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Integrating Institutional Framework, Traffic Calming Measures, Human Culture and Enforcement Cameras for Reducing Road Accidents 'Case Study - Mbeya City, Tanzania'

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Abstract: *Road accidents threat lives of many people and properties everywhere in the world. When this problem prevails, prediction studies conducted suggest that the number of death and fatal events caused by road accidents keep increasing in the areas where appropriate measures are either not taken at all, or, are taken slowly. This paper conducted conversation studies with traffic police in Mbeya City and had come- up with the preliminary findings for road accident occurrence. The two black spot stretches identified are the Jakaranda and the stretch from Mafiati to Ituta. The preliminary results helped to conduct an in-depth study on Traffic Culming Measures (TCMs) within these stretches. It was identified that TCMs' elements (space, height and width) were not secured as per specifications. This result created a need to review and evaluate more literatures on: TCMs, institutional framework on road safety, human culture and enforcement cameras. Evaluation information from these parameters, coupled with the experience practiced elsewhere helped to formulate an integrative model to reduce road accident. This model has four parameters: institutional framework on road safety, TCMs, human culture and enforcement cameras. The road regulators and implementers are urged to implement the model since it has implications of use in Tanzania and in other developing countries.*

Key words*: Institutional framework, Enforcement cameras, culture, TCMs, Road accidents.*

I. Introduction and Back Ground Information

Road accidents threat lives of many people and properties. In the year 2004 for example, World Health Organization (WHO) 's report alerted that, worldwide, about 1.2 million persons were killed on the road and an addition of 20-50 million were injured; further indicating that road traffic deaths accounted for 23% of all injury deaths worldwide (WHO, 2004). The study then predicted a 67% increase in road traffic accident mortality in overall global by 2020 if appropriate action would not be taken. With the view, Bishop et al., (2013) explain that Sub-Saharan Africa has some of the most dangerous roads in the world with a total of fatality rate of 28.3% per 100000 people. In Tanzania's context, in two wards in Dar es Salaam, predominant road accident events are reported, whereby; children are mostly affected group (Aloyce, 2010; Zimmermana et al., 2011). In addition, traffic police report the specified years to which fatal road accidents had occurred recently, where numbers are placed in the brackets as follow: in 2013 (4002), in 2014 (3760), and in 2015 (3468) (SUMATRA, 2017). This intensive study (i.e. SUMATRA, 2017) maintains that the country being characterized by a low level of road safety activities, the problem remain as compared to better performing countries.

Road accidents have negative implications, including: (i) causes deaths to the innocent people (ii) loose of property – a damaged car or house, road furniture etc. (iii) injured people suffer with pains (iv) loosing time and money resource during treatment and burials and (v) psychological effect to the affected groups, amongst others. As a result, overall nation economy is affected.

While problem of road accidents exist, some specific models that help to alleviate the situation exist in the literature. They include: installation of road cameras to discipline over-speeding and overtaking drivers (DfT, 2003; Boos, 2009; Al Darei, 2009), enforcing road laws and policies on road operations (Saito et al., 2017; Bishop et al., 2013, Gana and Emmanuel, 2014); effective utilization of the TCMs (Vaitkus et al., 2017; Vanderschuren and Jobanputra, 2009); and study of human culture on road users (Elsland et al., 2009; Cooper and Psychol, 2002). Although each specified model solved a specified problem on a characterized environment, it may need adaption in new place. Moreover, these models are not integrated together; therefore, some weaknesses may not be capitalized by the strengths within the models. For these reasons, a combined road safety attribute managements may not been: developed, implemented, shared and benefited.

Several efforts were already tried by some stakeholder groups to reduce road accident problems in the country. They include: establishing and committing a week of safety drive 'Wiki Ya Nenda Kwa Usalama' that educate/remind road users to adhere to the road guidelines and regulations; Police and other stakeholders provide lessons to the public through Radios and Televisions on appropriate ways of using road facility; mandated organs continue insisting drivers to upgrade their driving skills; re-registration of the driver licenses; giving penalty to drivers who offence the laws, amongst others. Despite these efforts, road accidents still persist. In order to strengthen these efforts; this study develops an integrated model with four parameters: Institutional framework on road safety, TCMs, Human Culture and the enforcement cameras to help reduce road accidents in Tanzania.

This paper is organized into five sections. Whereas section one describes introduction to the study, section two outlines the methods adopted. Section three discusses the relevant literature. Section four presents study findings and develops an integrative model. Finally, section five presents the conclusions and recommendations.

