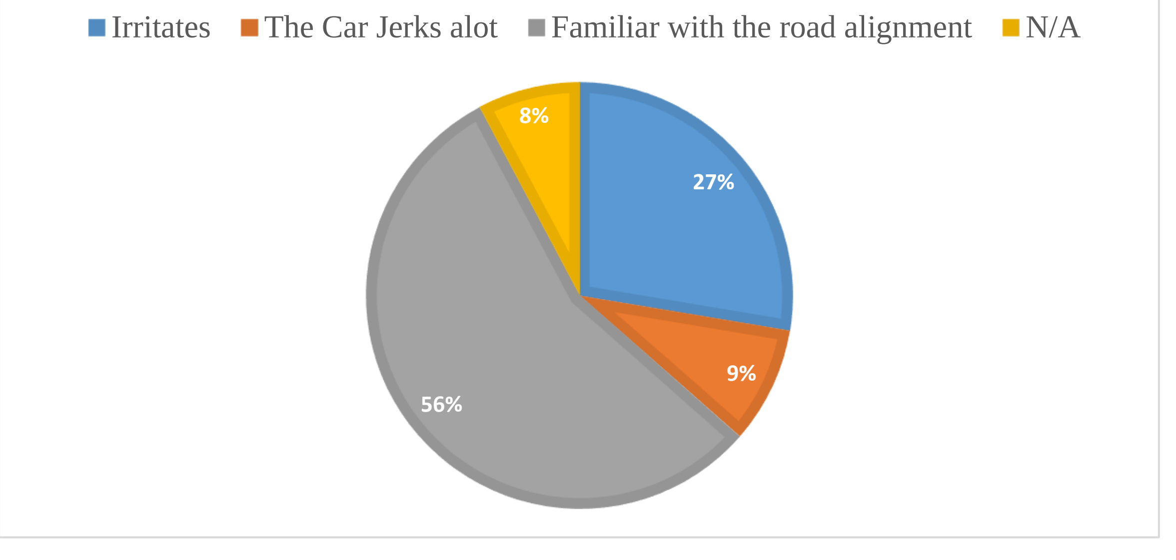


Figure 26. Reasons for driving at high speed

4.3 Road geometric elements and human behaviour impact on road accidents

4.3.1 Road Geometrics

The road geometric elements data has been concentrated on those elements which impact the driver's ability to control the vehicle while driving in accident-prone areas. Figure 27 below summaries the results of super-elevation, road radius, horizontal clearance, available sight stopping distance, lane width and shoulder width on the areas where a Speed radar gun was used to catch drivers speed. The graph indicates that the superelevation on all the curves is within the design standards, while radius of the curves, horizontal clearance, available sight distance, lane width and shoulder width is below the design requirement standards as indicated by their lower percentages.

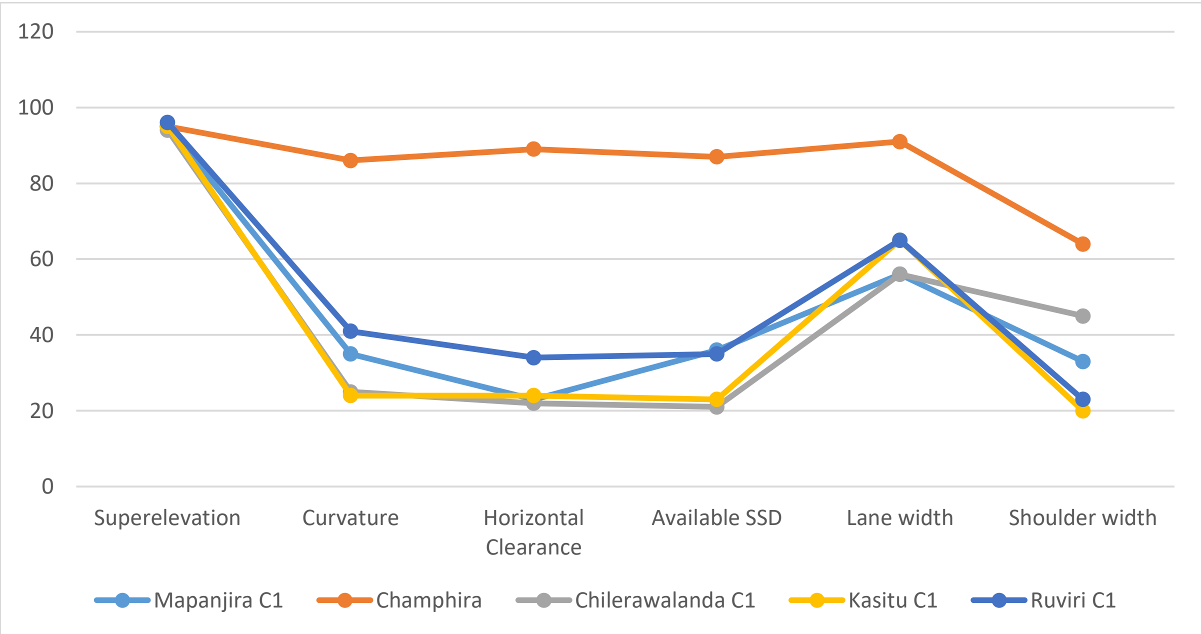


Figure 27. Road geometric elements on selected curves

4.3.2 Human behaviour (Vehicle Driving Speed)

Vehicle driving speed data was obtained from the use of speed radar gun stationed at two locations to measure the speed of the same vehicle twice as data presented in appendix 1 shows. The first two locations were at Mapanjira curve 1 and Chilerawalanda curve 1of which 82 vehicles speed were measured and recorded. From the data obtained, it has been revealed that 78% of the vehicles were over speeding on both locations, 9% over speed at one location and 13% did not over speed and this has been summarised in Figure 28 below,

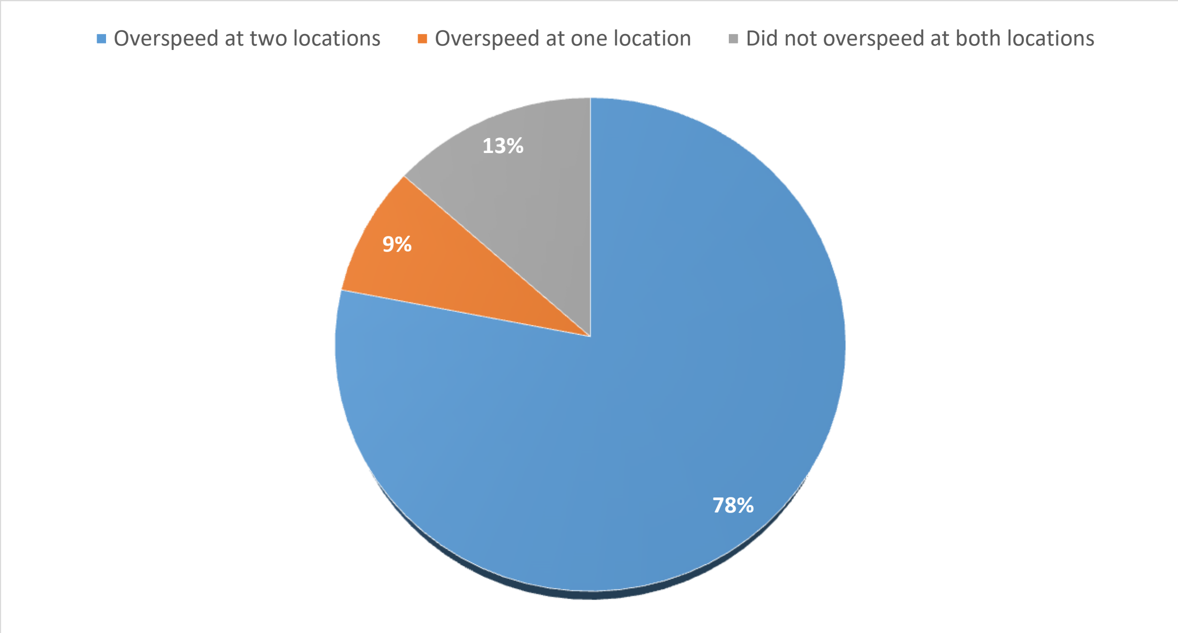


Figure 28. Vehicle speed tracking at Mapanjira and Chilerawalanda

The second two locations were at Kasitu curve 1 and Ruviri curve 1 where the speed of 82 vehicles was measured and recorded as shown in appendix 2. From the data obtained, it has been revealed that 61% of the vehicles were over speeding on both locations, 30% over speed at one location and 9% did not over speed and this has been summarised in Figure 29 below,

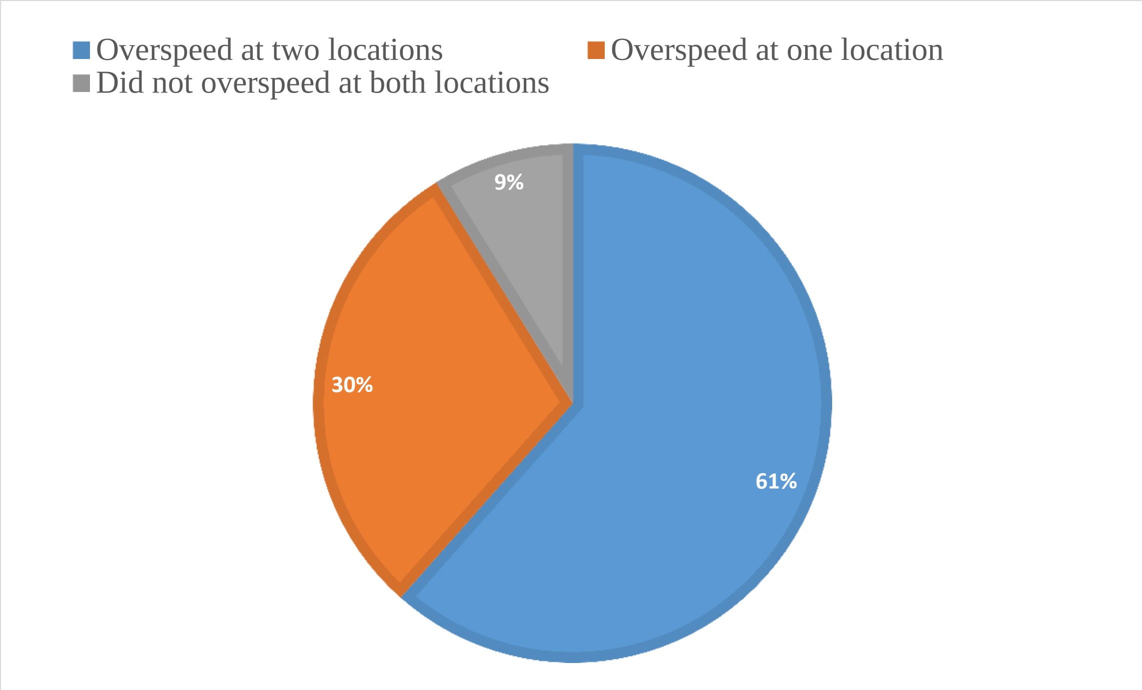


Figure 29. Vehicle speed tracking at Kasitu and Ruviri

Nexus of road geometrics and human behaviour

The graph below indicates the average speed of drivers on the selected curves. Figure 30 shows that drivers drive at high speed on these curves even though the road geometrics are below the design standards as stipulated in AASHTO and SATTC.

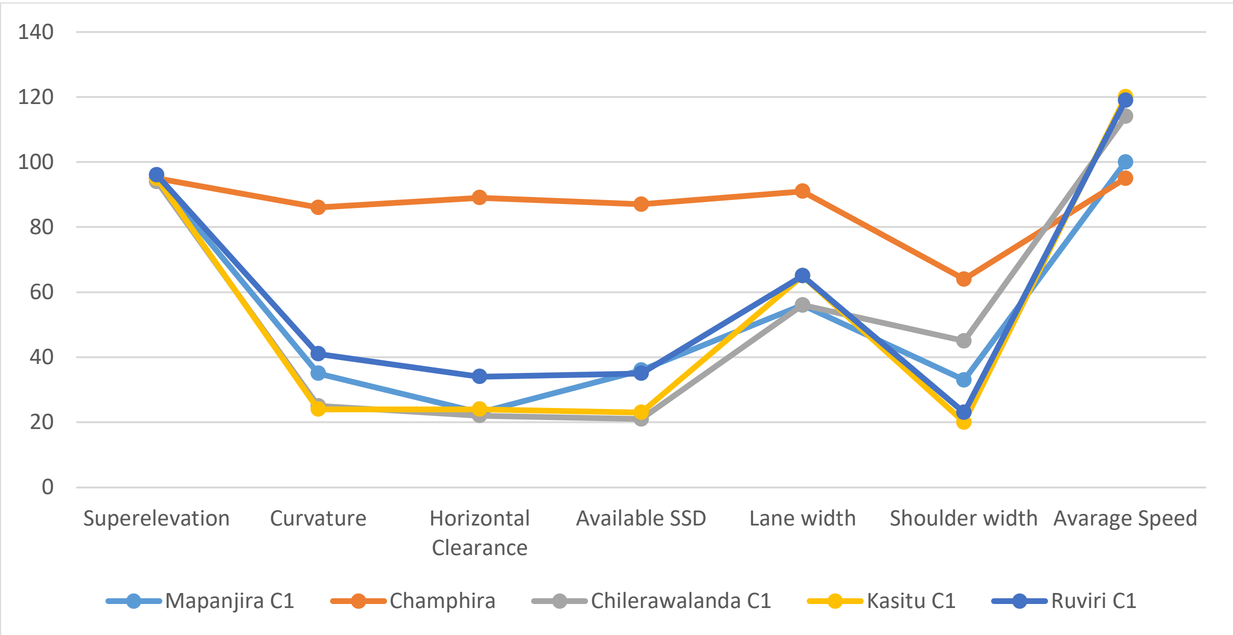


Figure 30. Nexus of road geometrics and human behaviour

4.4 To determine the deviations of existing road alignment from standard geometric alignment on accident-prone sections

4.4.1 Mapanjira

The reverse curve has been maintained to take advantage of the topography of the area but spiral curves have been introduced to make sure they provide a smooth transition in the change of gradient from the straight line into the curve. The red dotted lines indicate existing road alignment plotted from the survey data.

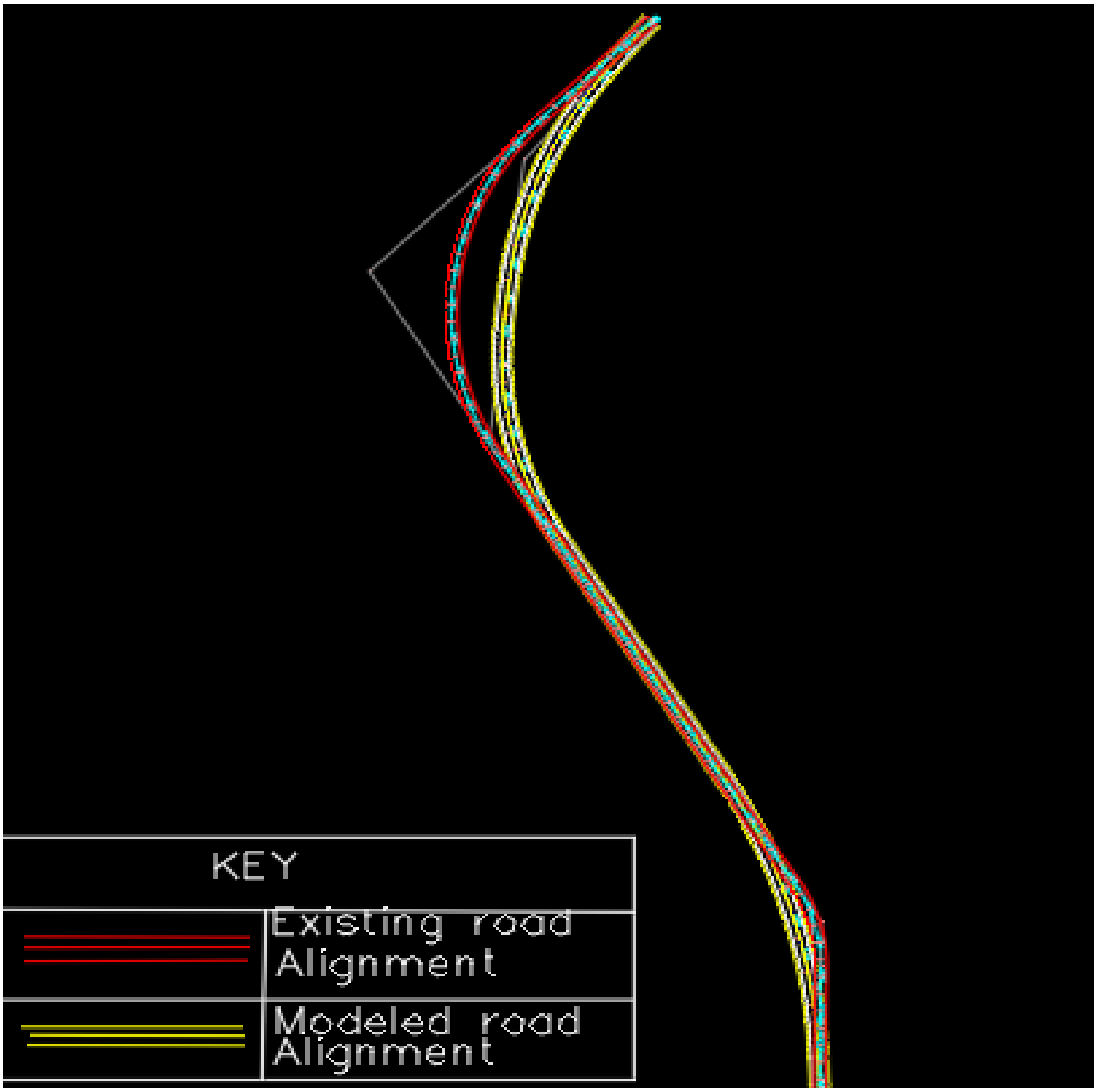


Figure 31. The new modelled Mapanjira road section

4.4.2 Champhira

There has been an introduction of two compound curves to the road alignment to make sure that there is smooth transition from the tangents. In between the tangents and the curves, transition curves have also been used to make sure that there is gradual change in gradient hence providing the drivers comfortability in driving. The red dotted lines indicate existing road alignment plotted from the survey data.

