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CARBON DIOXIDE (CO_2) EMISSION SCENARIOS FROM MOTORIZED ROAD TRANSPORT IN KISUMU CITY

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ABSTRACT: *The global increase in the number of motor vehicles in the urban environment has greatly contributed to the increase in the amount of carbon dioxide released to the atmosphere which contributes to global warming. The study analyzed the relationship between the total CO_2 emission from motorized road transport and the atmospheric CO_2 concentration using the digital CO_2 meter to sample atmospheric air to determine the atmospheric CO_2 concentration in parts per million by volume at various time intervals in the Kisumu Bus Park and within the city and its neighborhoods'. The theoretical framework of this study was the Kinetic Theory of Gases. The study recommended that the government should invest heavily in the public transport sector by enacting laws and policies aimed at discouraging the importation and use of low seating capacity vehicles and invest in the high seating capacity vehicles (BRT) and non-motorized road transport.*

KEY WORDS: motorized road transport, BRT, carbon dioxide, emission

INTRODUCTION

In 2008, 8.6 gigatonnes of carbon (31.8 gigatonnes of CO_2) were released from fossil fuels worldwide (World Bank, 2008). CO_2 has gradually accumulated in the atmosphere, and as of 2009, its concentration was 39% above pre-industrial levels (World Bank, 2009). This has exceeded the balancing effect of sinks (US GCRP, 2010) and is directly associated to global warming (US NRC, 2010). The continued increase in the number of fossil fuel-propelled motor vehicles around the world poses a threat to natural environmental health.

The number of automobiles on our roads has continued to grow since it is a primary mode of transport for many economies. NEPAD approximated that the number of both public and private vehicles on the road in Africa in 2006 to be 20 million. Out of this number 11% were in East Africa most of which were in poor condition (UN, 2009). The Kenya National Bureau of Statistics (KNBS) approximated that Kenya had a total of about 1 million registered vehicles by the year 2008 with an annual registration of about 121,000 during the same year. Kisumu City with a population of 404,160 in 2009 is projected to have a population of 538,089 in 2019. This will significantly increase to meet the transport needs of the growing population.

Research Problem

Motorized road transport emissions have greatly contributed to the overall CO_2 emissions and consequently global warming. Data from various cities showing the number of vehicles on the

road and their emissions contribution is however scanty. There was need to establish the extent of emissions of CO_2 by motorized road transport by analyzing the relationship between the total CO_2 emission from motorized road transport and the atmospheric CO_2 concentration.

Study Objectives

i. To analyze the relationship between the total CO_2 emission from motorized road transport and the atmospheric CO_2 concentration.
ii. To suggest a strategy for planning of low carbon emitting urban PSV transport.

METHODOLOGY

This study used survey research design. Survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. From sample results, the researcher generalizes or makes claims about the population. It includes studies using questionnaires or structured interviews for data collection, with the intent of generalizing from a sample to a population (Creswell, 2009: Mugenda & Mugenda, 2013). The design is economical, convenient and rapid in data collection. The US EPA has guidelines on the types of air sampling for use by professionals. They include Grab Sampling, Short-Term Exposure Sampling and Full-Shift Exposure Sampling. This study used Short-Term Exposure Sampling which was conducted over 15 to 30 minutes interval within a shift. This sampling was used to define peaks after 2 or 3 readings in a row. The digital meter had direct reading and data logging property for moving averages. To accurately measure the concentration of CO_2, and being that air is continuous, several samples of air from the Bus Park were taken for analysis. The entire city was also stratified into various planning zones and measurements done at the various zones.

RESULTS AND DISCUSSIONS

Analysis of the Relationship between the Total CO_2 Emission from Motorized Road Transport and the Atmospheric CO_2 Concentration

The tally of various PSVs and cycles recorded at the Kisumu Bus Park at 7:00am (Table 1). The periodical tally of various PSVs and cycles at different times of the day and the atmospheric CO_2 concentrations corresponding to the specified times were also measured in the Kisumu Bus Park and recorded as Appendices. The Tally of PSVs and cycles emitting CO_2 at the Kisumu Bus Park was computed by summing the total entries and total exits at specified times. These were moving vehicles and therefore emitting CO_2 to the atmosphere at the specified times as shown on Table 2.