II. Methodology

In order to come-up with a replicate research result, in 2015, researchers interviewed road traffic polices in Mbeya City to ascertain road accident events as the preliminary study findings. These findings identified two black spot stretches which are road stretch from Mafiati to Ituta – 9 km and a Jakaranda road - 6 km. Causes of accidents in these stretches were identified to be caused by: high speed vehicles, negligence by the road users, negligence by the road law enforcers, road users' failure to conform to by-laws, fault vehicles, fatigue of drivers, drunk, overloaded tracks etc. Persistence of these problems is also supported by other authors (Mathew, 2014; SUMATRA, 2017). As for this, in-depth studies of TCMs within these two road stretches were conducted. The study findings, in line with other factors: institutional framework, culture and road cameras enforcement helped to develop an integrative model to reduce road accidents in Mbeya City, Tanzania.

III. Review And Evaluation Of The Literature

Review work was organized into four sub-sections, namely: (i) institutional framework on road safety, TCMs, human culture and enforcement cameras. They are described as follows.

Institutional Framework and Road Traffic Laws

Definition

According to a guideline prepared by Asian Development Bank ADB on 'Coordination and Management of Road Safety', road safety is regarded as the multidimensional social problem involving many government agencies, so the specified country must play a leading role in initiating, organizing and coordinating the national assault on road safety problems in the country (ADB, 1996; ADB, 2012).

Elements of Institutional Framework and Functionalities

The institution framework has five important aspects that provide overall guide to a road safety activity (ADB, 1996, pp 58, 4.1-1): (i) definition of responsibility (ii) assigning the task to initiate and coordinate the state's action (iii) setting up a permanent group to steer the actions, e.g. National Road Safety Council (NRSC) (iv) planning and assigning adequate technical and financial resources for the NRSC to carry out its tasks and (v) evaluation of the outcomes. The institution framework on road safety has the benefits that, when properly used, it provides overall control of all road safety matters in the country (Ijjasz, 2008).

Traffic Calming Measures

Traffic Calming Measures are the physical measures provided on the road surfaces for easily seen and use by the motorist; thereby, reducing the applied speeds. A TCM can be easily seen by the motorist if a visual road sign is well planned, designed, prepared and secured on a right destination. They appear on various categories, three of them (speed hump, speed bump and rumble strip) are briefly presented under the perspectives of functions, sizes, placements and maintenances. Descriptions follow:

Speed Humps

Speed hump is a raised area in the pavement surface extending transversely across the travel way. They are generally used on residential local streets, where, around these areas typical operational speed vehicles slow down to about 24 - 32km/h; where in, depending on the residents' activities, the humps are properly spaced (Massachusetts Highway Department, 2006; Metzger, 2008). Standard circular road humps in Tanzania are 100mm high with standard lengths of 4.0m and 9.5m for speed limits of 30km/h and 50km/h respectively. It is also accepted that other sizes may be adopted depending on site conditions (Mow, 2011). The road humps are recommended not to be closer than 20m apart and also not placed on a vertical curve less than the safe stopping site distance (MoW, 2011).

Speed Bumps

Speed bumps are abrupt features that rise and fall 75mm to 100mm over a span of 350mm to 1m. Bumps have comfortable crossing speeds of 8kph or less, which relegates them to parking lots and private driveways as opposed to public roadways with their higher posted speed limits. Their low design speeds may delay emergency vehicles; thus, causing serious injury or loss of life (Massachusetts Highway Department, 2006). Road bumps are 75mm-100mm high and 300mm-900mm long (Mow, 2011).

Rumble Strips

Rumble strips are transverse strips across the road. They create a vibratory and audible effect and are used to alert and warn drivers with high speed when approaching sharp bend, or intersections or a big change in the roadway. Each strip is marked with yellow thermoplastic lines across the top for better visibility. They are restricted of use in high-hazard locations, such as isolated high-volume, rural intersections, amongst others (Massachusetts Highway Department, 2006). Rumble strips usually have a rounded profile, a maximum height of 15mm and are installed in groups of four in number (Mow, 2011). The standard layout comprises of three groups of strips, the first pair 90m apart and the second pair 60m apart. Where approach speeds are less than 80km/h, the number of groups can be reduced to two or one.

The aforementioned TCMs are placed in the areas of huge traffic volume, example, at a place with multifunction society activities such as schools, dispensary, living areas, amongst others. They are provided with recommended sizes to accommodate specified speeds of the vehicles. For the TCM to be used and achieve a purpose, recommendation requirements must be met. The drivers are assisted to meet a need of reducing speeds as he tend to be informed on availability of the TCM through a well designed, planned, placed road signal(s) that are viewed in positions.