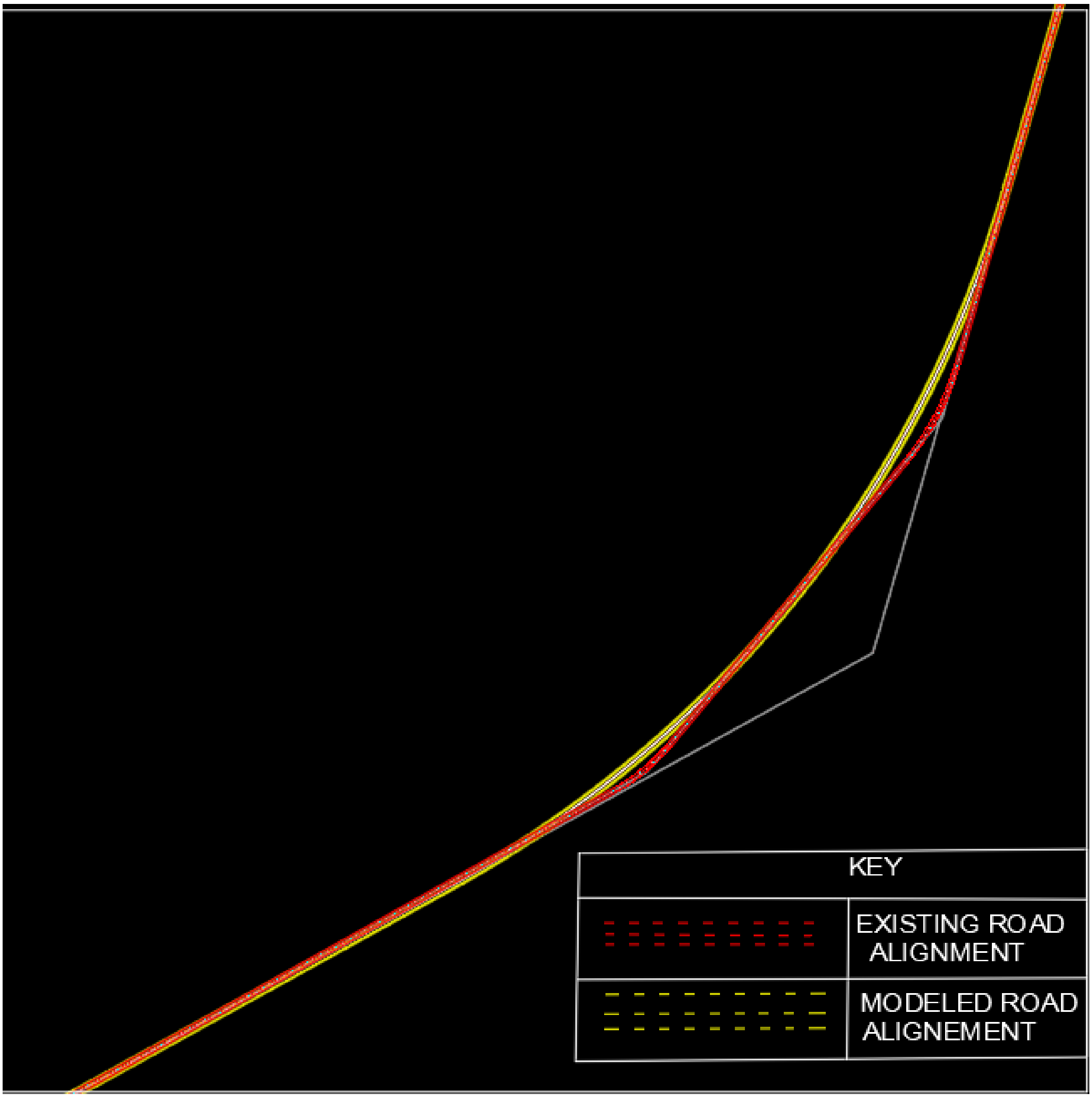


Figure 32. The new modelled Champhira road section.

4.4.3 Chilerawalanda

The road alignment has been improved with the introduction of lane widening on the second curve to provide enough horizontal clearance so that drivers have enough room for the sight distance. There has also been an introduction in the spiral curves to the simple curves so that they provide a smooth transition from the tangent into the curve. The red dotted lines indicate existing road alignment plotted from the survey data.

Figure 33. The new modelled Chilerawalanda road section

4.4.4 Ruviri

Due to the topography of this area, the broken-back curve has been maintained to avoid economic costs in aligning the road on original ground. The Transition curves has been introduced in the new model to make sure that smooth transition has been provided for the road alignment. The red dotted lines indicate existing road alignment plotted from the survey data.

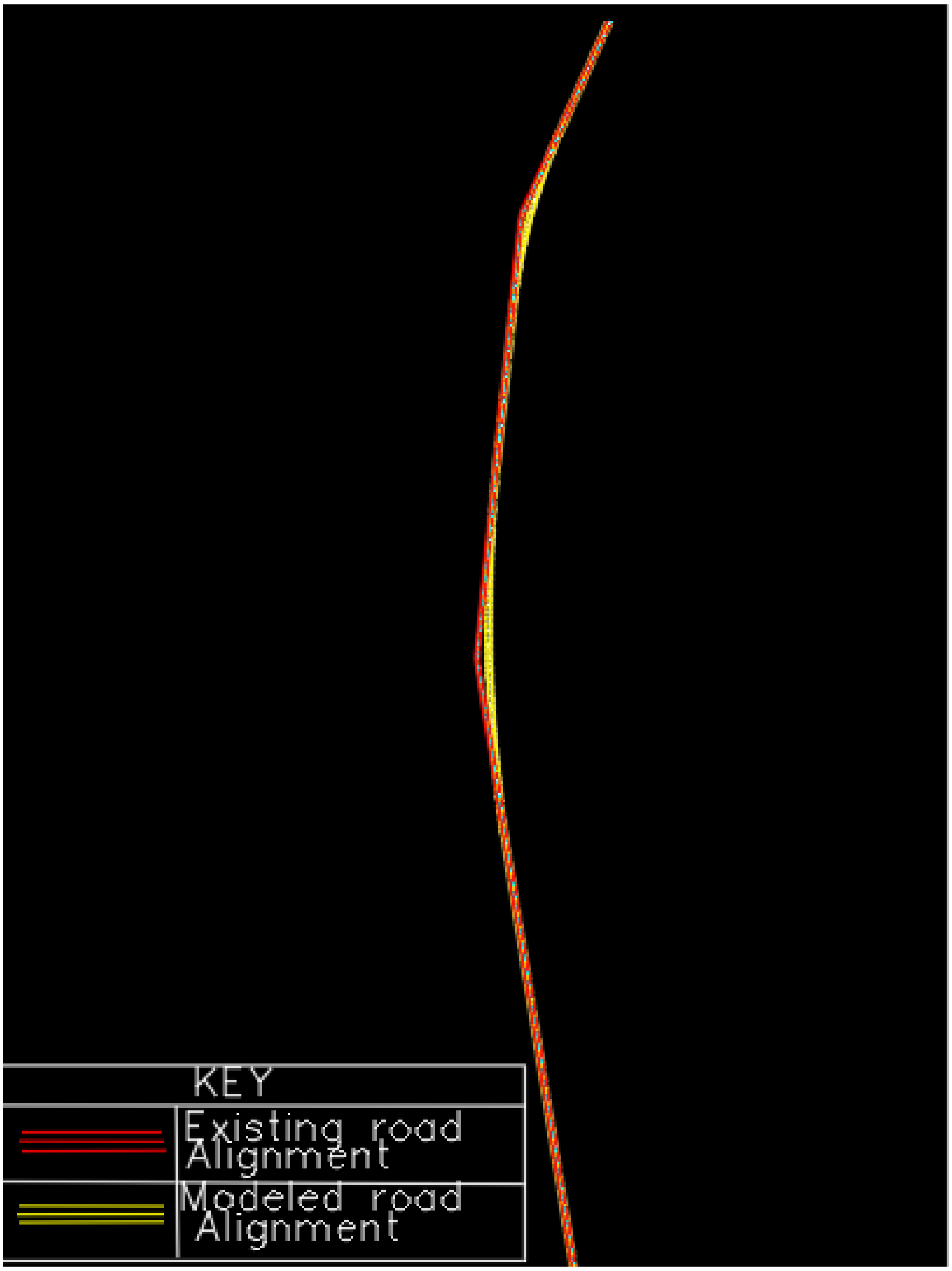


Figure 34. The new modelled Ruviri road section.

4.4.5 Kasitu

Maintaining the same reverse curve, spiral curves have been introduced to take advantage of the topography of the location. The road alignment has been improved to make sure that there is no sudden change in the gradient as one enters the curve. The radius on the first curve has been improved to maintain the minimum radius as required by SATTC and AASHTO. The red dotted lines indicate existing road alignment plotted from the survey data.

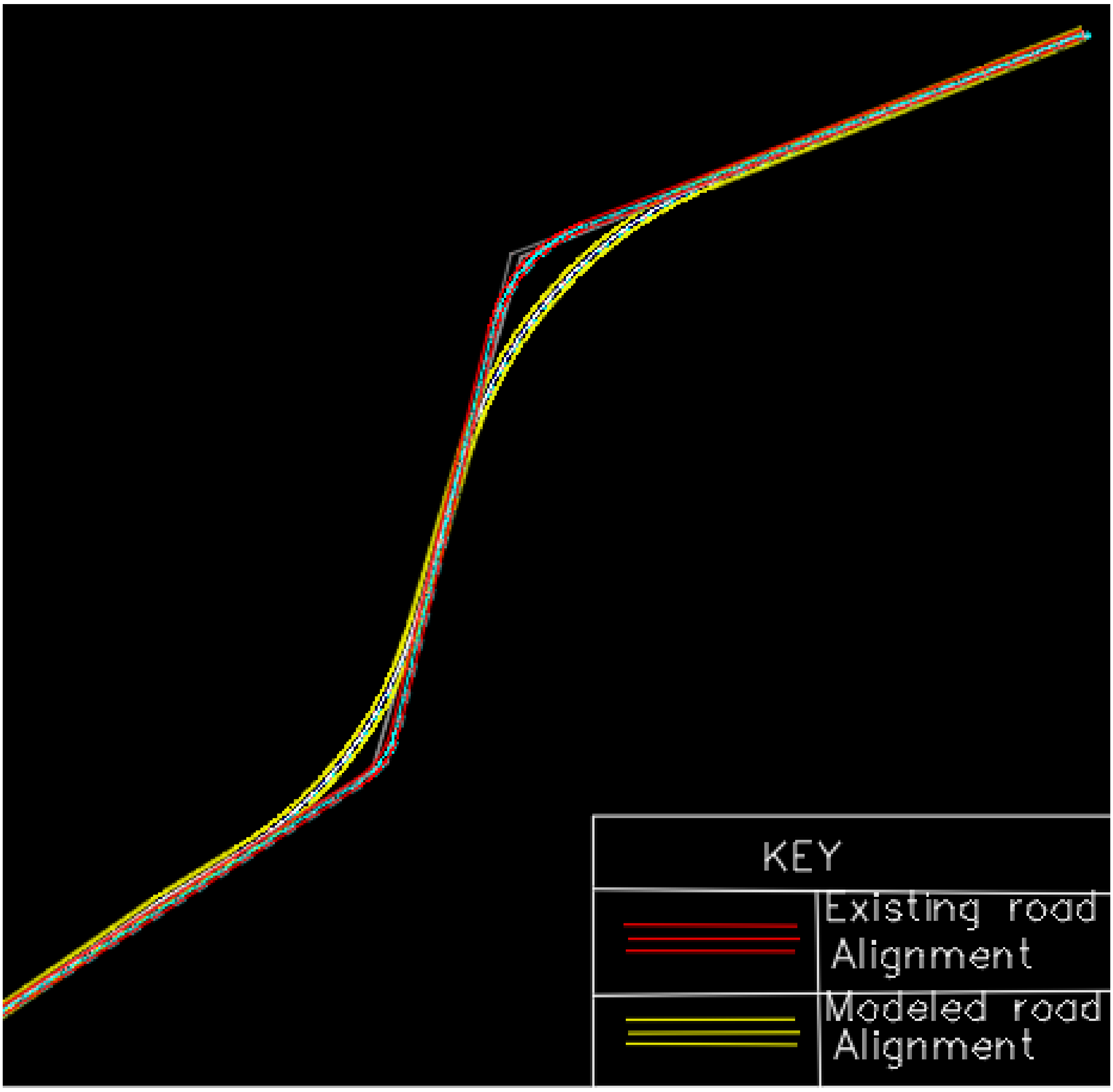


Figure 35. The new modelled Kasitu road section

CHAPTER 5: DISCUSSION

5.1 Geometric elements of the Mzuzu-Jenda M1 Road Stretch in accident-prone areas

5.1.1 Mapanjira

As stated in AASHTO (2011) the use of a reverse curve has mostly resulted in drivers getting involved in car accidents because drivers find challenging to manoeuvre correctly as the roads alignment super-elevation changes abruptly. From the results of the plotted data, it has also been revealed that there are no spiral curves that enable a proper transition of the gradient as one moves from tangent to the simple curve.

The results indicate that the super-elevation on this curve is in accordance with the design standards as stipulated in AASHTO,2011. The calculation of the centrifugal force, gravitation force applied by the vehicle, the acceleration and the deceleration of the vehicle is in equilibrium, which means the applied maximum super-elevation of 8% is correct for the curve for the vehicle traveling at 50 km/hr. not to swerve away from the centre of gravity.

There are small deflection angles on both curves which make the radii to be smaller than the minimum required by SATTC. The presence of the small deflection angles makes drivers unable to control the vehicle even at the indicated speed level, as Haure (1993) pointed out that when deflection angle reduces there is a direct proportional to the length of the curve hence making the curve dangerous for the road users.

The horizontal clearance on this road section is less than what is required as it is less than the Mid-ordinate of the curve. The Mid-ordinate of the curve provides the adequacy of the horizontal clearance required on that particular curve.

The cross section elements of the road indicate that the road lane width is 3.4m which is less than the required lane width of a two-lane road. SATTC stipulates that the road width required on a two-lane road should not be less than 3.5m. This makes drivers more especially of heavy vehicles drive on almost the centre of the road which makes passing with other vehicles challenging.

There is also no shoulder width on this road section. Apart from being used by the pedestrians, road shoulders providers extra space for the drivers to be able to manoeuvre.

5.1.2 Champhira

The road alignment on this curve indicates that there are spiral curves that were included in the construction of the compound curve. These provides a gradual transition of the gradient changes from tangents to the curve.

The results indicate that the super-elevation on this curve is in accordance with the design standards as stipulated in AASHTO Road Design of 2011. The calculation of the centrifugal force, gravitation force applied by the vehicle, the acceleration and the deceleration of the vehicle is in equilibrium, which means the applied maximum super-elevation of 8% is correct for the curve for the vehicle traveling at 80km/hr. not to swerve away from the centre of gravity.

There is enough horizontal clearance for the drivers as the horizontal clearance is greater than the Mid-ordinate of the curve.

The lane and shoulder width indicates to be in accordance to the design standards as stipulated in both SATTC and AASHTO.

5.1.3 Chilerawalanda

The road alignment indicates that there is a broken-back curve. Further analysis revealed that there are spiral curves on the first curve but not on the second curve. The second curve has been combined with a crest vertical curve and lack of the spiral curves makes it even more dangerous for driving.

The results indicate that the super-elevation on this curve is in accordance with the design standards as stipulated in AASHTO Road Design of 2011. The calculation of the centrifugal force, gravitation force applied by the vehicle, the acceleration and the deceleration of the vehicle is in equilibrium, which means the applied maximum super-elevation of 8% is correct for the curve for the vehicle traveling at 60 km/hr not to swerve away from the centre of gravity.

The stopping sight distance on the second curve is not adequate and this makes driving even within the required speed limit to be challenging and hence making the second curve dangerous.

There is not enough horizontal clearance inside the curve. The calculated horizontal clearance is less than the Mid-ordinate of the curve. This obscures drivers sight to be able to see objects ahead. The required sight distance is also lower than the available site distance and this makes drivers not being able to see the required clear distance as they travel at the required speed limit.

Cross section elements indicate that there is enough lane width as the design standards but the shoulder width has been eaten away. This provides challenges for the drivers as they manoeuvre on this road section since they have to use the second lane of the road for space and making passing with other vehicles difficult and dangerous.

5.1.4 Ruviri

Similar to Chilerawalanda road section, the road section at Ruviri has a broken-back curve. From the results of the plotted data, it has also been revealed that there are spiral curves on both curves.

The results indicate that the super-elevation on this curve is in accordance with the design standards as stipulated in AASHTO Road Design of 2011. The calculation of the centrifugal force, gravitation force applied by the vehicle, the acceleration and the deceleration of the vehicle is in equilibrium, which means the applied maximum super-elevation of 8% is correct for the curve for the vehicle traveling at 60km/hr not to swerve away from the centre of gravity.

The results also reveal that there is enough horizontal clearance for both curves. The calculated horizontal clearance on both curves is more than the Mid-ordinate on each of the curves.

The sight distance on the curve also indicate that there is enough sight stopping distance as the available sight distance is greater the required sight distance.

The cross section elements of the curves reveal that the lane width is enough as per the design standards. The lane width on the left is enough but on the right it has been eaten away by traffic and making the road not to have enough space.

5.1.5 Kasitu

The road section indicates that there is a reverse curve with transition and spiral curves on both simple curves. The first curve has a defection angle and radius which are less than the minimum required per SATCC standards. This makes the curve to be a very sharp curve and making manoeuvring challenging. The presence of the successive curve on the opposite side of the first one makes it difficult to consolidate speed for the drivers.

The results indicate that the super-elevation on this curve is in accordance with the design standards as stipulated in AASHTO Road Design of 2011. The calculation of the centrifugal force, gravitation force applied by the vehicle, the acceleration and the deceleration of the vehicle is in equilibrium, which means the applied maximum super-elevation of 8% is correct for the curve for the vehicle traveling at 60 km/hr not to swerve away from the centre of gravity.

Even though the horizontal clearance of the road is smaller than the Mid-ordinates on both curves, through the bush clearing there is enough clearance for the drivers as they pass through the curve.

There is also enough sight stopping distance for the road users.

5.2 Analysing human behaviour leading to road accidents on Mzuzu-Jenda M1 road stretch

The positive coefficient implies that the gender of the one driving increased the likelihood of an accident happening. Specifically, male drivers were the ones more involved in accidents. Men drove at high speed along the stretch compared to women. For every woman who responded to drive above 100 km/hr, double were the men who drove at such speed. Women are therefore seen to be more cautious on road compared to men. 45% of the women drivers involved in car accidents were not familiar with the road stretch while only 30% of men drivers were not familiar. Men drivers familiar with the road stretch even drove at the strips with high speed compared to female drivers. Likewise, the male drivers, the female drivers who drove at the strips with higher speed also cited car jerking and irritation being other reasons other than familiarity which led them to drive with high speed at the rumble strips. It can therefore be concluded that gender and familiarity with the road led drivers to made them drive at high speed along the stretch and indeed even at the strips. Studies done by (Kloeden et al, (1997), (Tanishita et al, 2016) and (WHO,2018) reveals that there a positive relationship between driving at high speed and likelihood of being involved in an accident. Most of the drivers had considerable driving experience and respondents indicate to have driven for 24-36 months.

Despite the coefficients of other age ranges have a positive sign which implies that age increased the likelihood of an accident happening among drivers the only age range which was significant and to be explained in this survey is age category 20-25 Years. This range was significant at $p>0.089$ which is significant at 10%. This means that only drivers belonging to the age range 20-25 years increased the probability of an accident happening. The drivers within this age range responded that they were driving at high speed even on rainy weather conditions and rainy condition was found to increase the probability of an accident happening at $p>0.074$ which is significant at $p>0.1$ increased the chances of the accident happening.

Drivers experiencing accident along the Jenda road stretch while the road condition was either wet or dry had an equal percentage of about 26.5% respectively. However, when computing in logit model only rainy road condition was found significant at $p>0.074$ which is significant at $p>0.1$. Therefore, driving while the road condition is rainy increased the probability of the drivers having an accident along Mzuzu-Jenda M1 road stretch.

The study reveals that males are the ones usually involved in an accident and are the ones mostly driving vehicles that are highly associated with accidents vis-a-vis: taxis and trucks.

During the time of an accident, taxis were travelling at a high speed (above 100km/hr) while a majority of the respondents responded that they could not even ascertain the speed at which the taxi was travelling. The same pattern is observed in trucks as about 15.7 percent of the respondent responded that trucks were travelling at high speed at the time of the accident. The Pearson Chi-Square (24.068) shows a significant (5%) relationship between vehicle type and speed at the time of an accident.

5.3 Evaluating the relationship between road geometric elements and human behaviour and its impact on road accidents

The results have indicated that most drivers drive at high speed than the speed limit as indicated on the sign posts placed at designated location. The higher the speed of the vehicle, the shorter the time a driver has to take to stop and avoid a crash. An increase within the average speed of 1km/hr typically leads to a third higher risk of a crash involving injury with a 4-5% increase for crashes leads to fatalities (WHO, Road safety - Speed, 2004).

The presence of the road geometric elements which are lower than the required as stipulated in the design standards of AASHTO and SATCC makes driving at high speed even more dangerous because the drivers are unable to control the vehicle. This is so because the higher the speed the more the sight stopping distance, horizontal clearance, lane width and even shoulder is required to give enough room for the vehicle to be controlled.

There is a nexus between road geometrics and human factor in causing road accidents along the road stretch

The results are in line with studies done by Jason et al, 2014; Pranay et al, 2015; Jayvant et al, 2015; Abbas, 2018; Mulugeta,2018; Mandefro,2019 in which they found that geometric elements constructed below the design standards leads to accidents occurrence. Gender, Age, road condition, road visibility and driving at high speed plays a role the likelihood of accidents happening along the stretch as shown by positive coefficients of the statistical analysis and this in line with studies done by Li, 2010; Manong'a, 2015; Charles et al, 2017; Banza et al, 2017.