Table 1: Tally of PSVs at the Kisumu Bus Park at 7am

TYPE	TALLY
SALOON TAXI	20
VAN	115
MINI BUS	9
BUS	4
LORRY	0
PICK UP	0
TUKTUK	5
MOTORCYCLE	10

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Table 2: Periodical Tally of PSVs, Tricycles and Motorcycles emitting CO_2 and the Measured Atmospheric CO_2 Concentration at Kisumu Bus Park

TIME	**7:00-7:15**	**7:15-7:30**	**7:30-7:45**	**7:45-8:00**	**8:00-8:15**	**8:15-8:30**	**8:30-8:45**	**8:45-9:00**	**9:00-9:15**	**9:15-9:30**
No	133	147	196	162	228	200	264	248	219	219
CO_2	433	450	502	466	530	500	567	544	521	519
TIME	**9:30-9:45**	**9:45-10:00**	**10:00-10:15**	**10:15-10:30**	**10:30-10:45**	**10:45-11:00**	**11:00-11:15**	**11:15-11:30**	**11:30-11:45**	**11:45-12:00**
No	237	251	280	229	206	235	251	203	243	248
CO_2	537	510	606	566	534	535	553	517	541	548
TIME	**12:00-12:15**	**12:15-12:30**	**12:30-12:45**	**12:45-13:00**	**13:00-13:15**	**13:15-13:30**	**13:30-13:45**	**13:45-14:00**	**14:00-14:15**	**14:15-14:30**
No	170	266	249	217	225	215	267	188	201	207
CO_2	520	569	550	515	525	519	570	526	500	507
TIME	**14:30-14:45**	**14:45-15:00**	**15:00-15:15**	**15:15-15:30**	**15:30-15:45**	**15:45-16:00**	**16:00-16:15**	**16:15-16:30**	**16:30-16:45**	**16:45-17:00**
No	229	216	198	249	201	214	210	235	199	228
CO_2	533	518	499	545	501	517	510	538	496	530

The total volume of CO_2 periodically emitted at the Kisumu Bus Park was calculated using mass balance. This was done by first calculating the emission from each category of PSVs and the cycles and then finding the sum at given time intervals.

When the instantaneous concentrations of CO_2 were recorded across various points of the city, data was obtained comprising the spatial location of points in terms of Longitudes and Latitudes and the atmospheric CO_2 levels, Plate 1 to Plate 5 were obtained by using specific colours to represent measured similar concentrations.