Culture: Definition and Layers of Culture

Definitions

The term 'culture' has many definitions: it is the way people behave, the way they work, speak or interact with others (Hofstede, 1990). It has some elements that are in-built into human and other elements that are learned. That is, an individual may inherent an in-born culture, which he/she adopts on a day to day life. Such culture is in such a way that, it can be changed or shaped to fit to new surroundings or operative's requirements (Schein, 1997). Individuals on different working environments have norms, values and behaviour that can be shaped to meet the intended needs (Schein, 1990; Kettinger, et al., 1997); this may apply on the context of the road users.

Layers of Human Culture

Culture of the human being can be found in three layers (Hofstede, 1990; Schein, 1997), two of them are shortly described here for the sake of adoption in this study. They are briefly explained as follows:

(i) **Artifacts**: display things that: are on surface; can be seen, can be heard, one can feel, are visible, gives stories, manners of dressing, amongst others.

(ii) **Basic assumptions**: is a layer of culture that is most difficult to discern because it exist at largely unconscious level. In this layer, there are lots of hidden and unrecognizable issues that are difficult to predict (Hofstede, 1990).

The two layers of culture provide good lessons when viewing the two road users, a driver and a road police (law enforcer) negotiating an event in which a driver is claimed to break the road safety rule (e.g. over speeding) and a compromise is hard to reach.

Speed Cameras Installation

Long road routes (i.e. routes between districts, regions or even between countries) comprise combination of locations with huge human related activities that deserve provision of TCM to reduce road accidents (Vaitkus et al., 2017). On areas with little or no human activities, enforcement cameras are necessary to be installed to meet the same need of reducing accidents likely to be caused by over speeding cars. Since their introduction, enforcement cameras are consistently proven to be a successful method of reducing causalities on the roads (PCTS, 2003). In Singapore, enforcement cameras helped to reduce number of speeding-related accidents by 29.9%, to 762 in 2017, from 1087 accidents in 2016 (SPF, 2017). In the United Kingdom, the study of speed cameras across six areas found a 35% reduction in people killed and seriously injured at camera sites compared to before cameras are installed (PACTS, 2017). An evaluation of 28 camera sites in New South Wales, Australia found a reduction in fatalities from 21 in the three years before camera installation to 1 in the two years after installation (RTA, 2003). These facilities (road cameras) also create fairness environment to drivers violating the rules since all of their events are been captured, recorded and stored; this also maximizes revenue of the country.

Due to potentials on the need to utilize enforcement cameras, new implementers and drivers need to be familiarized with their operatives. In order to equip into a good way of implementing enforcement cameras, experience of countries implemented them is useful. Learning from Singapore, the motorists were kept aware of the cameras as some of them were painted in orange colour and more warning signs put-up before enforcement cameras zones begin (SPF, 2017).

Summary of the Reviewed Work

Four factors: institutional framework, TCMs, culture and enforcement cameras are reviewed and evaluated for the purposes of understanding specific concepts per a specified factor. It also integrated ideas within these factors to help formulate a tool to manage road safety. Institutional framework in Tanzania constitutes organs and responsibilities - NRSA, RRSA and DRSA amongst others that do not appropriately work in a collaborative manner (SUMATRA, 2017). This deficit can just be remedied since it is just a managerial tasks that adopt normal strategies. TCM elements need to be secured on their specified sizes (length, height and space) and positions as specified; in contrary, they may cause disturbances or even accidents. Inbuilt culture, e.g. basic assumption has hidden aspects that cannot be understood by other person(s); this concept needs to be understood, evaluated and remedial measure deployed on road safety context. Enforcement cameras provide evidences of the fault events caused by over speeding drivers; this helps to caught road law breaker, educate them, penalize them as necessary; thus, focus in reducing road accidents. A reviewed work on road cameras practiced elsewhere gives lessons to new users (such as road uses in Tanzania).

IV STUDY FINDINGS

Findings from a Survey

This study was aimed at reducing or curbing road accidents through developing an integrative model. The model developed has four parameters, institutional framework on road safety, TCMs, culture and enforcement cameras. Before discussing four parameters of the model, it is necessary to present preliminary data from police Mbeya, for prevalent of road accidents in studied road stretches in Mbeya City.