The results are also agreement with a study done by WHO, 2004. The higher the speed of the vehicle, the shorter the time a driver has to take to stop and avoid a crash. An increase within the average speed of 1km/hr typically leads to a third higher risk of a crash involving injury with a 4-5% increase for crashes leads to fatalities.As shown by the results, despite the fact that in almost all the accident prone areas along the M1 stretch has geometric elements which were constructed below the design standards as stipulated in AASHTO and SATCC which has a strong likelihood in causing accidents, drivers drive at high speed beyond the recommended ones and this leads to road accidents occurrences.

5.4 The new alignment in accident-prone areas

The alternative road alignment has provided enough clearance both in horizontal and vertical alignment in compliance with the specifications as stipulated in AASHTO and SATCC using AutoCAD Civil 3D Software and also the economic and environmental factors have been taken into consideration. In some of the models like at Ruviri and Chilerawalanda, additional pavement space, called climbing lane, has been introduced to provide additional space for heavy vehicles which climb slowly on the crest curve. The aim has been to provide enough room for other vehicles to have enough space within their travelling lanes.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, the continued fatal accidents which are concentrated within the Mzuzu-Jenda M1 section have been attributed to the road geometrics and the behaviour of the road users. As it has been noted that in most of the curves there is no adequate sight stopping distance for the drivers attributed to the sharp curves. This always sets a challenge for the drivers to be able to maneuverer their vehicles even at the recommended speed limit as indicated on the road signs.

The other reason for the accidents is to do with the lack of horizontal clearance in most of the curves. There is no enough clearance for the drivers to be able to see the objects ahead even within the present limited sight distance. The presence of reverse curves without spiral and transition curves in a number of places like Kasitu and Mapanjira is also another contributing factor to the accidents. The use of spiral curves provides the required transition of gradients from the tangent line of the road alignment to the curve. The sudden change in the road alignment cross fall (normal road alignment gradient from the centre of the road to either side of road lane i.e. left and right), makes drivers unable to make timely decisions to maneuverer the vehicle.

Despite the threats which road geometrics possess, it has also been revealed that the other cause of accidents is driving at high speed beyond the recommended speed limit as depicted on the sign posts. The researcher found out that most driver’s drive at high speed on this road section defying the speed limits indicated on the road signs. Driving at high speed always makes the driver unable to make a timely judgment in the sudden change of the road alignment. Despite the installation of the rumble strips in most curves to warn drivers of the dangerous road alignment ahead, most drivers continue to drive at high speeds on these rumble strips. Most drivers stated that they are familiar with road alignment and hence the observed high speeds.

Hence, the results have found out that there is a relation between the road geometrics and human factor on the causation to traffic accidents on this road section.

6.2 Recommendations

Basing on the results of the research, the researcher recommends the following;

- There is a need to implement the redesigning of the road section as designed by the researcher which has taken into consideration the use of spiral curves and transition curves to make sure that there is no sudden change in road alignment.
- There is a need to include shoulder widening in areas which because of economic reasons the reconstruction of the road may not be challenging. The use of shoulder widening helps to provide enough room for the heavy vehicles so that when passing with other vehicles it may be possible to have enough room.
- As it has been indicated that even though rumble strips have been installed in most of the curves but they are not doing enough in curbing high speed driving. Therefore, there is a need to provide speed trap limiters which will make the drivers able to slow down.
- There is a need to provide strict measures of enforcing adhering to the speed limits on this section of the road. As in other nations, GPS trackers have been installed in critical road section to make sure that, they are able to track those driving at high speed. This provision will be able to make sure drivers are cautious in driving at high speed.
- Further studies can be done on quantifying accidents occurrence due to either Road geometrics or human factor and also which is the most important factor- geometric or human?

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Appendix 1: Speed vehicle data measured at Mapanjira Curve 1 and Chilerawalanda Curve1

Vehicle Speed One							
Mapanjira		**Chilerawalanda**		**Mapanjira**		**Chileralawanda**	
Vehicle	**Speed**	**Vehicle**	Speed	**Vehicle**	**Speed**	**vehicle**	**Speed**
Land cruiser	62	Land cruiser	56	Saloon	118	Saloon	91
Saloon	60	Saloon	65	Saloon	102	Saloon	96
Land cruiser	62	Land cruiser	85	Semi-track	97	Semi-track	91
Saloon	64	Saloon	97	Semi-track	79	Semi-track	97
Saloon	54	Saloon	71	Saloon	101	Saloon	90
Track	35	Track	57	Saloon	109	Saloon	94
Track	45	Saloon	68	Track	45	Track	25
Land cruiser	61	Land cruiser	113	Track	23	Track	40
Saloon	59	Saloon	102	Track	30	Track	45
Saloon	53	Saloon	62	Track	40	Track	20
Land cruiser	92	Land cruiser	71	Bus	85	Bus	77
Pick up	62	Pick up	68	Bus	89	Bus	75
Saloon	74	Saloon	95	Land cruiser	100	Land cruiser	72
Pick up	72	Pick up	89	Pick up	91	Pick up	93
Track	45	Track	56	Saloon	101	Saloon	99
Saloon	76	Saloon	90	Pick up	98	Pick up	68
Saloon	103	Saloon	90	Semi-track	58	Semi-track	25
Pick up	64	Saloon	97	Minbus	70	Minbus	85
Track	46	Track	23	Saloon	80	Saloon	86
Saloon	64	Saloon	90	Land cruiser	56	Land cruiser	68
Pick up	92	Pick up	109	Land cruiser	68	Land cruiser	89
Saloon	96	Saloon	98	Semi-track	58	Semi-track	65
Saloon	65	Saloon	89	Saloon	69	Saloon	55
Saloon	45	Saloon	94	Pick up	89	Pick up	78
Saloon	68	Saloon	93	Saloon	96	Saloon	56
Saloon	86	Saloon	98	Track	35	Track	20
Bus	68		75	Semi-track	78	Semi-track	46
Saloon	103	Saloon	94	Track	46	Track	35
Track	65		72	Track	45	Track	25
Land cruiser	62	Saloon	104	Track	40	Track	40
Saloon	81	Saloon	94	Saloon	109	Saloon	88
Saloon	98	Saloon	98	Saloon	108	Saloon	105
Pick up	72		88	Saloon	100	Saloon	82
Semi-track	32		48	Saloon	108	Saloon	80
Track	42	Track	56	Pick up	78	Pick up	86
Semi-track	64		51	Saloon	94	Saloon	83
Saloon	96	Saloon	83	Land cruiser	91	Land cruiser	80
				Saloon	81	Saloon	77
				Pick up	96	Pick up	74
				Saloon	91	Saloon	71
				Semi-track	103	Semi-track	68
				Saloon	80	Saloon	65
				Track	40	Track	32
				Saloon	86	Saloon	71
				Coaster Bus	69	Coaster Bus	78

Appendix 2. Vehicle speed data tracked at Kasitu Curve1 and Ruviri Curve1

Vehicle Speed One							
Kasitu		Ruviri		Kasitu		Ruviri	
Vehicle	**Speed**	**Vehicle**	**Speed**	**Vehicle**	**Speed**	**Vehicle**	**Speed**
Land cruiser	65	Land cruiser	88	Land cruiser	43	Land cruise	87
Saloon	68	Saloon	45	Saloon	56	Saloon	78
Land cruiser	78	Land cruiser	104	Land cruiser	73	Land cruise	56
Saloon	86	Saloon	56	Saloon	50	Saloon	79
Saloon	56	Saloon	75	Bus	89	Saloon	63
Track	43	Track	83	Track	53	Track	46
Pick up	78	Pick up	56	Pick up	48	Pick up	87
Saloon	45	Saloon	68	Saloon	46	Saloon	96
Pick up	69	Pick up	56	Pick up	78	Pick up	89
Track	27	Track	52	Track	64	Track	56
Saloon	96	Saloon	69	Saloon	39	Saloon	63
Saloon	81	Saloon	78	Saloon	76	Saloon	89
Saloon	64	Saloon	53	Saloon	84	Saloon	78
Saloon	56	Saloon	108	Saloon	78	Saloon	52
Track	23	Track	46	Track	56	Track	42
Track	16	Track	28	Track	42	Track	53
Land cruiser	78	Land cruiser	68	Land cruiser	89	Land cruise	74
Saloon	74	Saloon	96	Saloon	53	Saloon	78
Saloon	63	Saloon	56	Bus	58	Bus	68
Land cruiser	45	Land cruiser	86	Land cruiser	96	Land cruise	78
Land cruiser	64	Land cruiser	46	Saloon	26	Saloon	86
Saloon	63	Saloon	78	Land cruiser	75	Land cruise	108
Land cruiser	75	Land cruiser	52	Land cruiser	58	Land cruise	49
Saloon	46	Saloon	38	Saloon	69	Saloon	56
Saloon	76	Saloon	78	Pick up	48	Pick up	78
Track	56	Track	42	Track	63	Track	30
Pick up	56	Pick up	78	Saloon	29	Saloon	40
Saloon	48	Saloon	67	Saloon	39	Saloon	78
Pick up	63	Pick up	68	Saloon	89	Saloon	48
Track	56	Track	23	Saloon	48	Saloon	87
Bus	79	Bus	78	Track	29	Track	42
Saloon	56	Saloon	48	Track	37	Track	38
Bus	78	Saloon	85	Land cruiser	59	Land cruise	42
Saloon	54	Saloon	58	Saloon	63	Saloon	78
Track	45	Track	36	Saloon	82	Saloon	110
Track	28	Track	56	Land cruiser	63	Land cruise	46
Land cruiser	69	Land cruiser	78	Saloon	78	Saloon	84
Saloon	73	Saloon	108	Land cruiser	89	Land cruise	58
				Land cruiser	62	Land cruise	46
				Saloon	78	Saloon	68
				Saloon	91	Saloon	42
				Saloon	65	Saloon	79
				Saloon	78	Saloon	84
				Saloon	72	Saloon	87

Appendix 3. Champhira Topographic Survey data

POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI
1	564550.3	8637452	1,482.04	C	39	563653.8	8636637	1,481.86	C
2	564537.9	8637416	1,482.03	C	40	563608.2	8636612	1,481.83	C
3	564522.5	8637389	1,482.02	C	41	563561.1	8636587	1,481.80	C
4	564505.2	8637363	1,482.02	C	42	563510.5	8636557	1,481.75	C
5	564480.5	8637325	1,482.01	C	43	563453.3	8636520	1,481.69	E
6	564457.9	8637291	1,482.01	C	44	564704.8	8637970	1,482.31	E
7	564428.8	8637247	1,482.00	C	45	564706.2	8637970	1,482.31	E
8	564404.6	8637211	1,482.00	C	46	564697.8	8637970	1,482.31	E
9	564382.4	8637181	1,482.00	C	47	564696.3	8637971	1,482.31	E
10	564362.2	8637154	1,481.99	C	48	564691	8637971	1,482.31	E
11	564343.2	8637128	1,481.99	C	49	564680.7	8637973	1,482.31	E
12	564316.5	8637092	1,481.99	C	50	564673.7	8637974	1,482.30	E
13	564296	8637064	1,481.99	C	51	564710.2	8637968	1,482.31	E
14	564273.8	8637038	1,481.99	C	52	564717.1	8637967	1,482.31	E
15	564245.6	8637009	1,481.99	C	53	564727.9	8637965	1,482.32	E
16	564216.9	8636979	1,481.99	C	54	564687.8	8637906	1,482.26	E
17	564193.4	8636954	1,481.99	C	55	564679.6	8637907	1,482.26	E
18	564168.9	8636928	1,481.99	C	56	564686.2	8637906	1,482.26	E
19	564128.4	8636899	1,481.99	C	57	564677.9	8637907	1,482.26	E
20	564086.2	8636869	1,481.99	C	58	564669.5	8637908	1,482.26	E
21	564039.9	8636837	1,481.99	C	59	564662.2	8637908	1,482.25	E
22	563999.6	8636809	1,481.98	C	60	564656	8637909	1,482.25	E
23	563961.9	8636782	1,481.97	C	61	564691.9	8637905	1,482.26	E
24	563925.5	8636763	1,481.97	C	62	564700	8637902	1,482.26	E
25	563861.8	8636736	1,481.95	C	63	564707.6	8637899	1,482.26	E
26	563815.3	8636716	1,481.94	C	64	564673.7	8637906	1,482.26	E
27	563766.9	8636695	1,481.92	C	65	564663.1	8637850	1,482.22	E
28	564701.5	8637971	1,482.31	C	66	564671.1	8637848	1,482.22	E
29	564683.1	8637907	1,482.26	C	67	564669.7	8637849	1,482.22	E
30	564666.5	8637850	1,482.22	C	68	564661.6	8637850	1,482.22	E
31	564650.2	8637794	1,482.18	C	69	564656.5	8637852	1,482.22	E
32	564628	8637712	1,482.14	C	70	564649.5	8637852	1,482.22	E
33	564613.1	8637657	1,482.11	C	71	564641.6	8637854	1,482.21	E
34	564592.5	8637581	1,482.08	C	72	564675.9	8637847	1,482.22	E
35	564576.3	8637527	1,482.06	C	73	564684.9	8637845	1,482.22	E
36	564562.1	8637486	1,482.05	C	74	564693.6	8637842	1,482.22	E
37	563731.8	8636678	1,481.90	C	75	564676.5	8637785	1,482.19	E
38	563689.2	8636655	1,481.88	C	76	564670	8637787	1,482.18	E

Appendix 4. Champhira Topographic Survey data2

EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI
564660.5	8637790	1,482.18	E	115	564609.6	8637577	1,482.08	E	153	564542.3	8637414	1,482.03	E
564654.9	8637792	1,482.18	E	116	564617.5	8637575	1,482.08	E	154	564547.8	8637412	1,482.03	E
564646.7	8637794	1,482.18	E	117	564602.6	8637519	1,482.06	E	155	564533	8637417	1,482.03	E
564653.4	8637792	1,482.18	E	118	564597.5	8637521	1,482.06	E	156	564540.7	8637414	1,482.03	E
564645.3	8637794	1,482.18	E	119	564591.4	8637522	1,482.06	E	157	564534.3	8637416	1,482.03	E
564639	8637795	1,482.18	E	120	564580.7	8637525	1,482.06	E	158	564526.9	8637418	1,482.03	E
564629.7	8637796	1,482.18	E	121	564585.9	8637523	1,482.06	E	159	564514.6	8637423	1,482.03	E
564621.9	8637797	1,482.18	E	122	564571.6	8637528	1,482.06	E	160	564520.5	8637421	1,482.03	E
564632.7	8637711	1,482.14	E	123	564573	8637528	1,482.06	E	161	564494.3	8637401	1,482.02	E
564624.6	8637713	1,482.14	E	124	564579.4	8637525	1,482.06	E	162	564508.1	8637395	1,482.02	E
564631.2	8637711	1,482.14	E	125	564563.8	8637530	1,482.06	E	163	564517	8637390	1,482.02	E
564623.2	8637713	1,482.14	E	126	564557.9	8637532	1,482.06	E	164	564502.2	8637397	1,482.02	E
564636.2	8637710	1,482.14	E	127	564549.6	8637534	1,482.06	E	165	564527.1	8637387	1,482.02	E
564641.1	8637709	1,482.14	E	128	564588.6	8637477	1,482.05	E	166	564531.8	8637384	1,482.02	E
564649.7	8637708	1,482.14	E	129	564582.3	8637478	1,482.05	E	167	564539.5	8637381	1,482.02	E
564654.6	8637704	1,482.14	E	130	564566.4	8637483	1,482.05	E	168	564547.3	8637377	1,482.02	E
564617.2	8637715	1,482.14	E	131	564575.5	8637479	1,482.05	E	169	564518.5	8637389	1,482.02	E
564605.8	8637717	1,482.13	E	132	564557.5	8637488	1,482.05	E	170	564525.3	8637387	1,482.02	E
564600.3	8637718	1,482.13	E	133	564565	8637484	1,482.05	E	171	564509.7	8637361	1,482.02	E
564610.8	8637716	1,482.14	E	134	564558.9	8637487	1,482.05	E	172	564500.5	8637364	1,482.02	E
564603.6	8637657	1,482.11	E	135	564550.6	8637490	1,482.05	E	173	564508.1	8637361	1,482.02	E
564594	8637660	1,482.11	E	136	564538.1	8637493	1,482.05	E	174	564502.1	8637364	1,482.02	E
564588.6	8637660	1,482.11	E	137	564544	8637491	1,482.05	E	175	564492.2	8637369	1,482.02	E
564623.5	8637654	1,482.11	E	138	564533.1	8637494	1,482.05	E	176	564497	8637365	1,482.02	E
564633.8	8637651	1,482.11	E	139	564553.4	8637450	1,482.04	E	177	564486.1	8637371	1,482.02	E
564638.2	8637649	1,482.11	E	140	564546.9	8637453	1,482.04	E	178	564479.5	8637373	1,482.02	E
564617.7	8637656	1,482.11	E	141	564554.5	8637449	1,482.04	E	179	564512.4	8637359	1,482.02	E
564609.5	8637657	1,482.11	E	142	564545.4	8637453	1,482.04	E	180	564520	8637353	1,482.02	E
564616.2	8637656	1,482.11	E	143	564539.3	8637454	1,482.04	E	181	564526.9	8637349	1,482.02	E
564608	8637657	1,482.11	E	144	564529.8	8637457	1,482.04	E					
564597.1	8637580	1,482.08	E	145	564524.7	8637458	1,482.04	E					
564589	8637581	1,482.08	E	146	564561.5	8637447	1,482.04	E					
564595.7	8637580	1,482.08	E	147	564572.8	8637444	1,482.04	E					
564587.6	8637582	1,482.08	E	148	564575.9	8637441	1,482.04	E					
564582.1	8637583	1,482.08	E	149	564568.4	8637446	1,482.04	E					
564574.7	8637584	1,482.08	E	150	564566.3	8637407	1,482.03	E					
564565.4	8637586	1,482.08	E	151	564561.6	8637407	1,482.03	E					
564602.1	8637579	1,482.08	E	152	564555.5	8637410	1,482.03	E					