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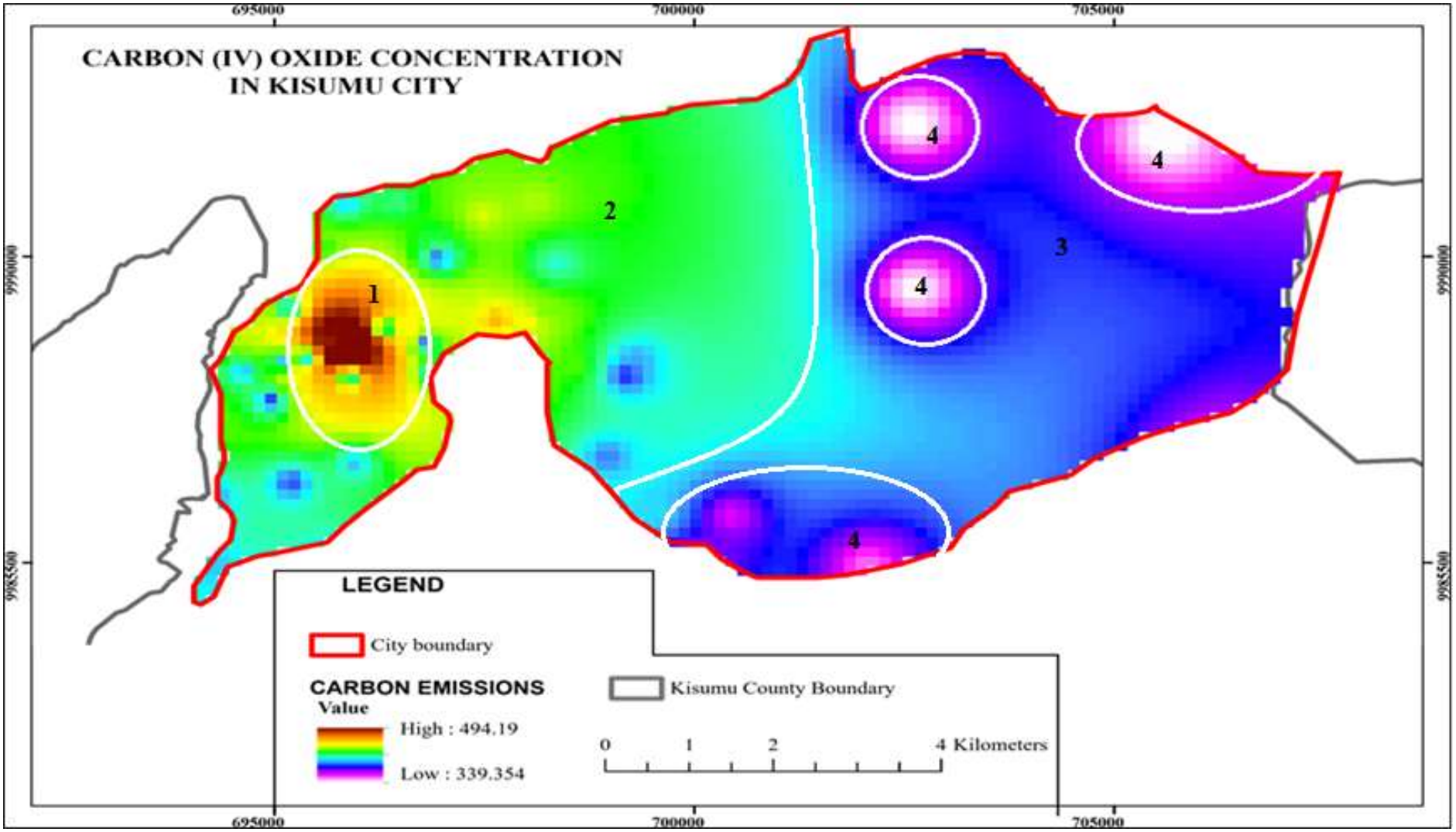

