ROAD SAFETY THROUGH PLANNING FOR ROADS AND ROAD ENVIRONMENT: PEDESTRIAN AND VEHICULAR INTERACTIONS AS A WAYS TOWARD SUSTAINABILITY OF URBAN LOCAL UNTARRED ROADS AND FRONTAGES IN DEVELOPING COUNTRIES.

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ABSTRACT

Sustainable cities must be creative cities, the aim of this paper is to examine the relationships between pedestrian crossing time, vehicular traffic and road layout, and to express these relationships in the form of practical predictive models to demonstrate how far, and in what ways, and vehicular traffic can contribute to the reduction of pedestrian crossing time. Time-lapse photography was used to study models of pedestrian crossings and vehicular traffic at two selected untarred shopping roads in Ile-Ife, Nigeria. Exploratory data analysis was conducted by plotting scatter diagrams for pedestrian crossing times and vehicular characteristics (e.g. Vehicle volume and speed). Predictive equations for the pedestrian crossing time were developed using multiple linear regression. The correlation coefficients associated with the equations range from 0.47 to 0.68, and pedestrian crossing time can be predicted with an accuracy of 0.29 and 0.36 seconds, depending on the type of crossing situations. The paper concludes that in considering pedestrian crossing the road, the traffic engineer and transportation planner in developing countries cannot rely entirely in empirically tested overseas models of pedestrian behavior to sustain the environment. Road surface quality, vehicle volume and vehicle speed should be the major factors in planning for roads and road environment.

Keywords: Pedestrian-Vehicle, Road Environment, Urban Untarred roads, PV Model, Developing Countries

1.0 INTRODUCTION

The urban settlement of today is an agglomeration of several components such as commercial, residential, recreational, institutional land-use types. These are united by the transportation system. Transportation creates what is known as place utility. It does this by overcoming the impediment obstacles between the origin and destination.

Sustainable development is a concept, which has captured the imagination of scholars, politicians, professionals and practioners at all geographical scales.

Our cities and towns face a wide variety of critical environmental problems (i.e., emission from automobiles; health-threatening pollution; stratospheric ozone depletion). Furthermore, our cities and towns face enormous human problems in the form of widespread, persistent poverty and human misery. It should be noted that the world is not headed toward a sustainable future, but rather toward a variety of potential human and environmental disasters. The World Commission on Environment and Development, that the United Nations established in 1987, made a recommendation under ‘Our Common Future’ the Commission concluded that “a new developmental path was required, one that sustained human progress not just in a few places for a few years, but for the entire planet into the distant future.” The question arises what is sustainable development? The Commission defined ‘Sustainable development as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987 p9). This definition is all well and fine, except for the fact that the crucial little word ‘need’ is left undefined or unspecified. From the above definition one can see that sustainable development demands a creative process that replaces unsustainable practices with new sustainable practices that requires an understanding of future pattern of needs.

In an attempt to make the concept of sustainable development more specific, the author gives a narrow definition focused on the livable environment of sustainable development of Cities and Towns. This means that we have to shift from our present modes of transport towards modes that are less energy consuming and less polluting. In order to meet the sustainable demands, one needs to change his attitudes towards the use of cars in cities and towns for work trips, and increase the use of public transport, without retarding economic growth and social development.

1.1 Factors that contributing to creative potential

As a dynamic process, creativity appears to depend on the development of ideas, the willingness and resources to put those ideas into practice. The factors discussed herein could encourage a practical approach to change towards sustainable cities.

The creativity initiative involves the establishment of a new set of forum that draws from both public, private, community and academic sectors to consider issues within the city, and also to suggest policy for sustainable development for cities transport.

However, with the emerging awareness that sustainable development is about economy, environment and society, as well as the ecology, the relevance of cities environmental creativity and sustainability appears growing rapidly.

Further, educational provision has always been innovative in most cities. Most cities have excellent networks of community educational institutions. Unfortunately while educational provision has been seen as a potential of creativity and sustainable development for cities - it appears this has not been fully utilized. It should be noted that careful design and planning of roads can provide open space for pedestrians, or play areas for children, away from vehicular flow and for minimal through traffic on local streets in residential areas, where pedestrian accidents particularly those involving young children, are likely to occur (Appleyard, 1981, Buchana 1963, Oluwoye 1988, 1997).