Information from Police Traffic

Conversation with police traffic in Mbeya city were conducted in 2015 and identified two black spot stretches that are: (i) stretch from Mafiati to Ituta [on Tanzam Highway] and (ii) a Jakaranda road stretch. Result also identified that, road accidents in Mbeya city persist due to a number of factors: high speed vehicles, negligence by the road users, negligence by the road law enforcers, road users' failure to conform to road traffic laws, fault vehicles, fatigue by long trip drivers, drunk, overloaded tracks amongst others. Information helped researchers to study further on TCMs on two selected road stretches, embed these concepts with human culture issues, institutional framework on road safety and enforcement cameras. Presentation of results come from evaluation of the literature and physical study conducted on two selected road stretches for TCMs; totality of information helps to develop an integrative model to reduce road accidents in Tanzania. Discussion of each element of the model follows.

Parameters to Reduce Road Accidents

Institutional Framework on Road Safety

SUMATRA (2017) identifies structure of institutional framework in the field of road safety in the country identifying as constituting three levels of operational, they include: National Road Safety Council (NRSC), Regional Road Safety Committees (RRSC) and District Road Safety Committees (DRSC) and also incorporates other stakeholders. The names and functionality of incorporated stakeholders are given in Table 1. Each of stakeholder group and the unique responsibility on road safety matters is defined.

Table1: Stakeholders forming Institutional framework on road safety in Tanzania

Stakeholders involvements	Responsibilities
Ministry of Home affairs and Traffic Police	This Ministry, through the Traffic Police is responsible for enforcement of traffic laws and regulations, annual vehicle inspection, and driver testing as well as licensing and supervision of driving schools.
Ministry of Works, Transport and Communication	Responsible to: prepare, monitor, evaluate and review the implementation of policies, legislations, regulations guidelines and standards, road safety education, road safety campaigns, etc.
SUMATRA	On which, amongst other roles, it also details accident investigation of bus crashes to better understand the causes.
TANTROADS	TANROADS has a Road Safety and Environment Unit that make sure roads are safe, e.g. they have two road safety engineers who review the design (of new road) - the implication being that these are not formal safety audits. In addition, each TANROADS Regional Office has a designated road safety focal person.
President's Office Regional Administration and Local Government Authorities	Responsible to oversee the function of the local government system. The local authorities such as city councils and districts are responsible for the management and maintenance of roads under care, erecting road furniture as well as regulating speed
The Ministry of Health, Community Development, Gender, Elderly and Children	Among many tasks, the ministry is responsible for all medical and emergency care.
Ministry of Finance and Planning	This Ministry, through the Tanzania Revenue Authority is responsible for vehicle registration and fees, collection of driver license fees and renewal of driving licenses amongst others
Insurance	The insurance companies are responsible for motor vehicle insurance and, in case of accidents, they compensate victims covered by the insurance.
Road users	Representatives of commercial road transporters such as The Tanzania Truck Owners Association (TATOA) and Tanzania Bus Operators Association (TABOA). It gives voice between the owners and the government and are represented on different boards, some of which engaging with safety matters.
NGOs	Other stakeholders include NGOs such as AMEND and Road Safety Ambassadors

The institutional framework on road safety in the country has weaknesses in that it lacks effective communication and collaboration between individual members (SUMATRA, 2017). This weakness can be removed when responsible organs takes action, for example NRSA exercising the power committed. The effective institutional framework would work since all road events that violate road rules the specified penalties are stipulated in the road traffic Act, 1973 (and it continue been re-amended). For example: driving a motor vehicle while under the influence of drink or drugs is explained in section 44; careless or inconsiderate use of the motor vehicle is explained in section 50; over speeding and or overtaking is explained in section 51 amongst others.

Traffic Culming Measures (TCMs)

TCMs were studied on two road stretches – Mafiati to Ituta and Jakaranda road in Mbeya City. Many TCM elements on both of these studied stretches were found unsuitable of use according to specification (Table 2). For example, spacing provided on Mafiati - Ituta road stretch at Chainage number 6+325 of rumble strip was oversize since it was 300 mm instead of 200 mm required in specification. When spacing is exceeded, it has effects, for example, on causing more discomfort to the vehicle users. This situation may force drivers to reduce speed on almost up to a zero rate, creating another burden of causing back collision. Exceeded spacing also creates trouble to small sized vehicles to pass on the humps. These vehicles, some cases tend to pass in a diagonal-crossing-way that may add-up chances of causing accidents), amongst others. TCMs secured as per specified standard was speed humps in Jakaranda road in 0+624 and 0+724 in which the heights were 6000mm that lie between standard size of 4000 – 9000 mm.