Appendix 5. Ruviri Topographic Survey data

POINT	EASTING	NORTHIN	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHIN	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHIN	HEIGHT	DESCRIPTI
1	572811.5	8652181	1518.03	C	82	572876.3	8652303	1518.459	E	163	572761.7	8652072	1517.725	E
2	572799.2	8652145	1517.931	C	83	572842.5	8652262	1518.288	E	164	572757.2	8652073	1517.72	E
3	572791.6	8652123	1517.87	C	84	572836	8652264	1518.282	E	165	572768.5	8652070	1517.732	E
4	572787.4	8652103	1517.819	C	85	572842.5	8652262	1518.288	E	166	572791.3	8652068	1517.764	E
5	572783.9	8652069	1517.755	C	86	572834.4	8652264	1518.279	E	167	572801.2	8652067	1517.777	E
6	572779.7	8652029	1517.68	C	87	572823.3	8652267	1518.268	E	168	572805.9	8652067	1517.784	E
7	572777.9	8652011	1517.647	C	88	572828.4	8652265	1518.274	E	169	572812.3	8652066	1517.793	E
8	572774.4	8651980	1517.591	C	89	572815.8	8652269	1518.26	E	170	572783.2	8652029	1517.686	E
9	572771	8651949	1517.55	C	90	572812.5	8652270	1518.257	E	171	572774.9	8652029	1517.674	E
10	572767.4	8651914	1517.505	C	91	572847.2	8652261	1518.294	E	172	572784.7	8652030	1517.689	E
11	572765	8651885	1517.468	C	92	572861.2	8652255	1518.302	E	173	572774.9	8652029	1517.674	E
12	572762.7	8651858	1517.436	C	93	572865.6	8652254	1518.307	E	174	572776.3	8652029	1517.676	E
13	572759.5	8651822	1517.408	C	94	572844	8652262	1518.29	E	175	572771.8	8652030	1517.671	E
14	572757.6	8651801	1517.392	C	95	572825.4	8652212	1518.122	E	176	572763.8	8652030	1517.658	E
15	572754.4	8651768	1517.365	C	96	572819	8652214	1518.116	E	177	572752.2	8652031	1517.643	E
16	572751.9	8651741	1517.346	C	97	572826.8	8652211	1518.123	E	178	572755.3	8652031	1517.648	E
17	572748.2	8651694	1517.332	C	98	572817.5	8652214	1518.114	E	179	572786.6	8652029	1517.692	E
18	572746.1	8651667	1517.324	C	99	572812.7	8652215	1518.108	E	180	572795.8	8652027	1517.702	E
19	572742.6	8651621	1517.312	C	100	572806.2	8652218	1518.103	E	181	572805.9	8652026	1517.715	E
20	572740	8651586	1517.316	C	101	572800	8652219	1518.097	E	182	572807.7	8652007	1517.687	E
21	572737.4	8651552	1517.321	C	102	572795	8652220	1518.094	E	183	572799.1	8652009	1517.677	E
22	572735.5	8651528	1517.324	C	103	572835.9	8652208	1518.134	E	184	572789.9	8652009	1517.663	E
23	572736.7	8651492	1517.339	C	104	572848	8652204	1518.146	E	185	572782.7	8652010	1517.653	E
24	572741.7	8651451	1517.37	C	105	572830.2	8652210	1518.128	E	186	572774.5	8652011	1517.643	E
25	572746.8	8651408	1517.402	C	106	572840.6	8652207	1518.138	E	187	572781.3	8652011	1517.652	E
26	572752.4	8651364	1517.442	C	107	572816	8652179	1518.033	E	188	572773	8652012	1517.641	E
27	572758.4	8651320	1517.489	C	108	572814.5	8652180	1518.032	E	189	572766.8	8652012	1517.633	E
28	572764.6	8651274	1517.537	C	109	572808.3	8652183	1518.028	E	190	572762.9	8652012	1517.627	E
29	572770	8651235	1517.588	C	110	572806.9	8652183	1518.027	E	191	572751.2	8652015	1517.614	E
30	572777.5	8651180	1517.659	C	111	572801.1	8652186	1518.025	E	192	572777.8	8651980	1517.596	E
31	572785.9	8651128	1517.733	C	112	572797.2	8652187	1518.021	E	193	572771	8651980	1517.586	E
32	572795.1	8651081	1517.807	C	113	572795	8652187	1518.019	E	194	572769.5	8651980	1517.584	E
33	572805	8651031	1517.886	C	114	572792.1	8652188	1518.016	E	195	572779.3	8651979	1517.598	E
34	572811	8650992	1517.952	C	115	572786.1	8652190	1518.013	E	196	572784.2	8651979	1517.604	E
35	572817.8	8650947	1518.029	C	116	572819.5	8652179	1518.038	E	197	572794.6	8651977	1517.619	E
36	572822.5	8650910	1518.093	C	117	572825.9	8652175	1518.042	E	198	572798.1	8651977	1517.624	E
37	572825.6	8650877	1518.151	C	118	572828.7	8652174	1518.045	E	199	572802.1	8651977	1517.63	E
38	572829.5	8650837	1518.224	C	119	572836.5	8652172	1518.053	E	200	572764.3	8651981	1517.577	E
39	572832.7	8650802	1518.285	C	120	572822.6	8652177	1518.04	E	201	572755	8651982	1517.565	E
40	572838	8650751	1518.381	C	121	572802.5	8652144	1517.934	E	202	572753.1	8651982	1517.562	E
41	572844.2	8650709	1518.463	C	122	572795.8	8652146	1517.928	E	203	572746.6	8651983	1517.554	E
42	572850.1	8650668	1518.544	C	123	572803.8	8652144	1517.934	E	204	572774.3	8651948	1517.554	E
43	572857.6	8650614	1518.654	C	124	572794.2	8652146	1517.925	E	205	572767.6	8651949	1517.545	E
44	572865.4	8650554	1518.773	C	125	572792.1	8652147	1517.923	E	206	572775.8	8651948	1517.556	E
45	572872.3	8650500	1518.884	C	126	572787.8	8652148	1517.92	E	207	572766.1	8651949	1517.543	E
46	572822.3	8652213	1518.12	C	127	572783.4	8652148	1517.915	E	208	572759.8	8651949	1517.534	E
47	572839.4	8652263	1518.286	C	128	572773.4	8652152	1517.907	E	209	572748.3	8651951	1517.519	E
48	572856.1	8652311	1518.449	C	129	572805.4	8652143	1517.935	E	210	572742.7	8651952	1517.511	E
49	572888.8	8652385	1518.731	C	130	572810.5	8652141	1517.938	E	211	572780.3	8651948	1517.563	E
50	572924.6	8652465	1519.055	C	131	572816.8	8652139	1517.945	E	212	572790.3	8651946	1517.576	E
51	572921.3	8652466	1519.054	E	132	572820.2	8652138	1517.948	E	213	572798.4	8651945	1517.587	E
52	572928.8	8652462	1519.051	E	133	572824.7	8652136	1517.952	E	214	572772.4	8651915	1517.513	E
53	572927.7	8652463	1519.054	E	134	572796.1	8652121	1517.872	E	215	572779.3	8651914	1517.522	E
54	572919.9	8652466	1519.053	E	135	572794.7	8652122	1517.872	E	216	572791.1	8651912	1517.538	E
55	572912.6	8652467	1519.045	E	136	572788.2	8652124	1517.866	E	217	572794.6	8651912	1517.543	E
56	572904.5	8652469	1519.041	E	137	572786.7	8652124	1517.865	E	218	572762.4	8651914	1517.497	E
57	572896.9	8652472	1519.041	E	138	572797.7	8652121	1517.873	E	219	572753.9	8651915	1517.486	E
58	572930.4	8652461	1519.049	E	139	572806.1	8652118	1517.879	E	220	572748.6	8651915	1517.478	E
59	572938.3	8652457	1519.051	E	140	572813.2	8652115	1517.884	E	221	572740.6	8651916	1517.467	E
60	572947.8	8652455	1519.06	E	141	572816.7	8652114	1517.888	E	222	572737.4	8651916	1517.462	E
61	572949.6	8652454	1519.059	E	142	572819.8	8652113	1517.892	E	223	572770.8	8651914	1517.51	E
62	572893.3	8652383	1518.732	E	143	572782.4	8652126	1517.862	E	224	572763.9	8651914	1517.499	E
63	572885.2	8652385	1518.726	E	144	572774.6	8652128	1517.855	E	225	572769.8	8651885	1517.474	E
64	572891.7	8652383	1518.73	E	145	572763.8	8652130	1517.845	E	226	572768.3	8651885	1517.472	E
65	572883.9	8652386	1518.727	E	146	572769.5	8652127	1517.846	E	227	572761.5	8651885	1517.462	E
66	572878.7	8652387	1518.722	E	147	572790.7	8652103	1517.823	E	228	572760	8651885	1517.46	E
67	572869	8652391	1518.722	E	148	572784	8652103	1517.814	E	229	572757.3	8651885	1517.456	E
68	572864.6	8652392	1518.716	E	149	572792.2	8652102	1517.824	E	230	572752	8651885	1517.448	E
69	572873.4	8652389	1518.72	E	150	572782.5	8652103	1517.812	E	231	572745	8651885	1517.437	E
70	572897.7	8652380	1518.73	E	151	572777.4	8652104	1517.806	E	232	572737	8651886	1517.427	E
71	572904	8652378	1518.735	E	152	572763.3	8652107	1517.791	E	233	572774.1	8651884	1517.48	E
72	572912.2	8652374	1518.736	E	153	572771.3	8652105	1517.798	E	234	572788.9	8651882	1517.5	E
73	572852.8	8652312	1518.446	E	154	572796	8652101	1517.828	E	235	572780.4	8651884	1517.489	E
74	572860.6	8652310	1518.451	E	155	572802.6	8652099	1517.833	E	236	572793.5	8651882	1517.508	E
75	572859.1	8652310	1518.45	E	156	572811.9	8652097	1517.844	E	237	572786.4	8651912	1517.531	E
76	572851.2	8652313	1518.444	E	157	572815.1	8652097	1517.85	E	238	572784.6	8651946	1517.567	E
77	572839.7	8652317	1518.437	E	158	572787.2	8652069	1517.759	E	239	572766.1	8651858	1517.441	E
78	572830.4	8652321	1518.431	E	159	572780.5	8652069	1517.749	E	240	572757.7	8651858	1517.428	E
79	572846.2	8652313	1518.436	E	160	572788.7	8652068	1517.76	E	241	572759.2	8651857	1517.43	E
80	572863.6	8652307	1518.451	E	161	572779	8652069	1517.748	E	242	572767.5	8651857	1517.443	E
81	572871.1	8652304	1518.455	E	162	572772.3	8652070	1517.738	E	243	572772.1	8651857	1517.449	E

Appendix 6. Ruviri Topographic Survey data2

POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT
244	572781.2	8651856	1517.462	E	355	572710.2	8651553	1517.283	E	466	572774.1	8651179	1517.656	E	577	572845.7	8650838	1518.241
245	572788.9	8651855	1517.474	E	356	572746.1	8651554	1517.332	E	467	572772.6	8651180	1517.654	E	578	572837.5	8650837	1518.232
246	572792.6	8651855	1517.479	E	357	572756.5	8651551	1517.347	E	468	572782.3	8651181	1517.664	E	579	572840.1	8650878	1518.167
247	572751.3	8651858	1517.419	E	358	572764.8	8651551	1517.359	E	469	572787.7	8651182	1517.669	E	580	572851.8	8650879	1518.18
248	572741.5	8651859	1517.405	E	359	572751.3	8651554	1517.34	E	470	572794.1	8651182	1517.676	E	581	572841.4	8650752	1518.384
249	572735.2	8651859	1517.395	E	360	572739	8651529	1517.328	E	471	572802.7	8651183	1517.685	E	582	572834.7	8650750	1518.379
250	572762.9	8651822	1517.413	E	361	572732.2	8651528	1517.319	E	472	572805.1	8651183	1517.688	E	583	572843	8650751	1518.387
251	572756.1	8651823	1517.403	E	362	572740.5	8651528	1517.33	E	473	572785.2	8651236	1517.604	E	584	572833.3	8650750	1518.378
252	572764.4	8651822	1517.415	E	363	572730.6	8651528	1517.317	E	474	572790.8	8651128	1517.738	E	585	572829	8650749	1518.374
253	572771	8651821	1517.424	E	364	572728.1	8651529	1517.313	E	475	572782.6	8651127	1517.73	E	586	572824.4	8650749	1518.37
254	572776	8651820	1517.431	E	365	572723.8	8651529	1517.307	E	476	572789.4	8651128	1517.737	E	587	572814	8650748	1518.359
255	572787.4	8651819	1517.448	E	366	572745.6	8651529	1517.337	E	477	572781.1	8651127	1517.729	E	588	572809.7	8650748	1518.355
256	572780.7	8651820	1517.438	E	367	572747.9	8651529	1517.34	E	478	572795.1	8651129	1517.742	E	589	572845.9	8650751	1518.39
257	572754.6	8651823	1517.401	E	368	572753.2	8651529	1517.347	E	479	572803.7	8651129	1517.752	E	590	572855.4	8650751	1518.401
258	572749.9	8651822	1517.394	E	369	572762.5	8651531	1517.36	E	480	572812.8	8651129	1517.762	E	591	572858.5	8650752	1518.404
259	572744.8	8651822	1517.386	E	370	572719.5	8651530	1517.301	E	481	572773.9	8651127	1517.721	E	592	572862.2	8650752	1518.408
260	572739.5	8651822	1517.378	E	371	572710.1	8651532	1517.288	E	482	572766.5	8651126	1517.714	E	593	572866.6	8650752	1518.413
261	572733	8651824	1517.369	E	372	572707.1	8651533	1517.283	E	483	572762.6	8651124	1517.712	E	594	572849.1	8650710	1518.467
262	572729.6	8651824	1517.365	E	373	572740.1	8651492	1517.343	E	484	572759.3	8651124	1517.709	E	595	572847.6	8650710	1518.466
263	572752.6	8651801	1517.384	E	374	572741.6	8651492	1517.345	E	485	572790.5	8651079	1517.805	E	596	572839.4	8650708	1518.46
264	572754.1	8651802	1517.387	E	375	572733.4	8651491	1517.335	E	486	572782.7	8651079	1517.797	E	597	572834	8650708	1518.454
265	572760.9	8651801	1517.396	E	376	572731.9	8651491	1517.333	E	487	572770.2	8651074	1517.789	E	598	572828.8	8650707	1518.45
266	572762.3	8651800	1517.398	E	377	572728.8	8651490	1517.329	E	488	572791.8	8651080	1517.805	E	599	572820.5	8650707	1518.441
267	572744.1	8651802	1517.372	E	378	572721.2	8651489	1517.32	E	489	572798.5	8651081	1517.811	E	600	572818.2	8650706	1518.439
268	572736.1	8651802	1517.36	E	379	572722	8651489	1517.321	E	490	572800	8651081	1517.812	E	601	572855.4	8650711	1518.473
269	572732.8	8651803	1517.356	E	380	572711.8	8651488	1517.308	E	491	572805.4	8651082	1517.818	E	602	572863.1	8650712	1518.479
270	572729.7	8651804	1517.352	E	381	572708.6	8651489	1517.303	E	492	572815.6	8651084	1517.827	E	603	572869.8	8650713	1518.486
271	572767.8	8651799	1517.405	E	382	572743.6	8651493	1517.348	E	493	572819.5	8651085	1517.831	E	604	572840.8	8650709	1518.46
272	572776.3	8651799	1517.418	E	383	572749.3	8651494	1517.355	E	494	572822.2	8651085	1517.835	E	605	572853.5	8650668	1518.547
273	572780.7	8651799	1517.424	E	384	572758.2	8651494	1517.367	E	495	572809.9	8651032	1517.89	E	606	572846.8	8650667	1518.542
274	572785.2	8651797	1517.43	E	385	572763.6	8651496	1517.373	E	496	572801.7	8651031	1517.883	E	607	572855	8650668	1518.548
275	572759.3	8651767	1517.372	E	386	572753.4	8651494	1517.361	E	497	572808.3	8651032	1517.888	E	608	572845.3	8650667	1518.541
276	572751	8651768	1517.36	E	387	572761.4	8651495	1517.371	E	498	572800.2	8651030	1517.882	E	609	572839.7	8650665	1518.537
277	572757.8	8651768	1517.37	E	388	572746.6	8651451	1517.376	E	499	572793.1	8651028	1517.878	E	610	572833.8	8650665	1518.531
278	572749.4	8651767	1517.358	E	389	572738.3	8651451	1517.365	E	500	572790.2	8651028	1517.875	E	611	572825.3	8650664	1518.524
279	572746.7	8651767	1517.353	E	390	572745	8651452	1517.374	E	501	572776.8	8651028	1517.861	E	612	572821.7	8650664	1518.521
280	572740.6	8651768	1517.345	E	391	572736.8	8651450	1517.364	E	502	572776.8	8651028	1517.861	E	613	572858.5	8650669	1518.55
281	572737.1	8651768	1517.34	E	392	572733.2	8651450	1517.359	E	503	572782.9	8651028	1517.868	E	614	572870.4	8650670	1518.562
282	572727.2	8651769	1517.326	E	393	572728.4	8651448	1517.354	E	504	572813.9	8651033	1517.893	E	615	572877.3	8650671	1518.568
283	572763.6	8651768	1517.379	E	394	572722.3	8651447	1517.347	E	505	572821.7	8651033	1517.904	E	616	572864	8650669	1518.557
284	572772.8	8651767	1517.392	E	395	572715.1	8651446	1517.337	E	506	572830.4	8651033	1517.915	E	617	572861	8650614	1518.656
285	572784.5	8651767	1517.409	E	396	572751.8	8651452	1517.383	E	507	572835	8651034	1517.92	E	618	572854.3	8650613	1518.652
286	572756.8	8651741	1517.353	E	397	572762.1	8651454	1517.395	E	508	572840.6	8650997	1517.984	E	619	572861	8650614	1518.656
287	572748.5	8651741	1517.341	E	398	572768.1	8651454	1517.403	E	509	572834.7	8650995	1517.978	E	620	572862.5	8650614	1518.658
288	572755.3	8651741	1517.351	E	399	572755.5	8651452	1517.387	E	510	572822.7	8650995	1517.963	E	621	572852.8	8650613	1518.65
289	572759.8	8651741	1517.358	E	400	572750.2	8651408	1517.406	E	511	572819.7	8650994	1517.96	E	622	572846.9	8650612	1518.645
290	572768	8651740	1517.369	E	401	572743.5	8651407	1517.398	E	512	572815.7	8650993	1517.956	E	623	572838.1	8650611	1518.637
291	572775.7	8651740	1517.381	E	402	572751.8	8651407	1517.408	E	513	572807.6	8650992	1517.949	E	624	572831.3	8650611	1518.631
292	572780.1	8651740	1517.387	E	403	572742.1	8651406	1517.397	E	514	572814.3	8650993	1517.955	E	625	572868.4	8650615	1518.662
293	572747	8651741	1517.339	E	404	572735.4	8651406	1517.388	E	515	572806.1	8650991	1517.948	E	626	572881.5	8650616	1518.674
294	572741.8	8651741	1517.331	E	405	572731.3	8651404	1517.383	E	516	572799.8	8650991	1517.942	E	627	572875.5	8650615	1518.67
295	572735.8	8651741	1517.322	E	406	572724.2	8651404	1517.375	E	517	572795.2	8650990	1517.939	E	628	572885.5	8650617	1518.677
296	572725.5	8651742	1517.307	E	407	572717.8	8651402	1517.367	E	518	572790.8	8650990	1517.934	E	629	572868.7	8650555	1518.775
297	572753.1	8651694	1517.339	E	408	572756.1	8651409	1517.413	E	519	572790.8	8650990	1517.934	E	630	572862	8650553	1518.771
298	572744.8	8651694	1517.327	E	409	572769.3	8651408	1517.431	E	520	572783.4	8650989	1517.928	E	631	572860.6	8650553	1518.77
299	572751.6	8651694	1517.337	E	410	572773.5	8651410	1517.435	E	521	572822.8	8650947	1518.035	E	632	572870.2	8650555	1518.776
300	572756.4	8651694	1517.344	E	411	572761	8651407	1517.42	E	522	572821.2	8650947	1518.033	E	633	572875.9	8650555	1518.782
301	572765.8	8651694	1517.357	E	412	572755.8	8651365	1517.446	E	523	572814.5	8650947	1518.026	E	634	572884.8	8650555	1518.79
302	572770.7	8651693	1517.364	E	413	572749	8651364	1517.438	E	524	572813	8650946	1518.024	E	635	572890.4	8650557	1518.794
303	572774.9	8651693	1517.37	E	414	572757.3	8651364	1517.448	E	525	572805.6	8650946	1518.017	E	636	572855.2	8650551	1518.768
304	572743.2	8651694	1517.325	E	415	572747.6	8651363	1517.437	E	526	572803	8650944	1518.018	E	637	572846.9	8650552	1518.759
305	572737.5	8651695	1517.316	E	416	572745.3	8651363	1517.434	E	527	572793.3	8650943	1518.009	E	638	572841.8	8650550	1518.756
306	572730	8651694	1517.305	E	417	572743.6	8651363	1517.432	E	528	572791	8650943	1518.007	E	639	572837.4	8650550	1518.753
307	572723.2	8651694	1517.296	E	418	572736.8	8651363	1517.424	E	529	572828.4	8650948	1518.042	E	640	572877.1	8650501	1518.887
308	572719.9	8651695	1517.291	E	419	572731.9	8651361	1517.418	E	530	572840.2	8650948	1518.056	E	641	572868.9	8650500	1518.882
309	572749.4	8651666	1517.328	E	420	572725.3	8651360	1517.411	E	531	572848	8650948	1518.066	E	642	572877.1	8650501	1518.887
310	572742.7	8651666	1517.319	E	421	572759.9	8651364	1517.451	E	532	572826	8650909	1518.098	E	643	572875.7	8650500	1518.887
311	572741.2	8651666	1517.316	E	422	572764.9	8651365	1517.458	E	533	572819.2	8650909	1518.09	E	644	572879.8	8650501	1518.89
312	572750.9	8651666	1517.33	E	423	572774.9	8651365	1517.47	E	534	572827.4	8650910	1518.098	E	645	572885.4	8650502	1518.894
313	572757.5	8651665	1517.34	E	424	572780.1	8651365	1517.477	E	535	572817.6	8650909	1518.088	E	646	572894.2	8650502	1518.902
314	572763.1	8651665	1517.348	E	425	572763.2	8651320	1517.494	E	536	572809.5	8650908	1518.079	E	647	572902	8650504	1518.906
315	572770.7	8651665	1517.359	E	426	572755	8651320	1517.485	E	537	572797	8650907	1518.069	E	648	572867.5	8650499	1518.882
316	572774.4	8651664	1517.364	E	427	572761.7	8651321	1517.492	E	538	572794.2	8650906	1518.068	E	649	572861	8650499	1518.876
317	572736.1	8651666	1517.309	E	428	572753.5	8651320	1517.483	E	539	572834.4	8650909	1518.108	E	650	572855.2	8650496	1518.875
318	572725.7	8651667	1517.294	E	429	572769.2	8651320	1517.502	E	540	572841.6	8650910	1518.117	E	651	572842.6	8650496	1518.863
319	572720.5	8651668	1517.287	E	430	572775.4	8651322	1517.508	E	541	572846.2	8650910	1518.121	E	652	572848.1	8650497	1518.867
320	572716	8651667	1517.28	E	431	572784.6	8651322	1517.52	E	542	572851	8650911	1518.127	E	653	572917.9	8650501	1518.929
321	572747.4	8651620	1517.319	E	432	572749	8651319	1517.478	E	543	572830.5	8650878	1518.156	E	654	572944.6	8650508	1518.944
322	572739.2	8651621	1517.308	E	433	572740.2	8651319	1517.467	E	544	572822.2	8650877	1518.148	E	655	572959.2	8650514	1518.951
323	572746	8651620	1517.317	E	434	572736.6	8651317	1517.464	E	545	572829	8650878	1518.154	E	656	572949	8650560	1518.853
324	572749.4	8651620	1517.322	E	435	572731.5	8651317	1517.458	E	546	572820.7	8650877	1518.145	E	657	572902	8650559	1518.801
325	572756	8651619	1517.332	E	436	572759.7	8651274	1517.532	E	547	572817.6	8650877	1518.142	E	658	572920.4	8650562	1518.815
326	572756	8651619	1517.332	E	437	572750.5	8651272	1517.522	E	548	572811.6	8650876	1518.136	E				
327	572762.6	8651619	1517.341	E	438	572743.3	8651271	1517.514	E	549	572804.3	8650875	1518.13	E				
328	572768.6	8651617	1517.35	E	439	572737.7	8651271	1517.507	E	550	572798	8650874	1518.126	E				
329	572735.5	8651621	1517.302	E	440	572768.1	8651274	1517.541	E	551	572834.5	8650878	1518.161	E				
330	572727.7	8651621	1517.291	E	441	572759.7	8651274	1517.532	E	552	572845.7	8650879	1518.174	E				
331	572721.1	8651621	1517.282	E	442	572761.3	8651273	1517.534	E	553	572855.6	8650878	1518.186	E				
332	572716.8	8651622	1517.276	E	443	572769.5	8651275	1517.543	E	554	572834.4	8650837	1518.229	E				
333	572737.7	8651621	1517.305	E	444	572776.9	8651275	1517.551	E	555	572826	8650837	1518.219	E				
334	572743.4	8651586	1517.321	E	445	572787.1	8651276	1517.563	E	556	572832.8	8650838	1518.225	E				
335	572736.5	8651586	1517.312	E	446	572792.6	8651277	1517.568	E	557	572824.6	8650836	1518.218	E				
336	572744.9	8651586	1517.323	E	447	572783.6	8651276	1517.559	E	558	572819.2	8650836	1518.212	E				
337	572735	8651586	1517.31	E	448	572773.4	8651235	1517.592	E	559	572811.6	8650836	1518.204	E				
338	572727.6	8651587	1517.299	E	449	572766.6	8651234	1517.584	E	560	572805.5	8650835	1518.199	E				
339	572719.4	8651586	1517.288	E	450	572765.1	8651234	1517.582	E	561	572802.5	8650835	1518.196	E				
340	572715.8	8651587	1517.282	E	451	572774.9	8651235	1517.593	E	562	572842.1	8650838	1518.237	E				
341	572712.5	8651587	1517.278	E	452	572779.1	8651236	1517.597	E	563	572850.9	8650839	1518.245	E				
342	572747.8	8651586	1517.327	E	453	572790.8	8651236	1517.611	E	564	572856.6	8650839	1518.252	E				
343	572757.3	8651585	1517.341	E	454	572798.7	8651236	1517.62	E	565	572837.7	8650802	1518.291	E				
344	572765.9	8651585	1517.353	E	455	572758.4	8651233	1517.576	E	566	572829.4	8650801	1518.282	E				
345	572767.7	8651585	1517.356	E	456	572751.4	8651233	1517.567	E	567	572836.2	8650802	1518.289	E				
346	572750.9	8651586	1517.332	E	457	572745.8	8651233	1517.561	E	568	572827.9	8650801	1518.281	E				
347	572760.5	8651585	1517.345	E	458	572741.8	8651232	1517.557	E	569	572822	8650801	1518.275	E				
348	572740.8	8651552	1517.325	E	459	572747.6	8651177	1517.628	E	570	572813.9	8650800	1518.266	E				
349	572734	8651553	1517.316	E	460	572754.1	8651178	1517.634	E	571	572806.4	8650799	1518.26	E				
350	572742.3	8651552	1517.327	E	461	572758.3	8651179	1517.638	E	572	572839.9	8650802	1518.293	E				
351	572732.4	8651552	1517.314	E	462	572763.6	8651180	1517.643	E	573	572847.7	8650803	1518.301	E				
352	572727.9	8651552	1517.308	E	463	572767.2	8651180	1517.647	E	574	572856.7	8650805	1518.308	E				
353	572722.6	8651552	1517.3	E	464	572769.5	8651180	1517.65	E	575	572860.8	8650805	1518.313	E				
354	572714.1	8651553	1517.288	E	465	572780.7	8651182	1517.661	E	576	572850.5	8650805	1518.301	E				