The purpose of this paper is to examine and describe a particular interaction between pedestrians and vehicular traffic and to apply the findings for further studies and planning purposes of the Nigerian city Ile-Ife.

1.2 Background

The common scientific approaches to the reasoning of problems are mathematical reasoning or statistical reasoning (Oluwoye, 1992). Mathematical or formal reasoning is mostly deductive in that one reasons from general assumption to specifics, using mathematic precision. Models built with this approach are usually larger and more complex than those developed using statistical reasoning. Oluwoye (1992) also reported that a mathematical model is developed on the basis of axiomatic assumptions, which are useful, precise, reasonable and concerned with simplicity. Based on these general assumptions, the mathematician reasons a precise mathematical structure establishing a system of relationships referred to theory or model.

The time required by pedestrians to cross shopping roads at uncontrolled mid-blocks is an important factor in considerations of safety, efficiency and sustaining the environment in Nigeria.

The dust experienced by pedestrians wishing to cross untarred urban streets are of practical interest in view of the time lost by pedestrians, and because such time, especially when prolonged, may be associated with risk-taking and accident rates. The time associated with untarred urban streets may be said to comprise one aspect of the impact of vehicular traffic on the environment, which, together with pollution, etc. need to be taken into account in transportation planning studies in Third World countries.

In order to assess the overall influence of dust on pedestrians, it is necessary to know the crossing times imposed by vehicular traffic on people crossing the road. However, vehicle flow is not the only factor affecting pedestrian crossing time. Other vehicle characteristics, such as speed, composition and bunching of vehicles, also play a part, as do road configuration characteristics such as carriageway widths. An understanding of the underlying relationships is desirable, since it may enable those management measures to be identified which, under given road configuration and vehicular traffic conditions, minimize pedestrians crossing the road.

1.3 Objectives

This study sought to examine the relationships between pedestrian crossing time, vehicular traffic, and road configurations and to express these relationships in the form of practical predictive models to demonstrate how far, in what ways, dust can contribute to the pedestrian crossing time.

1.4 Main Approaches Used In Earlier Studies

A study by Virkler and Guell (1984) of six crossing locations in Richmond, Virginia and Columbia, Missouri, both in the USA, showed that pedestrians in large crossing groups walk at fairly uniform headways and uniform speeds. This is similar to the findings of Moore and Older (1965). It was also observed that pedestrian headways are close to 6.7 secs per pedestrian per foot width of walkway and speeds are close to 4.5 ft/sec.

The UK Department of the Environment (DOE) states that "Crossing time on adults pedestrian crossings is unaffected by vehicle flow (DOE, [p157], 1978). This equation was given by DOE for crossing without control (e.g. Zebra Crossings and Traffic Lights)

t = 4.19 + 0.0057Q + 0.59 W ....(1) where,

t = crossing time in seconds
Q = vehicle flow in vehicles per hour
W = road width in meters.

In specifying their model, DOE postulated delays in crossing due to increased vehicle flow leading to increased pedestrian crossing time. Other researchers (Virkler, 1982; Oluwoye, 1988, 1987) explained that crossing time could be affected by constraints before or after the crossing. For instance, sidewalk, parked vehicles, or the presence of other pedestrians might reduce the rate at which people could leave the kerb.

Most procedures used today treat crossing time as a function of road width divided by crossing speed (Cass 1876); Pignataro 1973; FHWA 1978; Oluwoye, 1997). However, crossing time is also a function of the crossing volume (Virkler 1982).

2.0 THE MEASUREMENT OF PEDESTRIAN CROSSING TIME

2.1 Measurement Units

The average pedestrian crossing speeds were obtained by measuring the pedestrian crossing speeds. Consequently, the following corresponding variables sampled as:the average vehicle speed, $\overline{U}$, is km/hr is the harmonic average of the vehicle speed, i.e.:

$$\bar{\mu} = \frac{L}{\sum_{i=1}^{n} \frac{ti}{n}} = \frac{nL}{\sum_{i=1}^{n} ti}$$

the average crossing speed, $\overline{U}$p, is m/sec is the harmonic average of the pedestrian crossing speeds, i.e. :

$$\bar{\mu}p = \frac{\Sigma \frac{w}{ti}}{n} = \frac{w\Sigma \frac{1}{ti}}{n}$$

the average crossing time, $\bar{t}$p, in seconds is the harmonic average of the pedestrian crossing time's i.e. $\bar{t}$p, = w/ $\overline{U}$p.
vehicle volumes, Q, are vehicles per 15 minutes.