There were also a problem with invisibility; TCMs were placed on un-suitable locations that do not allow sufficient visibility to motor vehicle drivers. With these view, drivers approach TCMs suddenly, causing discomfort to the passengers and also deteriorate the property. Other TCM's elements were already been worn out; needing maintenances, but, that was not done. The results of the existing sizes of the TCM elements (height, length and spacing) on two road stretches together with their specified standards are given in Table 4.2. Researchers have views that, responsible organ need to oversee these TCM and initiate a needful continuous monitoring.

The institutional framework through its element (TANROADS) or Local Government Authorities (district councils, cities etc) should ensure the TCMs are as per specified standards and are continuing to be undertaken maintenances.

Table 2: Current Performance of TCM in four studied stretches

Road	TCM	Chainage	Height (mm)		Length (mm)		Spacing (mm)	
			Existing	Standard	Existing	Standard	Existing	Standard
Mafiati - Ituta	Rumble strips	3+256	18	15	294	200	280	200
	Rumble strips	6+325	24	15	200	200	300	200
Jakaranda road	Speed hump	0+624	100	75-100	6000	4000-9000	-	-
	Speed hump	0+724	100	75-100	6000	4000-9000	-	-

Human Culture

The two layers (artifacts and basic assumptions) are considered on application to road safety on a side of the driver and the traffic police. For example, a driver violating the road law, 'over speeding or overtaking on a restricted area' but refuse to obey the rule to a traffic police. Or, a traffic policy is not sure that the said driver had exceeded speed limit but he/she tries to guess and forcing his attempt to be true, or, conducting over-inspection of a vehicle for the purposes of creating bribery environment; or on anyhow, becoming biased leading to violation of the road rules. In such cases, on surface layer of culture concept helps to visualize the open behaviours of the respective parties, although, no a witness party to resolve the problem if arose. On the other hand, the basic assumption culture concept on these two individuals cannot be seen or understood. This may cause consequences, driver continue violating the road rules, or traffic continuing stand on biased side, dissatisfying potential stakeholders such as government and citizens. The integrated factors, for example, 'deploying enforcement cameras' eliminates this hidden assumption attribute, as images of the over-speeding vehicles would be captured and stored automatically by a camera. These also creates fairness to all drivers and maximize revenues to the government since all drivers continue violating the rules would be captured and recorded in automated way.

Lessons for Enforcement Cameras

Lessons for application of the enforcement cameras from elsewhere are presented in Table 3. Information is presented through the use of four indicators: camera types, potentials, operation and costs. Indicators were selected and discussed to give lessons and motivate young country such as Tanzania to deploy enforcement cameras to reduce road accident events.

Table 3: Enforcement Cameras (Lessons from elsewhere) for Benchmarking Purposes

Indicators	Aspects of enforcement cameras as lessons
Camera types	They are of different types, but commonly used are: fixed, mobile and varied speed (Tang, 2017).
Camera use potentials	It is evident that enforcement cameras: (i) reduce road accidents that cause casualties and deaths (ii) create no biased because drivers are warned before reaching enforcement camera area and camera installed are automated, they thus capture car images and store them for references and (iii) all speed violation drivers become responsible for paying fines, this raise nation revenue of the country [this is different to a tradition system where only some violation drivers are captured] (Owen *et al.*, 2016, Tang, 2017; ROSPER, 2018)
Camera operations	Lessons from UK (Tang 2017) for example, cameras are typically enforced by safety camera partnership, a joint collaboration of: police force, local government, highway agency and health authorities. Area to fix the camera follow a given criteria (DfT, 2004): one that is huge kill and injury site, more than 29% of driver events exceed speed limit, amongst others. A warning is introduced on approaching site to remind drivers on camera fixed ahead.
Camera costs	Cost considered relate with purchasing, installing, operating and maintenance. For Traffic light camera, the average fixed cost per traffic light site was just £9,200 and average recurrent costs were over £5,600 per annum for each site; the average fixed cost per site for a speed camera was £12,500 and average recurrent costs were £8,500 per annum for each site (Hooke *et al.*, 1996)

Integrative Model Development

The organizations that have been successful in reducing road accidents are those that applied holist structure on road safety improvement. The integrative model to reduce road accidents in this study comprise of four parameters: institutional framework for road safety, TCMs, Culture and enforcement cameras. The four elements of integrative model is presented in Figure 1. Consequently, questions and suggested solutions on how to use the developed model are outlined in Figure 2.