Appendix7. Kasitu Topographic Survey data

POINT	EASTING	NORTHIN	ELEVATIO	DESCRIPTI	POINT	EASTING	NORTHIN	ELEVATIO	DESCRIPTI	POINT	EASTING	NORTHIN	ELEVATIO	DESCRIPTI
1	586487.6	8686629	1754.09	E	50	586209.6	8686476	1721.07	E	100	585984.7	8686356	1730.917	E
2	586441.4	8686607	1741.278	E	51	586183.2	8686457	1716.178	E	101	586008.5	8686420	1722.269	E
3	586406.1	8686591	1733.721	E	52	586159.4	8686436	1711.378	E	102	586053.5	8686452	1709.855	E
4	586366.9	8686578	1731.037	E	53	586125	8686412	1711.52	E	103	586090.6	8686486	1705.424	E
5	586321.6	8686563	1732.129	E	54	586101.1	8686375	1721.306	E	104	586127.6	8686523	1715.036	E
6	586273	8686547	1730.685	E	55	586072	8686341	1724.118	E	105	586193.7	8686560	1729.671	E
7	586233.7	8686528	1726.871	E	56	586072	8686301	1724.395	E	106	586246.7	8686584	1739.482	E
8	586200.8	8686512	1724.019	E	57	586045.6	8686237	1724.33	E	107	586336.6	8686610	1739.713	E
9	586166.8	8686495	1716.79	E	58	586037.6	8686187	1725.243	E	108	586386.9	8686642	1742.591	E
10	586139.9	8686482	1710.777	E	59	586032.3	8686145	1726.931	E	109	586447.7	8686658	1752.491	E
11	586108.8	8686455	1705.721	E	60	586011.2	8686102	1719	E	110	586416	8686698	1762.099	E
12	586061.6	8686414	1715.316	E	61	585939.7	8686036	1723	E	111	586373.7	8686685	1752.717	E
13	586037.4	8686376	1724.421	E	62	586267.8	8686457	1725.266	E	112	586323.4	8686655	1748.56	E
14	586023.9	8686329	1727	E	63	586273.1	8686417	1731.451	E	113	586294.3	8686605	1746.103	E
15	586008.9	8686277	1725.191	E	64	586220.2	8686441	1722.179	E	114	586270.5	8686637	1751.527	E
16	586000	8686247	1723.046	E	65	586222.9	8686407	1725.995	E	115	586212.3	8686613	1741.442	E
17	585993.3	8686209	1720.749	E	66	586191.1	8686428	1717.699	E	116	586164.6	8686587	1731.407	E
18	585986.5	8686155	1718.488	E	67	586191.1	8686378	1722.356	E	117	586101.1	8686558	1716.976	E
19	585975.1	8686123	1718.982	E	68	586156.7	8686396	1714.907	E	118	586064.1	8686513	1705.222	E
20	585965.9	8686097	1723.472	E	69	586162	8686349	1721.483	E	119	586021.8	8686491	1706.269	E
21	585942.8	8686076	1722.975	E	70	586135.5	8686364	1722.171	E	120	585990	8686441	1718.602	E
22	585923.6	8686059	1723	E	71	586135.5	8686298	1725.24	E	121	585963.6	8686388	1727.33	E
23	585908.1	8686045	1717.573	E	72	586106.4	8686333	1724.967	E	122	585958.3	8686351	1731.48	E
24	585870.2	8686025	1708	E	73	586109.1	8686274	1727.135	E	123	585929.2	8686293	1728.162	E
25	585843.5	8686007	1710.409	E	74	586056.2	8686264	1724.944	E	124	585905.3	8686237	1725.524	E
26	585800.3	8685979	1715.342	E	75	586101.1	8686232	1727.963	E	125	585897.4	8686184	1718.71	E
27	585770.1	8685959	1719.909	E	76	586082.6	8686195	1730.225	E	126	585871	8686134	1710.435	E
28	585739.1	8685938	1721.122	E	77	586085.3	8686158	1733.776	E	127	585833.9	8686087	1704.656	E
29	585708.6	8685917	1724	E	78	585595.8	8685886	1716.918	E	128	585783.6	8686057	1703.614	E
30	585682	8685898	1724	E	79	585569.3	8685925	1716.11	E	129	585733.4	8686028	1719.683	E
31	585660.4	8685883	1722.13	E	80	585537.6	8685960	1720.169	E	130	585722.8	8686071	1709.845	E
32	586516.5	8686589	1757.044	E	81	585609	8685965	1718.452	E	131	585770.4	8686100	1698.205	E
33	586474.2	8686573	1746.953	E	82	585632.8	8685920	1719.551	E	132	585804.8	8686137	1707.076	E
34	586437.2	8686550	1734.282	E	83	585582.6	8685989	1720.083	E	133	585844.5	8686195	1715.615	E
35	586389.5	8686544	1728.454	E	84	585603.7	8686005	1721	E	134	585878.9	8686269	1726.315	E
36	586328.7	8686521	1726.722	E	85	585635.5	8685975	1720.706	E	135	585900.1	8686338	1728.71	E
37	586286.4	8686505	1725.372	E	86	585669.9	8685938	1723.337	E	136	585929.2	8686399	1721.733	E
38	586532.4	8686544	1763.464	E	87	585659.3	8686015	1721.066	E	137	585950.3	8686436	1715.91	E
39	586537.7	8686510	1763.956	E	88	585701.6	8686002	1722.779	E	138	585976.8	8686489	1706.348	E
40	586498	8686531	1754.901	E	89	585693.7	8686050	1717.358	E	139	586016.5	8686531	1707.3	E
41	586447.7	8686521	1738.195	E	90	585706.9	8685952	1724.302	E	140	586053.5	8686560	1710.736	E
42	586410.7	8686507	1731.924	E	91	585746.6	8685991	1721.867	E	141	586106.4	8686592	1721.795	E
43	586357.8	8686499	1727.574	E	92	585783.6	8686015	1714.977	E	142	586154.1	8686616	1732.41	E
44	586318.1	8686476	1728.308	E	93	585826	8686036	1706.031	E	143	586212.3	8686655	1740.951	E
45	586323.4	8686436	1734.771	E	94	585876.2	8686089	1708.48	E	144	586267.8	8686687	1751.8	E
46	586368.4	8686457	1731.846	E	95	585908	8686110	1714.209	E	145	586315.5	8686706	1755.333	E
47	586431.9	8686470	1739.884	E	96	585942.4	8686150	1715.009	E	146	586344.6	8686714	1758.509	E
48	586487.4	8686494	1751.679	E	97	585945	8686200	1718.986	E	147	586392.2	8686727	1765.71	E
49	586246.7	8686483	1723.057	E	98	585953	8686251	1723.648	E	148	585871	8686232	1723.107	E
					99	585963.6	8686293	1728.257	E	149	585844.5	8686158	1712.639	E

Appendix 8. Mapanjira Topographic Survey data

POINT	EASTING	EASTING	NORTHING	DESCRIPTI	POINT	EASTING	EASTING	NORTHING	DESCRIPTI	POINT	EASTING	EASTING	NORTHING	DESCRIPTI
1	570477.9	8662216	1560.959	C	78	570559.9	8661652	1560.921	E	155	570549.4	8661766	1560.967	E
2	570458.9	8662192	1560.965	C	79	570553.1	8661651	1560.92	E	156	570552.9	8661768	1560.967	E
3	570440.4	8662170	1560.97	C	80	570551.6	8661651	1560.92	E	157	570523.8	8661778	1560.969	E
4	570428.4	8662145	1560.971	C	81	570561.4	8661652	1560.921	E	158	570514.4	8661774	1560.967	E
5	570434	8662160	1560.97	C	82	570569.4	8661651	1560.92	E	159	570515.6	8661775	1560.968	E
6	570449.3	8662180	1560.967	C	83	570576.1	8661652	1560.919	E	160	570523.8	8661778	1560.969	E
7	570422.7	8662130	1560.973	C	84	570584.7	8661651	1560.918	E	161	570522.3	8661777	1560.969	E
8	570416.2	8662112	1560.974	C	85	570548.9	8661651	1560.92	E	162	570527	8661779	1560.969	E
9	570411.9	8662096	1560.976	C	86	570543.1	8661651	1560.919	E	163	570537.9	8661782	1560.971	E
10	570407.3	8662078	1560.978	C	87	570537.4	8661651	1560.919	E	164	570546.8	8661785	1560.973	E
11	570405.6	8662062	1560.98	C	88	570531.2	8661651	1560.919	E	165	570509.5	8661773	1560.966	E
12	570405.6	8662048	1560.982	C	89	570527.6	8661651	1560.918	E	166	570500.5	8661770	1560.965	E
13	570405.6	8662037	1560.982	C	90	570525.2	8661667	1560.927	E	167	570494	8661767	1560.964	E
14	570405.7	8662022	1560.982	C	91	570531.9	8661667	1560.927	E	168	570504.8	8661791	1560.972	E
15	570405.7	8662006	1560.983	C	92	570531.9	8661667	1560.927	E	169	570500.3	8661790	1560.971	E
16	570405.7	8661990	1560.983	C	93	570542.4	8661667	1560.928	E	170	570491.6	8661787	1560.97	E
17	570407.3	8661974	1560.984	C	94	570549.7	8661666	1560.928	E	171	570482.1	8661785	1560.969	E
18	570412.5	8661960	1560.985	C	95	570551.3	8661666	1560.928	E	172	570514.5	8661794	1560.973	E
19	570417.7	8661944	1560.987	C	96	570558.1	8661666	1560.929	E	173	570519.8	8661796	1560.974	E
20	570424.2	8661925	1560.987	C	97	570559.7	8661666	1560.929	E	174	570525	8661797	1560.975	E
21	570429.8	8661909	1560.986	C	98	570564.6	8661666	1560.928	E	175	570533.1	8661798	1560.976	E
22	570441.8	8661893	1560.987	C	99	570569.3	8661666	1560.928	E	176	570537.8	8661800	1560.977	E
23	570456.6	8661882	1560.986	C	100	570580.5	8661666	1560.927	E	177	570506.6	8661791	1560.972	E
24	570466	8661875	1560.986	C	101	570547.8	8661685	1560.938	E	178	570500.6	8661814	1560.979	E
25	570482.2	8661863	1560.985	C	102	570546.6	8661684	1560.937	E	179	570492.8	8661811	1560.978	E
26	570492.7	8661851	1560.984	C	103	570554.8	8661685	1560.939	E	180	570494.3	8661812	1560.978	E
27	570493.1	8661838	1560.982	C	104	570556.4	8661685	1560.939	E	181	570501.9	8661815	1560.98	E
28	570497.5	8661813	1560.979	C	105	570561.7	8661686	1560.939	E	182	570507.3	8661816	1560.98	E
29	570510.2	8661791	1560.972	C	106	570570.4	8661686	1560.938	E	183	570516	8661817	1560.981	E
30	570519	8661776	1560.968	C	107	570578.7	8661687	1560.938	E	184	570524.7	8661819	1560.981	E
31	570526.7	8661760	1560.963	C	108	570539.7	8661684	1560.937	E	185	570526.8	8661820	1560.982	E
32	570533.8	8661741	1560.958	C	109	570530.7	8661682	1560.935	E	186	570489	8661811	1560.977	E
33	570541.7	8661720	1560.951	C	110	570523.7	8661682	1560.935	E	187	570482.9	8661807	1560.976	E
34	570547.1	8661701	1560.945	C	111	570519.1	8661698	1560.943	E	188	570473.9	8661806	1560.975	E
35	570551.5	8661684	1560.938	C	112	570530.4	8661699	1560.944	E	189	570470	8661804	1560.974	E
36	570554.7	8661666	1560.928	C	113	570534.5	8661700	1560.944	E	190	570498	8661838	1560.982	E
37	570556.5	8661652	1560.921	C	114	570542.1	8661701	1560.945	E	191	570489.8	8661837	1560.982	E
38	570559.8	8661625	1560.907	C	115	570550.3	8661702	1560.946	E	192	570496.5	8661839	1560.982	E
39	570561.9	8661608	1560.897	C	116	570543.7	8661700	1560.945	E	193	570488.3	8661838	1560.982	E
40	570562.6	8661592	1560.889	C	117	570552	8661701	1560.946	E	194	570482.3	8661838	1560.981	E
41	570559.2	8661592	1560.889	E	118	570560.2	8661702	1560.947	E	195	570471.9	8661837	1560.981	E
42	570566	8661592	1560.889	E	119	570566.3	8661702	1560.946	E	196	570464.9	8661835	1560.98	E
43	570567.5	8661592	1560.888	E	120	570577.6	8661703	1560.945	E	197	570503.3	8661839	1560.983	E
44	570557.7	8661593	1560.889	E	121	570571.3	8661726	1560.953	E	198	570513.8	8661841	1560.984	E
45	570570.3	8661593	1560.888	E	122	570566.5	8661725	1560.953	E	199	570520	8661842	1560.984	E
46	570580.9	8661592	1560.887	E	123	570557.2	8661723	1560.953	E	200	570495.6	8661851	1560.984	E
47	570591.2	8661592	1560.886	E	124	570550.4	8661723	1560.953	E	201	570497.1	8661852	1560.984	E
48	570584.8	8661592	1560.886	E	125	570546.7	8661721	1560.952	E	202	570488.8	8661851	1560.984	E
49	570551.7	8661592	1560.889	E	126	570544.9	8661721	1560.952	E	203	570487.3	8661850	1560.983	E
50	570542.2	8661594	1560.889	E	127	570538.4	8661719	1560.951	E	204	570482.6	8661850	1560.983	E
51	570538.4	8661594	1560.889	E	128	570536.9	8661719	1560.951	E	205	570474.2	8661849	1560.982	E
52	570535.5	8661595	1560.889	E	129	570532.3	8661718	1560.95	E	206	570465.3	8661849	1560.982	E
53	570532.3	8661612	1560.898	E	130	570524.7	8661717	1560.949	E	207	570502	8661854	1560.985	E
54	570537.5	8661611	1560.898	E	131	570517.2	8661717	1560.949	E	208	570513.3	8661857	1560.986	E
55	570541	8661611	1560.898	E	132	570511.5	8661715	1560.948	E	209	570521.6	8661860	1560.987	E
56	570547.9	8661610	1560.898	E	133	570505.9	8661735	1560.954	E	210	570485.2	8661865	1560.985	E
57	570553.2	8661609	1560.898	E	134	570517.4	8661739	1560.956	E	211	570479.8	8661861	1560.984	E
58	570556.9	8661608	1560.898	E	135	570518.9	8661739	1560.956	E	212	570477.8	8661860	1560.984	E
59	570558.5	8661608	1560.898	E	136	570523.2	8661739	1560.956	E	213	570468.7	8661859	1560.983	E
60	570565.3	8661608	1560.897	E	137	570528.9	8661740	1560.957	E	214	570464	8661855	1560.983	E
61	570566.9	8661608	1560.897	E	138	570530.1	8661741	1560.957	E	215	570486	8661867	1560.986	E
62	570570.9	8661607	1560.896	E	139	570537.2	8661742	1560.958	E	216	570492.5	8661872	1560.987	E
63	570582.1	8661606	1560.894	E	140	570537.2	8661742	1560.958	E	217	570499.6	8661877	1560.988	E
64	570585.9	8661606	1560.894	E	141	570544.4	8661743	1560.959	E	218	570505.9	8661882	1560.989	E
65	570591.2	8661607	1560.894	E	142	570546.4	8661743	1560.959	E	219	570516.9	8661887	1560.99	E
66	570563.2	8661625	1560.906	E	143	570555.8	8661744	1560.96	E	220	570462.9	8661873	1560.985	E
67	570556.4	8661625	1560.906	E	144	570564.5	8661745	1560.96	E	221	570468.8	8661877	1560.986	E
68	570554.9	8661624	1560.906	E	145	570538.4	8661743	1560.958	E	222	570469.8	8661879	1560.986	E
69	570564.7	8661625	1560.906	E	146	570529.8	8661761	1560.964	E	223	570462.9	8661873	1560.985	E
70	570568.9	8661625	1560.906	E	147	570523.1	8661760	1560.963	E	224	570454.7	8661868	1560.984	E
71	570576.2	8661625	1560.905	E	148	570531.2	8661762	1560.964	E	225	570447.9	8661861	1560.983	E
72	570581.8	8661625	1560.904	E	149	570521.8	8661759	1560.963	E	226	570442.3	8661856	1560.981	E
73	570586.6	8661626	1560.904	E	150	570513.4	8661755	1560.961	E	227	570472.3	8661882	1560.987	E
74	570549.1	8661625	1560.906	E	151	570505.8	8661755	1560.96	E	228	570478.9	8661887	1560.988	E
75	570544.9	8661625	1560.906	E	152	570500.2	8661752	1560.959	E	229	570483.8	8661896	1560.989	E
76	570535.6	8661625	1560.905	E	153	570534.6	8661763	1560.965	E	230	570443.4	8661896	1560.987	E
77	570529.5	8661625	1560.905	E	154	570539.8	8661764	1560.965	E	231	570439.7	8661891	1560.986	E