2.2 Survey Methods

Data were collected at two sites, the intersection of Oduduwa and Iremo Roads. Both roads were classified as Local (see diagrams 1 and 2). The length of the road segments studied was 45 and 65 meters, respectively.

The road characteristics are:

Odoogbe road is a two-way untarred street which is 6.5 meters wide with shops on both sides. Parking is banned.

Diagram 1 – Location of a Camera at Odoogbe Market

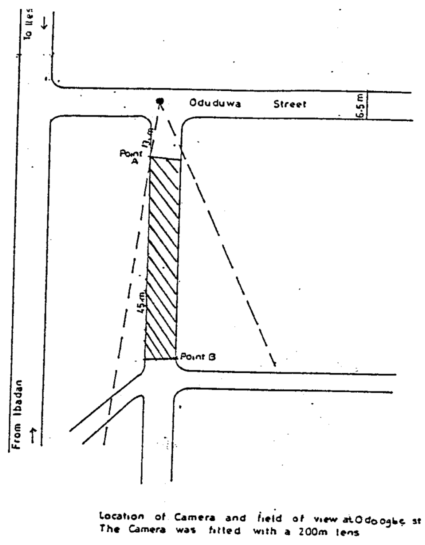


Diagram 1

(b) Aiyegbaju road is a two-way untarred local street which is 8.0 meters wide with shops on both sides. Parking is banned.

Diagram 2 – Location of a Camera at Aiyegbaju Market

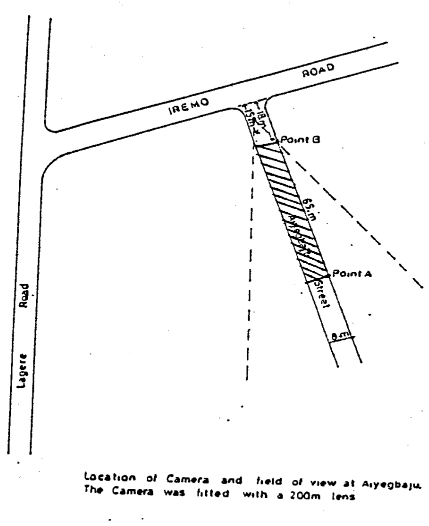


Diagram 2

The data were collected during the dry season and with full daylight conditions. A total of ten time periods was collected on both roads.

A photographic technique was used to record the data. A time-lapse camera was operated from an elevated vantage point of 3.0 m and the travel time of vehicles passing the length of segment, pedestrian crossing speeds and vehicle volumes were measured for 10 consecutive periods each of length 15 minutes.

The field included both the road and its environments. Pedestrians crossing the road were also recorded.