Plate 1: Variations in Atmospheric CO_2 Concentration in Kisumu City in ppmv

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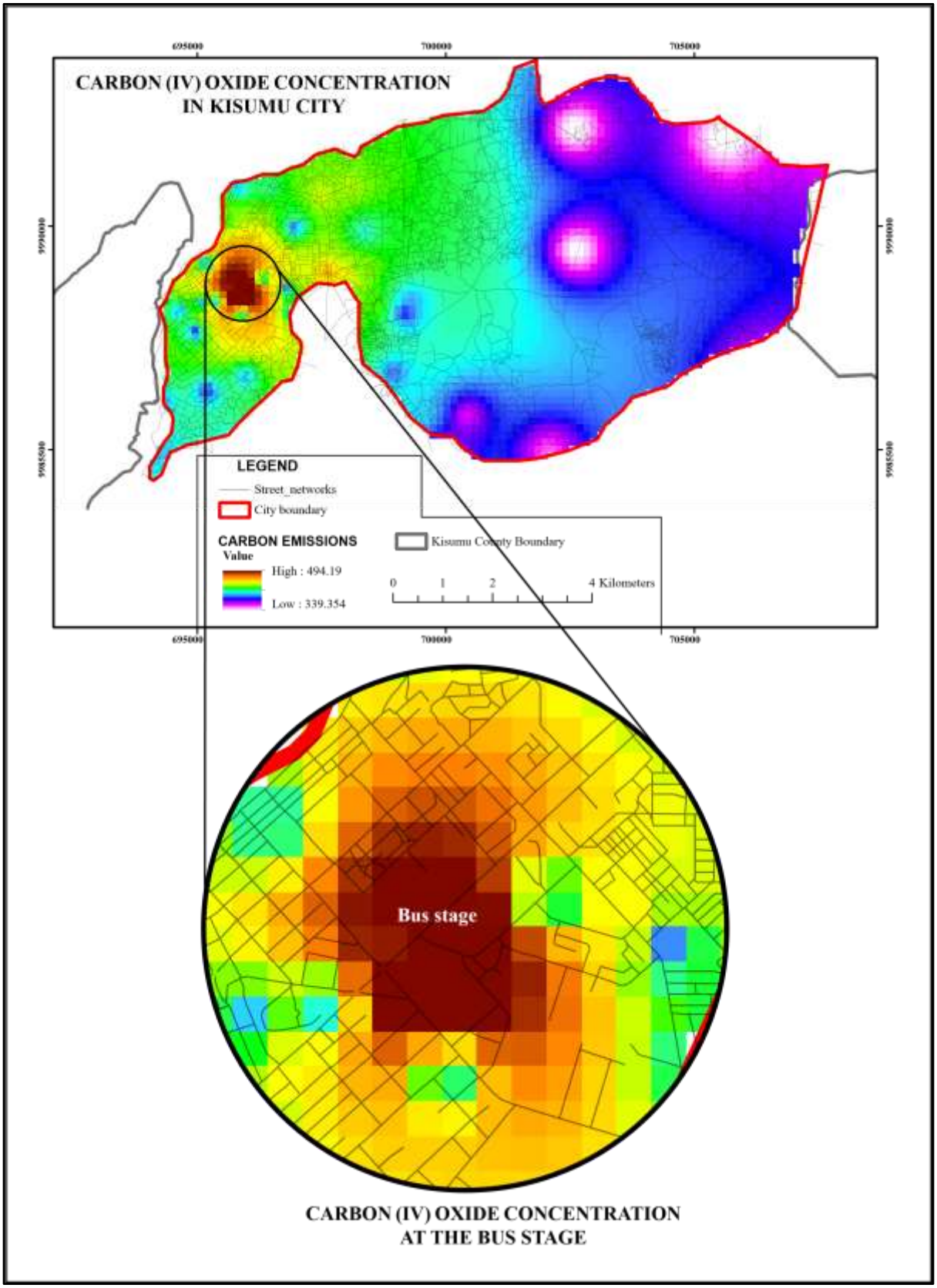

Plate 2: Pictorial representation of Atmospheric CO_2 Concentration in Kisumu City in ppmv

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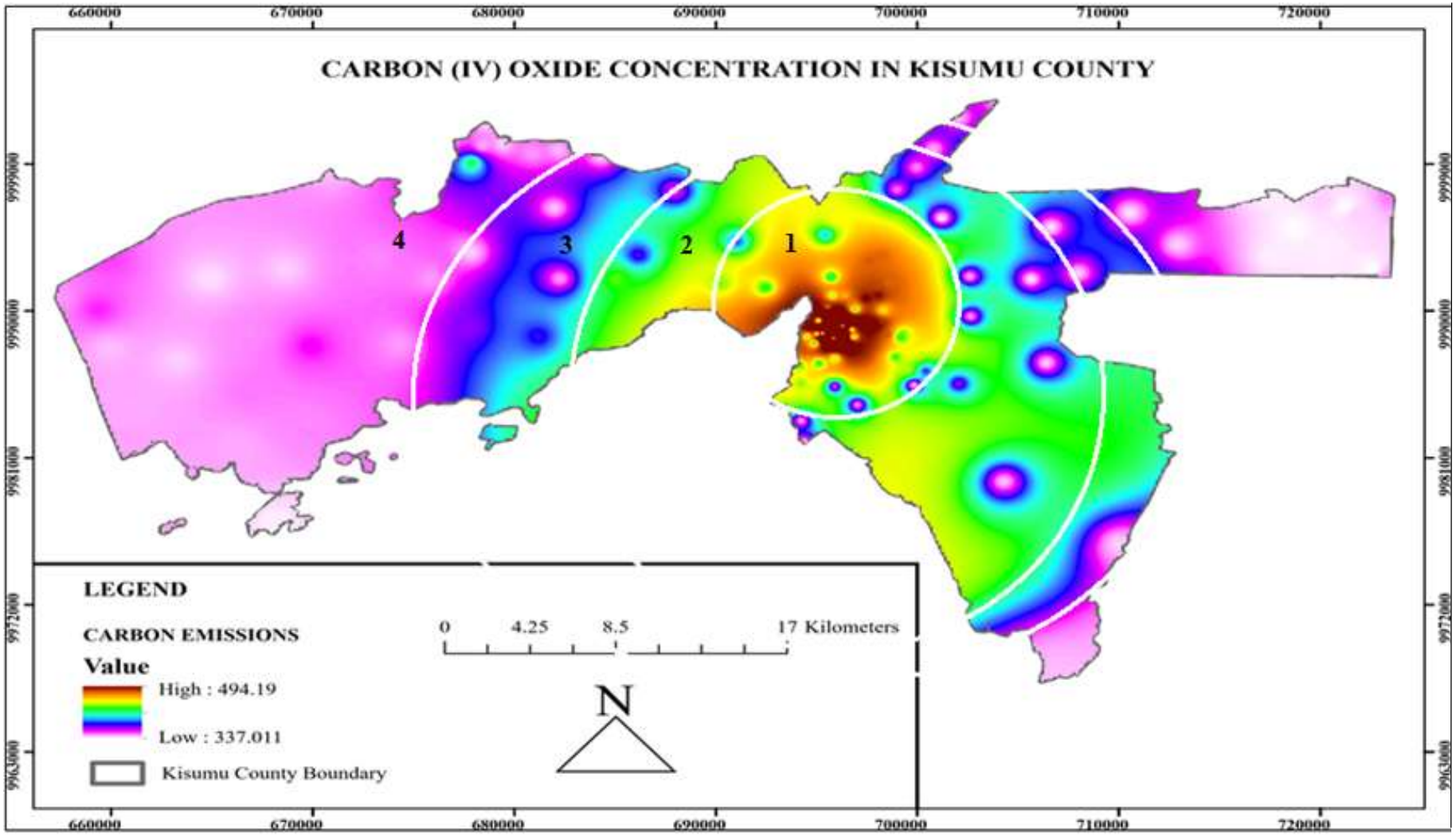