Appendix 9. Mapanjira Topographic Survey data2

POINT	EASTING	EASTING	NORTHIN	DESCRIPTI	POINT	EASTING	EASTING	NORTHIN	DESCRIPTI	POINT	EASTING	EASTING	NORTHIN	DESCRIPTI
232	570445.4	8661897	1560.987	E	309	570395.6	8662007	1560.981	E	386	570420.8	8662092	1560.978	E
233	570438.1	8661890	1560.985	E	310	570400.8	8662007	1560.982	E	387	570424.8	8662091	1560.979	E
234	570435.2	8661886	1560.984	E	311	570410.6	8662006	1560.984	E	388	570434.6	8662089	1560.982	E
235	570427.2	8661881	1560.982	E	312	570402.3	8662006	1560.982	E	389	570438.5	8662088	1560.983	E
236	570421.9	8661874	1560.98	E	313	570409.1	8662006	1560.983	E	390	570421.1	8662112	1560.975	E
237	570448.7	8661899	1560.988	E	314	570413.9	8662007	1560.984	E	391	570427.4	8662110	1560.977	E
238	570457.8	8661907	1560.989	E	315	570421.2	8662007	1560.986	E	392	570436.3	8662107	1560.979	E
239	570462.9	8661910	1560.99	E	316	570431.1	8662007	1560.988	E	393	570442	8662104	1560.981	E
240	570452.2	8661904	1560.989	E	317	570421.7	8661990	1560.986	E	394	570419.8	8662113	1560.975	E
241	570432.9	8661911	1560.987	E	318	570409.1	8662023	1560.983	E	395	570413	8662114	1560.973	E
242	570426.6	8661908	1560.985	E	319	570402.3	8662022	1560.982	E	396	570411.3	8662113	1560.973	E
243	570434.1	8661912	1560.987	E	320	570410.6	8662023	1560.983	E	397	570407.8	8662114	1560.972	E
244	570425	8661908	1560.985	E	321	570400.8	8662022	1560.981	E	398	570397.3	8662116	1560.97	E
245	570419.3	8661905	1560.983	E	322	570394.4	8662021	1560.98	E	399	570389.2	8662119	1560.968	E
246	570409	8661901	1560.98	E	323	570385.8	8662021	1560.978	E	400	570426	8662129	1560.973	E
247	570403.9	8661898	1560.979	E	324	570377.5	8662021	1560.977	E	401	570427.4	8662129	1560.974	E
248	570437.5	8661914	1560.988	E	325	570380.8	8662021	1560.977	E	402	570429.7	8662128	1560.974	E
249	570449.9	8661921	1560.991	E	326	570414.9	8662023	1560.984	E	403	570440.5	8662126	1560.977	E
250	570456.2	8661925	1560.992	E	327	570422.7	8662023	1560.986	E	404	570443.3	8662125	1560.977	E
251	570448.8	8661939	1560.992	E	328	570435.7	8662024	1560.989	E	405	570451.3	8662121	1560.978	E
252	570441.7	8661934	1560.992	E	329	570430	8662024	1560.987	E	406	570419.2	8662131	1560.972	E
253	570434.8	8661930	1560.99	E	330	570410.5	8662038	1560.983	E	407	570417.6	8662131	1560.972	E
254	570419.7	8661923	1560.986	E	331	570417.2	8662038	1560.984	E	408	570414.9	8662131	1560.971	E
255	570413.9	8661922	1560.984	E	332	570426.4	8662038	1560.986	E	409	570411.9	8662132	1560.97	E
256	570408.5	8661917	1560.983	E	333	570432.8	8662039	1560.988	E	410	570404.8	8662133	1560.969	E
257	570399.2	8661915	1560.98	E	334	570400.7	8662037	1560.981	E	411	570400.9	8662134	1560.968	E
258	570428.7	8661928	1560.988	E	335	570409	8662037	1560.983	E	412	570394.3	8662135	1560.966	E
259	570427.5	8661926	1560.988	E	336	570402.2	8662036	1560.981	E	413	570431.7	8662144	1560.972	E
260	570421	8661924	1560.986	E	337	570395.1	8662037	1560.98	E	414	570425.2	8662146	1560.971	E
261	570420.8	8661946	1560.987	E	338	570388.7	8662037	1560.979	E	415	570423.7	8662147	1560.97	E
262	570414.5	8661943	1560.986	E	339	570383.8	8662036	1560.978	E	416	570432.9	8662143	1560.973	E
263	570413.1	8661943	1560.986	E	340	570375.6	8662038	1560.976	E	417	570436.6	8662141	1560.974	E
264	570422.3	8661946	1560.988	E	341	570375.6	8662050	1560.976	E	418	570448.5	8662138	1560.975	E
265	570428	8661948	1560.989	E	342	570381.1	8662049	1560.977	E	419	570453	8662137	1560.976	E
266	570433.4	8661950	1560.99	E	343	570386.7	8662049	1560.978	E	420	570433.2	8662127	1560.975	E
267	570440	8661952	1560.991	E	344	570395.7	8662049	1560.98	E	421	570442.9	8662140	1560.975	E
268	570443.8	8661955	1560.992	E	345	570400.7	8662049	1560.981	E	422	570419.8	8662149	1560.969	E
269	570409.5	8661941	1560.985	E	346	570410.5	8662048	1560.983	E	423	570412.2	8662150	1560.968	E
270	570404.8	8661939	1560.984	E	347	570402.2	8662048	1560.981	E	424	570405.7	8662151	1560.966	E
271	570398.2	8661937	1560.983	E	348	570409	8662047	1560.983	E	425	570399.1	8662152	1560.965	E
272	570392.6	8661936	1560.982	E	349	570413	8662047	1560.983	E	426	570438.4	8662157	1560.971	E
273	570407.8	8661958	1560.984	E	350	570422.5	8662048	1560.985	E	427	570443.4	8662154	1560.973	E
274	570407.8	8661958	1560.984	E	351	570431.8	8662047	1560.987	E	428	570448	8662152	1560.973	E
275	570416	8661960	1560.986	E	352	570410.5	8662062	1560.981	E	429	570454.6	8662149	1560.974	E
276	570409.1	8661959	1560.985	E	353	570402.2	8662062	1560.98	E	430	570459.3	8662146	1560.975	E
277	570417.2	8661961	1560.986	E	354	570409	8662062	1560.981	E	431	570436.8	8662158	1560.971	E
278	570423.4	8661962	1560.987	E	355	570400.7	8662062	1560.979	E	432	570430.6	8662160	1560.969	E
279	570430.2	8661965	1560.989	E	356	570397.1	8662062	1560.978	E	433	570429.3	8662161	1560.969	E
280	570438.4	8661968	1560.99	E	357	570390.6	8662062	1560.977	E	434	570425.8	8662164	1560.968	E
281	570403.4	8661956	1560.983	E	358	570378.4	8662062	1560.975	E	435	570417.6	8662167	1560.966	E
282	570398.1	8661955	1560.982	E	359	570383	8662063	1560.975	E	436	570413.7	8662168	1560.965	E
283	570391.4	8661951	1560.981	E	360	570413.5	8662062	1560.982	E	437	570409.4	8662173	1560.963	E
284	570387.7	8661949	1560.98	E	361	570419.8	8662062	1560.983	E	438	570419.2	8662187	1560.961	E
285	570410.7	8661975	1560.984	E	362	570431.9	8662062	1560.986	E	439	570421.7	8662184	1560.962	E
286	570403.9	8661974	1560.983	E	363	570423.6	8662063	1560.984	E	440	570424.8	8662181	1560.964	E
287	570412.3	8661975	1560.985	E	364	570412.1	8662077	1560.979	E	441	570431.9	8662175	1560.967	E
288	570402.3	8661974	1560.983	E	365	570404.1	8662079	1560.977	E	442	570434.9	8662173	1560.968	E
289	570398.6	8661972	1560.982	E	366	570412.1	8662077	1560.979	E	443	570437.4	8662171	1560.969	E
290	570388.2	8661971	1560.98	E	367	570410.7	8662077	1560.979	E	444	570436.5	8662173	1560.968	E
291	570379.7	8661968	1560.978	E	368	570402.5	8662079	1560.977	E	445	570443.3	8662168	1560.97	E
292	570417.3	8661976	1560.986	E	369	570414.7	8662077	1560.98	E	446	570444.3	8662167	1560.971	E
293	570425.3	8661978	1560.987	E	370	570422.2	8662075	1560.981	E	447	570448.4	8662165	1560.971	E
294	570431	8661979	1560.989	E	371	570431.9	8662074	1560.984	E	448	570457.9	8662158	1560.973	E
295	570435.2	8661981	1560.989	E	372	570425.4	8662075	1560.982	E	449	570463.1	8662154	1560.974	E
296	570410.6	8661990	1560.984	E	373	570398.9	8662079	1560.976	E	450	570453	8662177	1560.969	E
297	570416.1	8661991	1560.985	E	374	570392.6	8662080	1560.975	E	451	570458	8662175	1560.97	E
298	570428.5	8661991	1560.988	E	375	570383.8	8662082	1560.973	E	452	570465.7	8662168	1560.971	E
299	570433.5	8661992	1560.989	E	376	570380.1	8662082	1560.972	E	453	570472	8662164	1560.972	E
300	570400.8	8661990	1560.982	E	377	570387.6	8662081	1560.973	E	454	570451.7	8662178	1560.968	E
301	570409.1	8661990	1560.984	E	378	570415.1	8662094	1560.977	E	455	570445.9	8662182	1560.967	E
302	570402.3	8661990	1560.982	E	379	570408.4	8662096	1560.975	E	456	570444.6	8662182	1560.967	E
303	570397	8661990	1560.981	E	380	570416.4	8662094	1560.977	E	457	570441.7	8662185	1560.966	E
304	570388.3	8661990	1560.979	E	381	570407	8662096	1560.975	E	458	570436.3	8662191	1560.963	E
305	570379.4	8661989	1560.978	E	382	570403.3	8662097	1560.974	E	459	570431.8	8662197	1560.961	E
306	570377.7	8662008	1560.977	E	383	570395.2	8662099	1560.972	E	460	570428.5	8662200	1560.959	E
307	570388.3	8662008	1560.979	E	384	570385.8	8662103	1560.97	E	461	570464.7	8662189	1560.966	E
308	570383.1	8662007	1560.978	E	385	570391.1	8662102	1560.971	E	462	570461.4	8662190	1560.966	E

Appendix 10. Mapanjira Topographic Survey data3

POINT	EASTING	NORTHING	ELEVATION	DESCRIPTI	POINT	EASTING	EASTING	NORTHING	DESCRIPTI	POINT	EASTING	EASTING	NORTHING	DESCRIPTI	POINT	EASTING	EASTING	NORTHING	DESCRIPTI
463	570455.4	8662193	1560.964	E	540	570463.2	8662054	1560.99	E	617	570535.4	8661925	1560.996	E	694	570642.3	8661601	1560.885	E
464	570467.6	8662186	1560.967	E	541	570483.5	8662051	1560.991	E	618	570416.4	8661867	1560.977	E	695	570602.1	8661588	1560.882	E
465	570471.5	8662181	1560.968	E	542	570435.6	8662045	1560.988	E	619	570403.7	8661851	1560.972	E	696	570635.4	8661584	1560.876	E
466	570474.9	8662177	1560.97	E	543	570448.6	8662044	1560.99	E	620	570377.2	8661834	1560.964	E	697	570650.8	8661583	1560.874	E
467	570479	8662175	1560.971	E	544	570471.3	8662041	1560.991	E	621	570436.5	8661847	1560.979	E	698	570521.1	8661597	1560.889	E
468	570454	8662194	1560.964	E	545	570481.6	8662039	1560.992	E	622	570416.4	8661808	1560.968	E	699	570505.8	8661594	1560.887	E
469	570450.7	8662196	1560.963	E	546	570441.4	8662040	1560.989	E	623	570538.1	8661889	1560.992	E	700	570486.7	8661592	1560.884	E
470	570446.1	8662199	1560.962	E	547	570450.1	8662036	1560.99	E	624	570578.4	8661906	1560.993	E	701	570476.2	8661589	1560.882	E
471	570442.6	8662203	1560.961	E	548	570460.3	8662033	1560.991	E	625	570554.5	8661900	1560.994	E	702	570513.2	8661623	1560.903	E
472	570437.2	8662209	1560.958	E	549	570478.9	8662031	1560.992	E	626	570534.4	8661858	1560.987	E	703	570486.2	8661623	1560.901	E
473	570480.8	8662214	1560.96	E	550	570440.6	8662024	1560.99	E	627	570570.9	8661867	1560.989	E	704	570477.8	8661622	1560.9	E
474	570474.3	8662217	1560.959	E	551	570454.3	8662020	1560.991	E	628	570549.2	8661867	1560.989	E	705	570514.3	8661652	1560.918	E
475	570481.8	8662213	1560.96	E	552	570468.3	8662019	1560.991	E	629	570533.3	8661844	1560.985	E	706	570492	8661648	1560.915	E
476	570472.6	8662217	1560.959	E	553	570477.4	8662017	1560.992	E	630	570556.1	8661843	1560.987	E	707	570477.2	8661647	1560.913	E
477	570469.2	8662219	1560.958	E	554	570370.3	8662021	1560.975	E	631	570573	8661846	1560.986	E	708	570510	8661672	1560.928	E
478	570464	8662224	1560.956	E	555	570357	8662023	1560.972	E	632	570536.5	8661822	1560.983	E	709	570474	8661671	1560.926	E
479	570455.4	8662226	1560.955	E	556	570331.6	8662023	1560.967	E	633	570554.5	8661822	1560.984	E	710	570462.4	8661665	1560.922	E
480	570484.7	8662209	1560.961	E	557	570311	8662023	1560.961	E	634	570574.6	8661825	1560.983	E					
481	570493	8662204	1560.963	E	558	570368.8	8662039	1560.974	E	635	570457.6	8661808	1560.974	E					
482	570496.3	8662200	1560.964	E	559	570354.6	8662039	1560.972	E	636	570448.6	8661830	1560.978	E					
483	570498.6	8662197	1560.965	E	560	570335.6	8662040	1560.968	E	637	570429.6	8661829	1560.975	E					
484	570433.1	8662236	1560.95	E	561	570314.4	8662040	1560.962	E	638	570465.6	8661797	1560.971	E					
485	570415.8	8662255	1560.942	E	562	570366.3	8662051	1560.974	E	639	570442.8	8661794	1560.969	E					
486	570394.2	8662260	1560.936	E	563	570354.2	8662052	1560.971	E	640	570420.7	8661784	1560.961	E					
487	570506	8662193	1560.967	E	564	570341.1	8662053	1560.968	E	641	570417.4	8661776	1560.958	E					
488	570521.2	8662184	1560.97	E	565	570327.1	8662055	1560.965	E	642	570469.3	8661778	1560.966	E					
489	570549.6	8662168	1560.976	E	566	570311.4	8662056	1560.96	E	643	570457.6	8661771	1560.962	E					
490	570535.2	8662146	1560.979	E	567	570363.1	8662065	1560.971	E	644	570432.2	8661765	1560.957	E					
491	570499.8	8662157	1560.975	E	568	570350.6	8662066	1560.968	E	645	570414.7	8661756	1560.951	E					
492	570480.6	8662164	1560.973	E	569	570332.4	8662069	1560.964	E	646	570552.9	8661801	1560.978	E					
493	570421.7	8662201	1560.958	E	570	570306.5	8662073	1560.956	E	647	570571.4	8661805	1560.979	E					
494	570397.2	8662215	1560.949	E	571	570374.5	8662085	1560.97	E	648	570596.3	8661810	1560.978	E					
495	570373.5	8662230	1560.941	E	572	570343.4	8662088	1560.964	E	649	570554.5	8661787	1560.974	E					
496	570348.3	8662193	1560.946	E	573	570318	8662089	1560.958	E	650	570576.2	8661787	1560.972	E					
497	570363.1	8662181	1560.952	E	574	570310.6	8662090	1560.955	E	651	570603.7	8661793	1560.971	E					
498	570404.2	8662173	1560.962	E	575	570359.7	8662085	1560.967	E	652	570480.4	8661763	1560.961	E					
499	570412.4	8662191	1560.959	E	576	570369	8662107	1560.966	E	653	570462.9	8661754	1560.957	E					
500	570387.9	8662199	1560.952	E	577	570342.2	8662107	1560.96	E	654	570444.4	8661751	1560.955	E					
501	570355.7	8662212	1560.942	E	578	570320.8	8662111	1560.955	E	655	570434.4	8661747	1560.952	E					
502	570372.8	8662201	1560.948	E	579	570358.9	8662107	1560.964	E	656	570566.1	8661769	1560.968	E					
503	570470	8662152	1560.974	E	580	570316.4	8661997	1560.963	E	657	570590.5	8661769	1560.965	E					
504	570480.6	8662146	1560.976	E	581	570349.7	8661998	1560.971	E	658	570609	8661780	1560.967	E					
505	570496.4	8662138	1560.978	E	582	570366.3	8661992	1560.975	E	659	570481.5	8661747	1560.956	E					
506	570529.3	8662126	1560.982	E	583	570370.9	8661968	1560.976	E	660	570457.1	8661732	1560.95	E					
507	570466.4	8662142	1560.976	E	584	570340.2	8661963	1560.97	E	661	570433.9	8661722	1560.944	E					
508	570474.2	8662134	1560.977	E	585	570320.6	8661958	1560.965	E	662	570495.2	8661729	1560.951	E					
509	570496.9	8662124	1560.98	E	586	570445.5	8661979	1560.991	E	663	570476.7	8661719	1560.947	E					
510	570461.9	8662131	1560.977	E	587	570458.7	8661980	1560.992	E	664	570459.2	8661708	1560.942	E					
511	570488.2	8662117	1560.981	E	588	570510.8	8661981	1560.995	E	665	570447.6	8661706	1560.941	E					
512	570454.7	8662119	1560.979	E	589	570448.6	8661995	1560.991	E	666	570575.6	8661746	1560.959	E					
513	570482.1	8662111	1560.982	E	590	570472.5	8661992	1560.992	E	667	570606.9	8661752	1560.958	E					
514	570515.7	8662105	1560.984	E	591	570500	8661996	1560.994	E	668	570624.3	8661758	1560.958	E					
515	570522.1	8662115	1560.983	E	592	570446.5	8662009	1560.99	E	669	570585.7	8661726	1560.952	E					
516	570383.2	8662137	1560.964	E	593	570469.8	8662005	1560.992	E	670	570625.4	8661728	1560.948	E					
517	570372.2	8662140	1560.961	E	594	570497.3	8662006	1560.993	E	671	570603.2	8661726	1560.95	E					
518	570353.6	8662145	1560.957	E	595	570377.7	8661946	1560.978	E	672	570500	8661709	1560.945	E					
519	570335.2	8662148	1560.953	E	596	570355.5	8661941	1560.973	E	673	570480.4	8661703	1560.942	E					
520	570389.8	8662154	1560.962	E	597	570329.1	8661930	1560.967	E	674	570455	8661694	1560.937	E					
521	570354.8	8662165	1560.954	E	598	570453.9	8661957	1560.992	E	675	570507.9	8661694	1560.94	E					
522	570334.3	8662170	1560.949	E	599	570471.4	8661963	1560.993	E	676	570478.8	8661690	1560.936	E					
523	570349.8	8662165	1560.953	E	600	570500.5	8661977	1560.994	E	677	570457.1	8661682	1560.931	E					
524	570377.5	8662120	1560.965	E	601	570467.2	8661942	1560.993	E	678	570588.9	8661704	1560.944	E					
525	570362.2	8662123	1560.962	E	602	570495.9	8661956	1560.995	E	679	570622.7	8661705	1560.941	E					
526	570340.2	8662127	1560.957	E	603	570511.3	8661954	1560.996	E	680	570641.8	8661701	1560.937	E					
527	570321.6	8662130	1560.953	E	604	570382	8661907	1560.975	E	681	570596.3	8661687	1560.936	E					
528	570456	8662098	1560.982	E	605	570361.3	8661898	1560.97	E	682	570630.7	8661681	1560.929	E					
529	570477	8662096	1560.984	E	606	570339.1	8661888	1560.963	E	683	570596.3	8661663	1560.923	E					
530	570487.6	8662092	1560.985	E	607	570373.5	8661930	1560.977	E	684	570625.4	8661663	1560.92	E					
531	570449.5	8662083	1560.984	E	608	570355.5	8661920	1560.972	E	685	570638.6	8661663	1560.918	E					
532	570461.3	8662080	1560.986	E	609	570333.8	8661913	1560.966	E	686	570597.3	8661651	1560.916	E					
533	570475.3	8662078	1560.987	E	610	570383.6	8661888	1560.973	E	687	570619	8661647	1560.912	E					
534	570485.7	8662073	1560.988	E	611	570358.7	8661868	1560.965	E	688	570658.3	8661643	1560.905	E					
535	570441.8	8662073	1560.986	E	612	570348.6	8661860	1560.961	E	689	570597.9	8661622	1560.901	E					
536	570457.7	8662067	1560.988	E	613	570475.6	8661921	1560.992	E	690	570622.7	8661618	1560.896	E					
537	570480.6	8662062	1560.99	E	614	570515.6	8661937	1560.996	E	691	570646	8661619	1560.894	E					
538	570439.7	8662062	1560.987	E	615	570503.7	8661902	1560.991	E	692	570605.8	8661603	1560.89	E					
539	570450.7	8662057	1560.989	E	616	570516.9	8661921	1560.995	E	693	570629.6	8661600	1560.886	E					