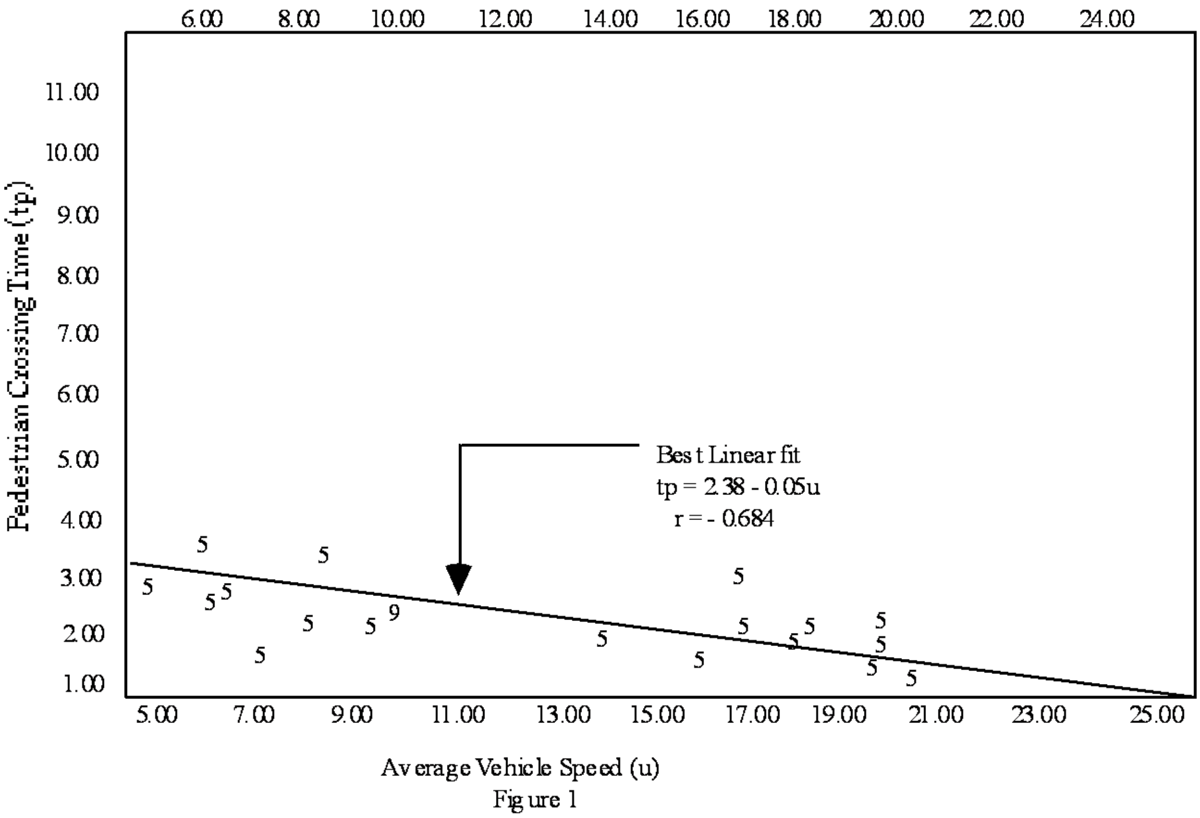
3.0 DATA ANALYSIS AND RESULTS

3.1 Simple Correlation Analysis

The results of this study were based on the aggregate data. In order to test the hypothesis that *tp* is dependent on vehicular traffic (Q and $\overline{U}$), a linear regression model was fitted between the $\bar{t}$p/Q and also against *tp*/$\overline{U}$.

Fitted linear regression models and data points are shown in Figures 1 and 1 for *tp* against $\overline{U}$ and *tp* against Q. The regression equations are given below:

Figure 1 – Relationship between Pedestrian Crossing Time and Average Vehicle Speed



STATISTICS
CORRELATION (R) - - 0.68414 R SQUARED- .46805
SIGNIFICANCE - O.OOOOO
STD ERR OF EST -0.29968 INTERCEPT (A) - 2.37846 SLOPE (B) - -0.05199
PLOTTED VALUES - 100 EXCLUDED VALUES - O MISSING VALUES - O