Plate 3: Variation in Atmospheric CO_2 Concentration in Kisumu County in ppmv

CONCLUSION

Pearson Product Moment Correlation shows a correlation of +0.927375 between the tally of PSVs emitting CO_2 and the atmospheric concentration of CO_2 at the Kisumu Bus Park. This strong relationship suggests that as the number of vehicles emitting CO_2 increased in the bus park, the atmospheric CO_2 concentration at the bus park also increased. The PSVs are probably giving out CO_2 which is contributing to the overall atmospheric CO_2. The correlation was subjected to t-test which confirmed that there is a significant relationship between motorized road transport and CO_2 emission.

Pearson Product Moment Correlation shows a correlation of +0.888489 between the volume of CO_2 emitted from PSVs and cycles and the atmospheric concentration of CO_2 in ppmv at the Kisumu Bus Park. This strong relationship suggests that as volume of CO_2 emitted by the PSVs increased in the bus park, the atmospheric CO_2 concentration at the bus park also increased. The correlation was subjected to t-test which confirmed that there is a significant relationship between the total CO_2 emission from motorized road transport and the atmospheric CO_2 concentration. Reduction in the number of cars on the streets will translate to reduction in CO_2 emission.

RECOMMENDATIONS

Public transport planning is the professional discipline responsible for developing public transport systems. It is a cooperative process designed to foster involvement by all users of the public transport system through a proactive public participation process.

1. There is need for regular sensitization of transportation stakeholders including operators, consumers, policymakers and policy implementors on environmental issues related to CO_2 emission and green economy.

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Motorized Road Transport is the mode of movement on the road using vehicles powered by a motor. The study considered motor vehicles, tricycles and motorcycles powered by fossil fuels.

BRT is an abbreviation for Bus Rapid Transport. It is a bus-based public transport system designed for the improvement of reliability, capacity and speed coupled with flexibility and affordability.

Carbon Dioxide, CO_2 is a naturally occurring chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom. It is a gas at standard temperature and pressure and exists in Earth's atmosphere in gaseous state.

Emission is the production or sending out of light, heat, gas, etc. (Hornby, 2010). CO_2 emission is therefore the sending out of CO_2 into the atmosphere. Here it was used to refer to the release of CO_2 into the atmosphere by Public Service Vehicles that use gasoline or diesel.