Appendix 11. Chilerawalanda Topographic Survey data (1)

POINT	EASTING	NORTHIN	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHIN	HEIGHT	DESCRIPTI
1	576509.5	8680958	1553.835	C	100	576364.2	8680862	1554.861	E
2	576478.7	8680939	1554.028	C	101	576368.2	8680856	1554.875	E
3	576449.5	8680917	1554.233	C	102	576372.3	8680852	1554.88	E
4	576420.9	8680896	1554.446	C	103	576375.7	8680846	1554.896	E
5	576395.8	8680877	1554.644	C	104	576380.2	8680837	1554.923	E
6	576366.9	8680859	1554.863	C	105	576346.4	8680812	1555.205	E
7	576329.2	8680835	1555.14	C	106	576341.3	8680818	1555.193	E
8	576279.3	8680804	1555.531	C	107	576334.9	8680826	1555.172	E
9	576225	8680776	1555.918	C	108	576321.7	8680840	1555.14	E
10	576179.3	8680755	1556.199	C	109	576313.1	8680847	1555.134	E
11	576138.6	8680736	1556.461	C	110	576309.9	8680853	1555.109	E
12	576097.7	8680714	1556.693	C	111	576305.9	8680856	1555.102	E
13	576051.4	8680688	1556.953	C	112	576331.6	8680831	1555.156	E
14	576009.9	8680665	1557.2	C	113	576324.9	8680837	1555.148	E
15	575980.5	8680644	1557.315	C	114	576331.4	8680833	1555.146	E
16	575947.3	8680613	1557.487	C	115	576324.5	8680838	1555.141	E
17	575920.7	8680577	1557.717	C	116	576278.9	8680837	1555.323	E
18	575900.3	8680541	1557.962	C	117	576286.9	8680824	1555.374	E
19	575882.3	8680505	1558.094	C	118	576301.4	8680808	1555.416	E
20	575853.8	8680450	1558.215	C	119	576311.2	8680802	1555.409	E
21	575837.4	8680418	1558.276	C	120	576359.9	8680835	1555.027	E
22	575813.2	8680372	1558.173	C	121	576293.9	8680778	1555.633	E
23	575786.5	8680322	1558.039	C	122	576256.3	8680826	1555.483	E
24	575768.7	8680287	1557.842	C	123	576281.6	8680800	1555.549	E
25	575755.7	8680251	1557.454	C	124	576274	8680807	1555.535	E
26	575737.9	8680201	1556.893	C	125	576281.3	8680801	1555.54	E
27	575720.7	8680153	1556.084	C	126	576275.9	8680806	1555.532	E
28	575714.4	8680112	1555.355	C	127	576263.5	8680816	1555.517	E
29	575709.4	8680071	1554.634	C	128	576267.5	8680811	1555.531	E
30	575709.5	8680038	1553.863	C	129	576283.7	8680797	1555.56	E
31	575711.2	8680003	1552.974	C	130	576291.9	8680784	1555.602	E
32	575715.4	8679955	1551.791	C	131	576213.9	8680801	1555.774	E
33	575720.8	8679905	1550.104	C	132	576216.5	8680788	1555.855	E
34	575724.7	8679870	1548.8	C	133	576219.3	8680783	1555.885	E
35	575729.3	8679828	1547.277	C	134	576208.8	8680800	1555.79	E
36	575737.4	8679782	1545.131	C	135	576227.3	8680771	1555.941	E
37	575755.8	8679694	1540.955	C	136	576221.5	8680780	1555.901	E
38	575768.8	8679617	1536.465	C	137	576226.5	8680773	1555.934	E
39	575774.4	8679540	1531.398	C	138	576222.4	8680778	1555.907	E
40	575779	8679467	1526.331	C	139	576212.2	8680793	1555.831	E
41	575769.7	8679412	1521.831	E	140	576238.3	8680750	1556.047	E
42	576512.6	8680954	1553.837	E	141	576234.7	8680759	1556.001	E
43	576506.5	8680962	1553.831	E	142	576229.8	8680767	1555.962	E
44	576511.6	8680955	1553.837	E	143	576182	8680750	1556.22	E
45	576507.2	8680960	1553.833	E	144	576184.5	8680744	1556.256	E
46	576491.4	8680982	1553.806	E	145	576189.4	8680730	1556.337	E
47	576517.3	8680949	1553.839	E	146	576176.5	8680759	1556.178	E
48	576523	8680939	1553.854	E	147	576172.5	8680764	1556.152	E
49	576495.9	8680974	1553.821	E	148	576169.4	8680771	1556.109	E
50	576498.7	8680969	1553.833	E	149	576180.7	8680751	1556.217	E
51	576502.7	8680965	1553.833	E	150	576177.6	8680758	1556.183	E
52	576460.6	8680961	1553.995	E	151	576166.9	8680779	1556.063	E
53	576464.2	8680954	1554.016	E	152	576140.7	8680732	1556.488	E
54	576468.8	8680949	1554.023	E	153	576135.6	8680740	1556.441	E
55	576473.7	8680946	1554.016	E	154	576140.1	8680733	1556.479	E
56	576476.7	8680942	1554.024	E	155	576136	8680739	1556.45	E
57	576480.9	8680935	1554.038	E	156	576130.7	8680746	1556.414	E
58	576480	8680936	1554.037	E	157	576123.7	8680752	1556.375	E
59	576475.6	8680943	1554.023	E	158	576116.8	8680757	1556.342	E
60	576483.8	8680930	1554.048	E	159	576152.3	8680709	1556.612	E
61	576490.6	8680924	1554.044	E	160	576148.3	8680717	1556.568	E
62	576494.4	8680917	1554.056	E	161	576142.6	8680726	1556.524	E
63	576469.3	8680894	1554.254	E	162	576092	8680719	1556.664	E
64	576464.7	8680902	1554.24	E	163	576085.4	8680726	1556.614	E
65	576445.8	8680920	1554.232	E	164	576078.4	8680736	1556.541	E
66	576452.4	8680913	1554.239	E	165	576080.5	8680732	1556.572	E
67	576447.2	8680920	1554.23	E	166	576094.9	8680716	1556.678	E
68	576451.5	8680914	1554.237	E	167	576093.7	8680717	1556.671	E
69	576442.5	8680924	1554.229	E	168	576100.5	8680708	1556.734	E
70	576436.3	8680930	1554.225	E	169	576104.5	8680705	1556.758	E
71	576428.6	8680937	1554.22	E	170	576099.8	8680710	1556.725	E
72	576424.8	8680939	1554.222	E	171	576108.5	8680699	1556.8	E
73	576400.4	8680915	1554.433	E	172	576099.1	8680711	1556.716	E
74	576407.4	8680907	1554.446	E	173	576113.7	8680692	1556.842	E
75	576418.5	8680898	1554.445	E	174	576053.8	8680684	1556.985	E
76	576423.7	8680891	1554.454	E	175	576058.4	8680674	1557.058	E
77	576416.9	8680899	1554.448	E	176	576063.9	8680666	1557.11	E
78	576423.2	8680893	1554.45	E	177	576045.6	8680694	1556.913	E
79	576426.2	8680889	1554.457	E	178	576037.5	8680702	1556.853	E
80	576411.2	8680902	1554.452	E	179	576029.3	8680708	1556.82	E
81	576429.4	8680886	1554.457	E	180	576053.1	8680685	1556.975	E
82	576437.1	8680877	1554.467	E	181	576048.6	8680690	1556.938	E
83	576440.5	8680873	1554.473	E	182	576047.3	8680691	1556.932	E
84	576416.2	8680854	1554.668	E	183	575991.8	8680688	1556.975	E
85	576407	8680864	1554.659	E	184	575998.2	8680678	1557.069	E
86	576400.6	8680871	1554.655	E	185	576027.7	8680642	1557.353	E
87	576411.3	8680859	1554.669	E	186	576021.9	8680646	1557.33	E
88	576388.8	8680883	1554.64	E	187	576015.9	8680654	1557.278	E
89	576381.9	8680892	1554.625	E	188	576012.3	8680660	1557.234	E
90	576374.8	8680899	1554.614	E	189	576007.4	8680667	1557.175	E
91	576393.3	8680879	1554.642	E	190	576011.3	8680661	1557.225	E
92	576397.5	8680874	1554.652	E	191	576006.1	8680668	1557.164	E
93	576398.8	8680873	1554.651	E	192	576000.1	8680672	1557.119	E
94	576391.7	8680880	1554.645	E	193	575993.7	8680682	1557.023	E
95	576350.6	8680883	1554.79	E	194	576001.5	8680622	1557.509	E
96	576356.3	8680878	1554.799	E	195	575990	8680629	1557.436	E
97	576359.5	8680870	1554.834	E	196	575983	8680639	1557.351	E
98	576363.5	8680863	1554.856	E	197	575977.8	8680646	1557.294	E
99	576369.5	8680855	1554.874	E	198	575982.4	8680641	1557.339	E

Appendix 12. Chilerawalanda Topographic Survey data (2)

POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI
199	575976.7	8680647	1557.285	E	298	575797.6	8680279	1558.043	E
200	575973.3	8680650	1557.257	E	299	575787.2	8680282	1557.981	E
201	575964.8	8680655	1557.2	E	300	575777.3	8680284	1557.917	E
202	575959.5	8680662	1557.131	E	301	575773.1	8680285	1557.892	E
203	575923.6	8680630	1557.324	E	302	575765.4	8680288	1557.798	E
204	575930.3	8680624	1557.374	E	303	575771.9	8680286	1557.882	E
205	575951.1	8680610	1557.516	E	304	575763.9	8680288	1557.78	E
206	575949.8	8680611	1557.508	E	305	575762.1	8680289	1557.758	E
207	575944.6	8680615	1557.467	E	306	575757.1	8680290	1557.695	E
208	575943.4	8680616	1557.458	E	307	575750.6	8680292	1557.616	E
209	575936.5	8680621	1557.413	E	308	575741.6	8680296	1557.509	E
210	575926.6	8680627	1557.348	E	309	575785.1	8680244	1557.768	E
211	575953.9	8680608	1557.535	E	310	575781	8680245	1557.744	E
212	575962.7	8680602	1557.595	E	311	575774.2	8680246	1557.698	E
213	575968.7	8680596	1557.647	E	312	575767.6	8680248	1557.612	E
214	575970.5	8680594	1557.666	E	313	575760.4	8680249	1557.515	E
215	575946.5	8680561	1557.873	E	314	575750.8	8680252	1557.387	E
216	575936.5	8680565	1557.828	E	315	575740.4	8680256	1557.255	E
217	575929.8	8680571	1557.774	E	316	575735	8680257	1557.183	E
218	575915.7	8680578	1557.698	E	317	575728.4	8680259	1557.103	E
219	575924.6	8680574	1557.745	E	318	575746.2	8680253	1557.327	E
220	575917.3	8680578	1557.703	E	319	575759	8680250	1557.498	E
221	575923.4	8680575	1557.737	E	320	575752.3	8680251	1557.407	E
222	575911.3	8680581	1557.672	E	321	575766.6	8680192	1557.296	E
223	575900.8	8680585	1557.623	E	322	575759.6	8680194	1557.196	E
224	575894.5	8680589	1557.587	E	323	575752.5	8680196	1557.092	E
225	575928	8680529	1558.076	E	324	575745.9	8680198	1557.003	E
226	575904.9	8680539	1557.983	E	325	575734.6	8680202	1556.846	E
227	575911	8680536	1558.014	E	326	575742.5	8680199	1556.955	E
228	575920	8680531	1558.05	E	327	575741.1	8680200	1556.936	E
229	575913.9	8680534	1558.027	E	328	575731	8680202	1556.793	E
230	575895.3	8680541	1557.947	E	329	575733.1	8680202	1556.825	E
231	575903.5	8680539	1557.976	E	330	575724	8680204	1556.694	E
232	575896.8	8680541	1557.953	E	331	575715.1	8680206	1556.567	E
233	575891	8680543	1557.927	E	332	575710.4	8680208	1556.503	E
234	575884	8680546	1557.863	E	333	575692.6	8680160	1555.723	E
235	575875.3	8680549	1557.792	E	334	575695.8	8680158	1555.749	E
236	575873.1	8680549	1557.773	E	335	575706.1	8680154	1555.862	E
237	575910.1	8680494	1558.239	E	336	575712.3	8680153	1555.95	E
238	575887	8680504	1558.132	E	337	575715.8	8680154	1556.014	E
239	575891.5	8680502	1558.168	E	338	575725.5	8680152	1556.148	E
240	575896.5	8680499	1558.192	E	339	575724.1	8680152	1556.132	E
241	575905.5	8680496	1558.219	E	340	575717.3	8680153	1556.035	E
242	575877.4	8680506	1558.059	E	341	575727.5	8680152	1556.183	E
243	575885.7	8680504	1558.12	E	342	575730.5	8680150	1556.21	E
244	575879.1	8680506	1558.069	E	343	575738.3	8680148	1556.307	E
245	575873.1	8680508	1558.025	E	344	575744.9	8680146	1556.394	E
246	575861.5	8680513	1557.929	E	345	575749.5	8680145	1556.446	E
247	575855.2	8680515	1557.88	E	346	575744.4	8680111	1555.867	E
248	575868.3	8680511	1557.98	E	347	575737.8	8680111	1555.758	E
249	575882.3	8680439	1558.448	E	348	575728.8	8680112	1555.611	E
250	575877.2	8680442	1558.403	E	349	575724.6	8680112	1555.54	E
251	575867.7	8680445	1558.327	E	350	575719.3	8680112	1555.441	E
252	575857.1	8680449	1558.241	E	351	575710.9	8680112	1555.292	E
253	575850.6	8680451	1558.188	E	352	575717.8	8680112	1555.413	E
254	575858.4	8680448	1558.253	E	353	575709.5	8680112	1555.274	E
255	575849.1	8680451	1558.177	E	354	575700.1	8680114	1555.131	E
256	575841.6	8680454	1558.113	E	355	575689.9	8680116	1554.981	E
257	575836.1	8680457	1558.066	E	356	575685.9	8680117	1554.937	E
258	575828.9	8680459	1558.008	E	357	575695	8680115	1555.065	E
259	575844.8	8680453	1558.14	E	358	575714.2	8680070	1554.71	E
260	575841.8	8680415	1558.31	E	359	575706	8680071	1554.571	E
261	575834.3	8680419	1558.249	E	360	575712.8	8680070	1554.687	E
262	575840.5	8680416	1558.301	E	361	575704.5	8680071	1554.546	E
263	575832.7	8680419	1558.238	E	362	575717.6	8680069	1554.767	E
264	575827.7	8680423	1558.187	E	363	575723.2	8680069	1554.868	E
265	575819.4	8680426	1558.115	E	364	575728.8	8680069	1554.967	E
266	575815	8680429	1558.077	E	365	575733.4	8680069	1555.05	E
267	575811.1	8680429	1558.049	E	366	575736.4	8680068	1555.105	E
268	575844.3	8680414	1558.328	E	367	575696.4	8680072	1554.418	E
269	575851.3	8680410	1558.378	E	368	575687.1	8680073	1554.259	E
270	575856.8	8680408	1558.417	E	369	575680.9	8680074	1554.151	E
271	575860.7	8680405	1558.446	E	370	575712.9	8680039	1553.953	E
272	575817.5	8680370	1558.205	E	371	575706.1	8680038	1553.798	E
273	575821.1	8680368	1558.231	E	372	575704.6	8680038	1553.769	E
274	575816.1	8680370	1558.195	E	373	575714.4	8680038	1553.978	E
275	575808.4	8680373	1558.14	E	374	575720.1	8680038	1554.073	E
276	575823.8	8680367	1558.251	E	375	575729.4	8680038	1554.255	E
277	575829.3	8680364	1558.292	E	376	575732.3	8680038	1554.313	E
278	575833.6	8680361	1558.325	E	377	575738.5	8680038	1554.436	E
279	575836.8	8680359	1558.349	E	378	575701.3	8680038	1553.707	E
280	575809.7	8680373	1558.149	E	379	575696.7	8680038	1553.613	E
281	575804.4	8680375	1558.111	E	380	575688.8	8680038	1553.478	E
282	575791.7	8680380	1558.022	E	381	575685.4	8680038	1553.409	E
283	575787	8680382	1557.989	E	382	575679.5	8680038	1553.277	E
284	575797.4	8680377	1558.063	E	383	575716.1	8680003	1553.078	E
285	575813.5	8680309	1558.245	E	384	575707.8	8680003	1552.898	E
286	575790.6	8680319	1558.071	E	385	575714.6	8680003	1553.041	E
287	575783.1	8680323	1558.015	E	386	575718.8	8680004	1553.145	E
288	575789.3	8680320	1558.061	E	387	575723.3	8680003	1553.217	E
289	575781.6	8680323	1558.004	E					
290	575776.2	8680325	1557.964	E					
291	575770.1	8680327	1557.899	E					
292	575764.2	8680330	1557.817	E					
293	575760.4	8680332	1557.765	E					
294	575796.6	8680317	1558.116	E					
295	575805.7	8680312	1558.186	E					
296	575810.3	8680310	1558.221	E					
297	575802.5	8680314	1558.161	E					