Figure 2 – Relationship Between Pedestrian Crossing Time and Vehicle Volume

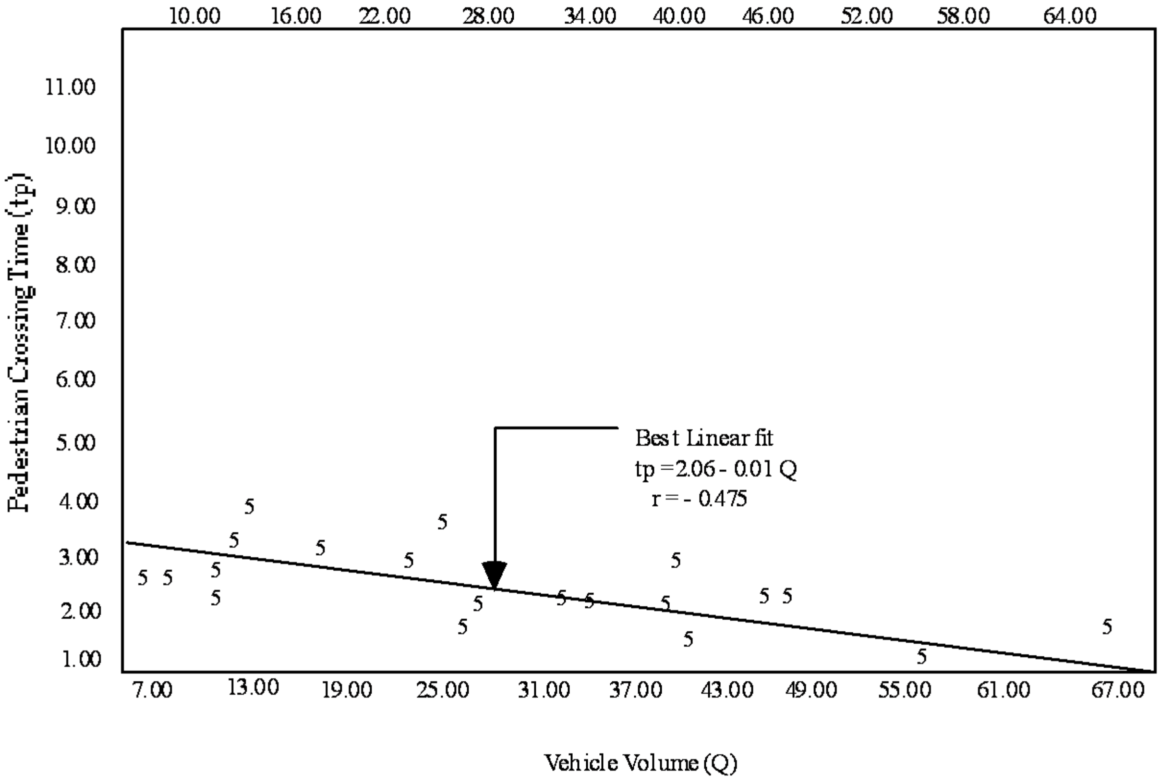


Figure 2

STATISTICS
CORRELATION (R) - - 0.47582 R SQUARED- 0.22641
SIGNIFICANCE - O.OOOOO
STD ERR OF EST -0.36139 INTERCEPT (A) - 2.05700 SLOPE (B) - - 0.01189
PLOTTED VALUES - 100 EXCLUDED VALUES - O MISSING VALUES - O

t_p = 2.06 - 0.01 Q -------(3)
(R^2 = 0.23, SE = 0.36 Sec)

where
R^2 = Coefficient of determination;
and SE = Standard Error

The model predicts that as vehicular flow increases the average time for a pedestrian to cross the road decreases; i.e. with increasing vehicle volume, pedestrians move quickly when crossing the road. The product - moment correlation coefficient is r = -0.476 which means that the relationship is significant at the 5% level (see Figure 2 above).

Equation 4 is for t_p and $/\overline{U}$.

$t_p = 2.38 - 0.05\overline{U}$ -------(4)
(R^2 = 0.47, SE, 0.30 sec)

There are several interpretations of the equation. As vehicle speed increases, pedestrians may choose to hurry across the road, thereby minimizing their time of exposure to vehicular traffic. Secondly, higher vehicle speeds may be associated with very low levels of vehicle volume, so that many pedestrians do not have to wait at the kerb before beginning their crossing. Another factor relates to the nature of untarred road surfaces. In the dry season, the passage of even one vehicle may generate an unpleasant, dusty atmosphere. Consequently, pedestrians may modify their crossing behavior to reduce the discomfort due to dust, as well as incorporate avoidance of risk of injury from vehicular traffic. The product-moment correlation coefficient $tp/\overline{U}$ is r = -0.684, which means that the relationship is significant at 5% level (see Figure 1).

3.2 The Influence of Vehicular Traffic and Road Width on Pedestrian Crossing Time.

A multiple regression analysis was carried out for pedestrian crossing time against measured vehicular traffic (volume and speeds) and road width. The following equation was obtained.

$$\underset{(0.077)}{} \quad \underset{(0.003)}{} \quad \underset{(0.117)}{}$$
$$t_p = 1.43 - 0.9\overline{U} + 0.005Q + 0.17W \text{ -------(5)}$$

(R^2 = 0.50, SE = 0.29 Sec)

<u>Note</u>: The product - moment correlation coefficient of $\overline{U}$ /Q is r = 0.81

where,

W = Carriageway width in (m)

Standard errors of the variables in Eq3 in bracket.