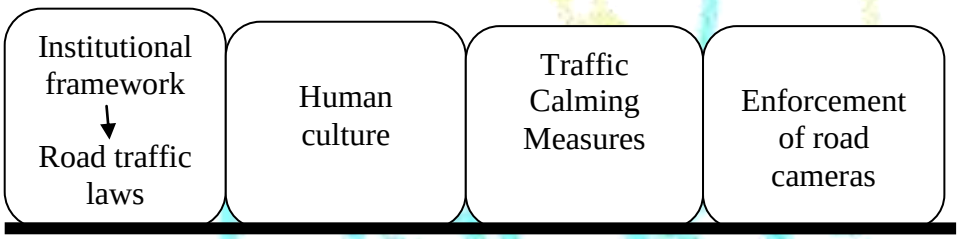

Figure 1: Integrative Model to Reduce Road Accidents

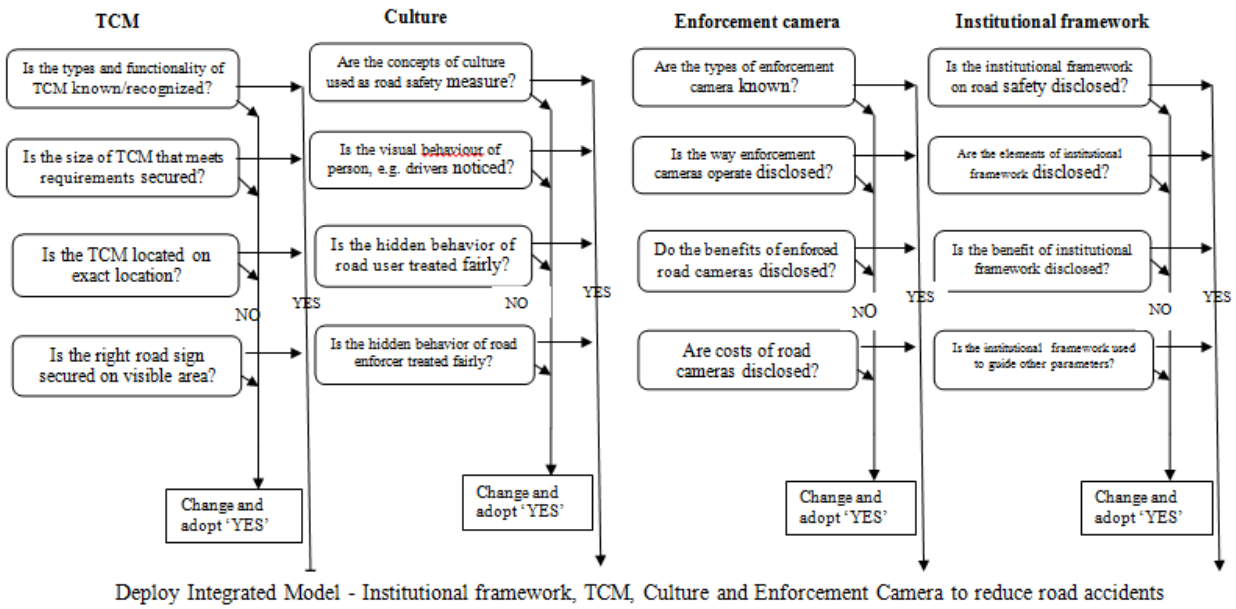

Figure 2: Guidance to Implement Integrative Model **to** Reduce Road Accidents

V. Concluding Remarks And Recommendations

This study was aimed to reduce road accidents in Mbeya City in Tanzania. The preliminary survey was conducted in traffic police in Mbeya city in 2015 and helped to identify two road black spot stretches (i.e. Mafiati to Ituta and at Jakaranda stretch). Causes of road accidents were identified as: over speeding, overtaking, fault vehicles, drinkage amongst others. The preliminary findings obtained from a survey guided in TCM case study on which elements (height, length and space) were found to be oversize. There were also other TCMs that were not visualized properly by the drivers causing discomfort to passengers as they suddenly approached the TCM. A study had also reviewed and evaluated literatures on: human culture, institutional framework and enforcement cameras and embedding these with a TCM attributes. Information then helped to develop integrative model to reduce road accidents in Mbeya city. The model comprises of four parameters: TCMs, institutional framework on road safety, human cultures of road users and enforcement of road cameras. The integrative model is presented to help manage road accidents in the country. This study has implication of use in Tanzania and in other developing countries. The study argues further studies to be conducted to validate the integrative model.

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