Appendix 13. Chilerawalanda Topographic Survey data (3)

POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI
388	575730.4	8680002	1553.346	E	487	575769.5	8679540	1531.201	E
389	575738	8680001	1553.484	E	488	575763.2	8679540	1530.925	E
390	575741.3	8680002	1553.558	E	489	575756	8679539	1530.599	E
391	575706.3	8680003	1552.861	E	490	575747.9	8679539	1530.275	E
392	575703	8680003	1552.792	E	491	575783.3	8679540	1531.688	E
393	575695.1	8680003	1552.645	E	492	575793.6	8679541	1532.027	E
394	575687.5	8680003	1552.482	E	493	575797.5	8679541	1532.147	E
395	575682.9	8680002	1552.371	E	494	575803	8679542	1532.407	E
396	575685.4	8679953	1551.076	E	495	575782.4	8679467	1526.46	E
397	575689.5	8679953	1551.161	E	496	575775.6	8679467	1526.221	E
398	575702.7	8679952	1551.428	E	497	575783.9	8679468	1526.536	E
399	575705.7	8679952	1551.489	E	498	575774.1	8679467	1526.17	E
400	575710.5	8679955	1551.685	E	499	575765.4	8679468	1525.816	E
401	575718.8	8679956	1551.877	E	500	575754.8	8679468	1525.404	E
402	575712	8679955	1551.72	E	501	575750.9	8679468	1525.204	E
403	575720.2	8679956	1551.918	E	502	575788.1	8679468	1526.678	E
404	575723.1	8679956	1551.975	E	503	575796.8	8679468	1526.967	E
405	575733	8679956	1552.2	E	504	575805.1	8679468	1527.258	E
406	575742.9	8679957	1552.435	E	505	575772.9	8679411	1521.899	E
407	575737.1	8679957	1552.307	E	506	575766.4	8679413	1521.727	E
408	575705.5	8679955	1551.576	E	507	575764.9	8679414	1521.694	E
409	575700.2	8679955	1551.452	E	508	575774.4	8679411	1521.921	E
410	575695.8	8679954	1551.334	E	509	575779.6	8679410	1522.014	E
411	575692.5	8679954	1551.258	E	510	575791.1	8679405	1522.136	E
412	575724.2	8679906	1550.206	E	511	575794	8679405	1522.196	E
413	575717.5	8679905	1549.997	E	512	575795.6	8679404	1522.201	E
414	575725.7	8679906	1550.242	E	513	575759.6	8679414	1521.518	E
415	575715.9	8679905	1549.97	E	514	575754.1	8679415	1521.327	E
416	575713.5	8679903	1549.853	E	515	575747	8679416	1521.07	E
417	575707	8679904	1549.717	E	516	575743.5	8679417	1520.99	E
418	575696.2	8679904	1549.445	E	517	575741.6	8679417	1520.939	E
419	575692.5	8679902	1549.304	E	518	575797.2	8679399	1521.886	E
420	575728.4	8679906	1550.312	E	519	575825.7	8679392	1522.481	E
421	575741.8	8679906	1550.628	E	520	575852.4	8679387	1523.156	E
422	575748.8	8679906	1550.811	E	521	575838.4	8679469	1528.553	E
423	575735.1	8679906	1550.482	E	522	575860.8	8679475	1529.706	E
424	575753.5	8679872	1549.591	E	523	575725.4	8679422	1520.584	E
425	575748.5	8679871	1549.446	E	524	575705	8679425	1519.868	E
426	575741.6	8679870	1549.245	E	525	575682.2	8679430	1519.244	E
427	575736.9	8679870	1549.1	E	526	575692.3	8679478	1523.463	E
428	575733.9	8679870	1549.022	E	527	575728.8	8679468	1524.263	E
429	575729.5	8679870	1548.943	E	528	575727.9	8679532	1528.929	E
430	575728.1	8679870	1548.89	E	529	575694.9	8679534	1527.793	E
431	575721.3	8679870	1548.708	E	530	575815.1	8679538	1532.483	E
432	575719.7	8679870	1548.669	E	531	575856.6	8679544	1534.232	E
433	575717.3	8679869	1548.59	E	532	575869.1	8679621	1539.462	E
434	575710.8	8679869	1548.399	E	533	575812.6	8679619	1537.802	E
435	575702.6	8679868	1548.161	E	534	575836.3	8679625	1538.794	E
436	575699.3	8679867	1548.061	E	535	575722.8	8679611	1534.428	E
437	575696.3	8679867	1547.985	E	536	575679.6	8679610	1532.797	E
438	575734.3	8679828	1547.418	E	537	575675.4	8679672	1536.838	E
439	575724.5	8679827	1547.117	E	538	575687.3	8679681	1537.862	E
440	575732.8	8679828	1547.368	E	539	575712.7	8679684	1538.871	E
441	575725.9	8679828	1547.172	E	540	575800.7	8679700	1542.507	E
442	575718.8	8679827	1546.955	E	541	575822.7	8679700	1543.006	E
443	575708.5	8679827	1546.663	E	542	575855.8	8679705	1544.029	E
444	575700.5	8679825	1546.382	E	543	575821	8679808	1548.303	E
445	575738.3	8679829	1547.542	E	544	575792.3	8679800	1547.404	E
446	575748	8679828	1547.786	E	545	575783.8	8679787	1546.607	E
447	575753.7	8679829	1547.956	E	546	575687.3	8679781	1543.644	E
448	575758.1	8679830	1548.129	E	547	575638.6	8679767	1541.272	E
449	575742.2	8679783	1545.32	E	548	575668.6	8679776	1542.828	E
450	575740.8	8679783	1545.261	E	549	575629.6	8679819	1543.931	E
451	575734	8679782	1545.019	E	550	575666.9	8679828	1545.606	E
452	575732.5	8679782	1544.971	E	551	575773.6	8679831	1548.571	E
453	575729.3	8679781	1544.823	E	552	575799.9	8679842	1549.42	E
454	575717.6	8679780	1544.416	E	553	575836.3	8679896	1551.918	E
455	575710.7	8679778	1544.137	E	554	575781.2	8679880	1550.502	E
456	575744.8	8679784	1545.409	E	555	575765.2	8679877	1550.083	E
457	575753.1	8679784	1545.677	E	556	575799	8679885	1550.993	E
458	575758.2	8679784	1545.833	E	557	575669.5	8679868	1547.322	E
459	575766.1	8679786	1546.131	E	558	575633.9	8679867	1546.2	E
460	575760.6	8679695	1541.153	E	559	575620.3	8679904	1547.359	E
461	575752.4	8679694	1540.814	E	560	575661.9	8679901	1548.508	E
462	575759.2	8679694	1541.076	E	561	575639.9	8679904	1547.989	E
463	575750.9	8679694	1540.753	E	562	575773.6	8679913	1551.626	E
464	575747.5	8679693	1540.628	E	563	575819.8	8679920	1552.567	E
465	575740.1	8679692	1540.279	E	564	575799	8679917	1552.144	E
466	575734	8679690	1539.97	E	565	575755	8679967	1552.956	E
467	575727.4	8679689	1539.682	E	566	575803.3	8679967	1553.732	E
468	575762.7	8679696	1541.258	E	567	575823.6	8679964	1553.929	E
469	575772	8679696	1541.592	E	568	575665.3	8679948	1550.489	E
470	575778.6	8679697	1541.83	E	569	575636.5	8679949	1549.708	E
471	575784.1	8679698	1542.019	E	570	575611.4	8679997	1550.353	E
472	575772.2	8679617	1536.597	E	571	575666.9	8679996	1551.851	E
473	575765.4	8679616	1536.314	E	572	575638.2	8679996	1551.13	E
474	575773.7	8679617	1536.658	E	573	575753.3	8680003	1553.843	E
475	575763.9	8679617	1536.273	E	574	575791.4	8680004	1554.489	E
476	575756.9	8679616	1535.993	E	575	575823.6	8680007	1554.948	E
477	575743.6	8679615	1535.44	E	576	575752.5	8680038	1554.708	E
478	575738.9	8679614	1535.203	E	577	575777	8680042	1555.26	E
479	575775.6	8679617	1536.718	E	578	575795.6	8680045	1555.524	E
480	575786.3	8679617	1536.968	E	579	575659.3	8680043	1553.028	E
481	575789.6	8679617	1537.083	E	580	575619.5	8680042	1551.928	E
482	575797.6	8679618	1537.326	E	581	575617.8	8680073	1552.664	E
483	575779.4	8679617	1536.799	E	582	575644.1	8680073	1553.358	E
484	575777.7	8679540	1531.515	E	583	575658.5	8680075	1553.758	E
485	575770.9	8679540	1531.269	E	584	575753.3	8680064	1555.359	E
486	575779.3	8679540	1531.563	E	585	575779.6	8680072	1555.905	E

Appendix 14. Chilerawalanda Topographic Survey data (4)

EASTING	NORTHING	HEIGHT	DESCRIPTI	POINT	EASTING	NORTHING	HEIGHT	DESCRIPTI
575810.5	8680074	1556.249	E	685	575857.4	8680570	1557.523	E
575755.8	8680116	1556.143	E	686	575864.2	8680653	1556.937	E
575782.9	8680110	1556.461	E	687	575889.6	8680609	1557.413	E
575782.9	8680110	1556.461	E	688	575893	8680675	1556.901	E
575666.1	8680113	1554.522	E	689	575902.3	8680650	1557.133	E
575629.7	8680119	1553.779	E	690	575866.8	8680625	1557.168	E
575631.4	8680168	1554.673	E	691	575835.4	8680582	1557.308	E
575664.4	8680157	1555.214	E	692	575910.8	8680633	1557.276	E
575675.4	8680156	1555.383	E	693	575914.8	8680719	1556.566	E
575643.2	8680164	1554.887	E	694	575944.7	8680672	1557.022	E
575761.8	8680149	1556.713	E	695	575932	8680697	1556.783	E
575773.6	8680140	1556.793	E	696	575966.7	8680741	1556.482	E
575783.8	8680139	1556.862	E	697	575986.1	8680702	1556.847	E
575819.5	8680132	1557.105	E	698	575978.5	8680725	1556.64	E
575780.4	8680190	1557.451	E	699	576008.2	8680768	1556.337	E
575804.1	8680184	1557.616	E	700	576027.6	8680721	1556.711	E
575814.3	8680178	1557.665	E	701	576015.8	8680745	1556.527	E
575824.4	8680173	1557.686	E	702	576044	8680799	1556.061	E
575698.3	8680212	1556.346	E	703	576069.1	8680747	1556.46	E
575641.3	8680228	1555.488	E	704	576051.3	8680773	1556.27	E
575665.3	8680222	1555.909	E	705	576088.6	8680807	1555.972	E
575673.7	8680285	1556.486	E	706	576117.4	8680773	1556.224	E
575700.8	8680268	1556.757	E	707	576104.7	8680796	1556.052	E
575711.8	8680262	1556.878	E	708	576137.7	8680831	1555.74	E
575795.6	8680235	1557.807	E	709	576166.9	8680779	1556.063	E
575816.8	8680227	1557.933	E	710	576152.9	8680808	1555.884	E
575849	8680215	1558.136	E	711	576165.6	8680845	1555.573	E
575807.5	8680271	1558.076	E	712	576202	8680820	1555.666	E
575834.6	8680259	1558.225	E	713	576182.6	8680824	1555.69	E
575861.8	8680250	1558.396	E	714	576163.1	8680794	1555.959	E
575700.8	8680328	1556.964	E	715	576235.9	8680869	1555.247	E
575727.9	8680311	1557.332	E	716	576247.8	8680846	1555.382	E
575714.4	8680366	1557.148	E	717	576262.2	8680899	1554.979	E
575739.8	8680349	1557.482	E	718	576297	8680850	1555.171	E
575760.4	8680332	1557.765	E	719	576266.4	8680891	1555.014	E
575832	8680300	1558.388	E	720	576317.2	8680927	1554.642	E
575861.7	8680296	1558.596	E	721	576338.4	8680890	1554.792	E
575881.9	8680288	1558.71	E	722	576266.4	8680891	1555.014	E
575881.9	8680288	1558.71	E	723	576324.8	8680907	1554.737	E
575895.5	8680246	1558.617	E	724	576278.2	8680872	1555.1	E
575864.2	8680200	1558.198	E	725	576348.5	8680951	1554.415	E
575854.1	8680155	1557.707	E	726	576358.7	8680922	1554.55	E
575845.6	8680104	1556.988	E	727	576384.9	8680968	1554.219	E
575841.4	8680075	1556.58	E	728	576396.8	8680935	1554.343	E
575837.1	8680058	1556.287	E	729	576408.6	8680988	1554.04	E
575844.7	8680156	1557.646	E	730	576424.8	8680939	1554.222	E
575816.5	8680124	1556.968	E	731	576431.5	8681007	1553.878	E
575923.5	8680206	1558.501	E	732	576444.2	8680984	1553.95	E
575892.2	8680172	1558.245	E	733	576418.8	8680972	1554.087	E
575901.5	8680210	1558.479	E	734	576385.8	8680950	1554.309	E
575855.8	8680354	1558.486	E	735	576354.4	8680935	1554.488	E
575893.9	8680333	1558.77	E	736	576459.4	8681029	1553.708	E
575911.6	8680322	1558.809	E	737	576477.2	8680994	1553.803	E
575882	8680407	1558.582	E	738	576462	8681012	1553.769	E
575908.2	8680384	1558.703	E	739	576531.4	8680918	1553.893	E
575928	8680375	1558.743	E	740	576543.2	8680896	1553.923	E
575898.1	8680438	1558.526	E	741	576550.9	8680882	1553.935	E
575917.6	8680423	1558.628	E	742	576497.5	8680899	1554.115	E
575954	8680402	1558.731	E	743	576514.5	8680863	1554.175	E
575920.1	8680493	1558.259	E	744	576518.7	8680856	1554.183	E
575944.7	8680473	1558.396	E	745	576475.5	8680880	1554.289	E
575969.4	8680456	1558.519	E	746	576486.5	8680850	1554.367	E
575945.5	8680521	1558.14	E	747	576489.9	8680841	1554.388	E
576004.8	8680487	1558.405	E	748	576442.5	8680862	1554.515	E
575951	8680567	1557.833	E	749	576450.1	8680833	1554.611	E
575986.1	8680539	1558.096	E	750	576460.3	8680818	1554.63	E
575995.5	8680535	1558.14	E	751	576411.2	8680836	1554.781	E
575994.6	8680592	1557.722	E	752	576417.9	8680823	1554.815	E
576009.8	8680560	1557.975	E	753	576426.4	8680802	1554.871	E
576032.7	8680603	1557.624	E	754	576387.5	8680823	1554.964	E
576053.7	8680574	1557.783	E	755	576394.2	8680796	1555.071	E
576053	8680636	1557.348	E	756	576401	8680785	1555.087	E
576070.8	8680609	1557.507	E	757	576357.8	8680806	1555.196	E
576097.1	8680661	1557.105	E	758	576363.8	8680780	1555.312	E
576137.4	8680622	1557.285	E	759	576370.5	8680766	1555.353	E
576132.2	8680699	1556.76	E	760	576301.6	8680782	1555.573	E
576147.9	8680671	1556.909	E	761	576307.9	8680763	1555.657	E
576126.7	8680674	1556.966	E	762	576307.9	8680763	1555.657	E
576111.4	8680625	1557.327	E	763	576311.3	8680752	1555.704	E
576171.6	8680692	1556.666	E	764	576332.2	8680719	1555.788	E
576191.9	8680670	1556.745	E	765	576322.4	8680795	1555.406	E
576206.3	8680704	1556.459	E	766	576343.4	8680753	1555.548	E
576245.3	8680675	1556.509	E	767	576348.5	8680746	1555.565	E
576255.4	8680735	1556.079	E	768	576234.2	8680699	1556.393	E
576285.9	8680706	1556.102	E					
576281.8	8680771	1555.73	E					
576317.2	8680742	1555.733	E					
575735.5	8680412	1557.41	E					
575760.9	8680393	1557.733	E					
575776.2	8680388	1557.911	E					
575765.2	8680454	1557.59	E					
575795.6	8680436	1557.917	E					
575781.2	8680494	1557.54	E					
575801.6	8680475	1557.76	E					
575788	8680456	1557.769	E					
575809.2	8680548	1557.406	E					
575834.6	8680529	1557.685	E					
575855.2	8680515	1557.88	E					
575832.9	8680601	1557.155	E					

MZUZU UNIVERSITY

PRIVATE BAG 201

LUWINGA

MZUZU

ROAD TRAFFIC ACCIDENT QUESTIONNAIRE

NEXUS OF HUMAN FACTOR AND ROAD GEOMETRICS ON TRAFFIC ACCIDENTS ON MZUZU-JENDA M1 ROAD STRETCH

Program: Masters of Science in Geoinformatics

Name of the Researcher: Japhet Khendlo

Email: jkhendlo@yahoo.com

Cell: 0881265802/0992600143

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

i. I agree to participate in the research study.

☐ **Yes** ☐ **No**

ii. I understand the purpose and nature of this study and I am participating voluntarily.

☐ **Yes** ☐ **No**

iii. I grant permission for the data generated from this interview to be used in the researcher's publications

☐ **Yes** ☐ **No**

Title: ……………………………………………

Age………………………………

Sex ☐ Male ☐ Female

Marital Status ……………………………….

Occupation ☐ Driver ☐ Other

<u>Part B Accident details</u>

Date of the Accident……………………….

Time of the Accident ☐ AM ☐ PM

What type of the vehicle were you driving?

☐ Truck ☐ Bus ☐ Tax ☐ Heavy duty vehicle

Which locations have been involved in accident on?

☐ Ruviri Champhira ☐ Chirelawalanda ☐ Champhira ☐

☐ Mapanjira ☐ Kasitu

What was the condition of the road at the time of accident?

☐ Dry ☐ Wet ☐ Rainy ☐ Other

What was the traffic condition at the time of accident?

☐ Light ☐ Moderate ☐ Heavy

What was the road visibility condition at the time of the accident?

☐ Clear ☐ adequate ☐ fair ☐ poor

☐ Full daylight ☐ Dim dark

What was your location inside the vehicle at the time of accident?

☐ Driver ☐ Passenger ☐ in-front seat

Your Vehicle was travelling at approximately

☐ Km/hr ☐ Unknown

Do you often drive along this section of M1road?

☐ Yes ☐ No

Was your vehicle COF expired or not at the time of the accident?

☐ Yes ☐ No

Do you often drive at high speed on the rumble stripes?

☐ Yes ☐ No

If Yes, why?

☐ Familiar with the road section

☐ Rumbles stripes irritates

☐ The Car jerks a lot