This model has a highly significant coefficient for $\overline{U}$ and coefficients for Q and W not significantly different from zero at the 0.05 level. Individual bivariate correlations indicate an inverse relationship between $t_p/\overline{U}$ (-0.68), t_p/Q (-0.47) and t_p/w (-0.60). Nevertheless, one could hypothesize that the relationship of the model would postulate negative regression coefficients signs for $\overline{U}$ and Q and positive for W for the following reasons:

(i) As vehicle speed increases, the crossing environment worsens due to increased risk to pedestrians from vehicle traffic and less pleasant conditions due to dust during the dry season. Hence t_p decreases as pedestrians hurry to cross.

(ii) As vehicle volume increases, risk to pedestrians and dust both increase and pedestrians hurry to cross.

(iii) As the width of the road considered increases, other conditions being equal the pedestrian crossing time increases.

The failure of the theoretical model to be confirmed is this test may be explained by the complexity of pedestrian crossing time but waiting time at the kerb before crossing.

3.3 Issues and Options of Unterred Pedestrian-Vehicle (PV) Model

The PV strategies provide a foundation for other strategies that change the use of roads and its environment, which in turn have various economic, social and environmental impacts. However, the following options will require a long-term frame; others are of a more operational kind. The issues of boundary exploration with land-use policies option are generally of a long-term nature and much will depend on the level of intervention, which is politically acceptable in Nigeria. Furthermore, policies to manage the road-space can be both short-term and long-term oriented. The issues of traffic management and pedestrian crossing with options of speed controls and volume controls can be introduced in short-term and may be effective in reducing conflict.

3.4 THE POLICY FORMULATION PROCESS

3.4.1 Land-use frontage/environment dominant; vehicle flow subservient situations.

The Odoogbe and Aiyegbaju are local roads situated in the center of Obalufon and Oduduwa streets; Iremo and Lagere roads. One option is to prevent an access to or exist from this street by means of full and partial barriers, turn prohibitions, do not enter signs and street closures three days before market day this would be important for visitors and for easy access for the area. Furthermore, if one considers a road/environment classification as a starting point in sustaining the unsealed roads and its environment and reducing the conflict between pedestrians and vehicles, then the formulating of options for the management of individual road/environments is essential. It should be noted that the issues and options presented in table 1 below should be considered only as part of a general approach to managing the road and its environment.

3.4.2 Range of options for sustaining conflict between pedestrians and vehicular traffic on shopping streets.

As one can see from 1 below, the options will vary greatly, depending on the nature and volume of traffic character and use of the roadside. However, the need for introducing planning controls of land-use frontage is essential.

Table 1 – Range of Policy Options to Sustain Pedestrian/Vehicular Interactions

Possible Implications for Frontage Management	**Road/ Environmental Options**	**Road Space Options**
1. Increased vehicle volumes, mix of local and through traffic, greater cross flows and additional turning and crossing movements in shopping streets, it is necessary to control the land-uses which are likely to adversely affect the traffic flow system resulting in reducing safety and	1. The vehicle speed is more affected by the land-use frontage, but it may be modified by law and enforcement.	1. Speed control through redesign of road space is suggested.

amenity.		
2. Crossing facilities, ease of crossing and minimum delay are necessary. There could be provision of facilities for pedestrians to cross the roads.	2. If shopping streets are dependent on passing trade, parking at kerb and clear signs to closely situated car park are important.	2. Based on research, observation and analysis It is proposed that the design speed in unsealed local roads with road width of 7m, 12km/h and road width less the 7m, 7km/h

4.0 CONCLUSIONS

The paper concludes that the issues and options of unterred pedestrian and vehicle (PV) strategies provide a foundation for other strategies that change the use of roads and its environment, which in turn have various economic, social and environmental impacts.

In considering pedestrians crossing the road, decision makers, traffic engineers and town planners in a developing country cannot rely entirely on empirically tested overseas models of pedestrian behavior. Road surface quality, vehicle volume, and vehicle speed are among the factors to be considered. The presence of dust, due to vehicular traffic on untarred roads, may have a significant effect on pedestrian behavior and may lead to decreased pedestrian crossing time with increased vehicle volume or increased average vehicle speed.

The policy formulation process discussed above is one of the basic approaches for sustaining and improving the pedestrian environment and promoting pedestrian safety in developed and developing countries. Such a policy formulation process could allow local engineers, planners, and public officials to arrive at better land-use control decisions in market areas of existing urban growth. The paper has described the way that time-lapse camera data may be utilized for decision-making in determining and sustaining pedestrian crossing behavior in such situations.

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