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Vehicle Emission Control Measures for Environmental Sustainability (Pollution Control) Regulation: Case of The Gambia

[1]Morro Krubally*, [2]Harcharanjit Singh, [3]Momodou Mustapha Fanneh
[1] Senior Lecturer, School of Business and Public Administration Department of Economics
University of the Gambia, Gambia
[2,] Associate Professor, AzmanHashim International Business School, UniversitiTeknologi Malaysia,
Kuala Lumpur, Malaysia.
[3,] Assistant Professor, School of Business and Public Administration Department of Economics
University of the Gambia, Gambia

Abstract: According United Nations (UN), world urbanization and its resultant population growth have risenapproximately fivefold between 1950 to 2011 (from 0.75 Billion to 3.6 Billion). The Gambia's population was61.27% higher as of 2018 the highest value over the past 58 years. The Gambia has a high level of urbanizationthrough the urban drift; Greater Banjul, Brikama areas carry 60% of the population. Similarly, motor vehicle activitycontinues on fast growth trajectory. Reports in 2018 showed that the Gambia ranked 170 ($22.5 Million) in vehicleimports in the world. Western and certain Eastern countries that are categorized as developed, enacted stronglegislation for the primary reduction of automobile emissions and enhanced better air quality. However, vehicularemission in developing countries including the Gambia has not received similar attention. Failure to controlvehicular emissions has been reported to result in significant effects on health levels (e.g., diseases related torespiration, the heart, cerebrovascular, severe obstructive pulmonary, lower respiratory infections, and cancers). Inspite of that, there is a significant increase in vehicle registration in the Gambia (i.e., 2.23 %) in 2013 for the last fiveyears, thus Gambia must have experienced a significant rise in daily traffic.

Keywords:Climate Change, Gambia, Sustainability, Emission Control, Pollutants.

I. Introduction

According to the United Nations (2012) report, world urbanization and its resultant population growth have risen approximately fivefold in the period from 1950 to 2011 from 0.75 billion to 3.6 billion. According to IndexMundi (2018), the urban population (% of total population) in The Gambia was 61.27% as of 2018 the highest value over in the past 58 years. Meanwhile, its lowest value was 12.13% in 1960. The Gambia has a high level of urbanization a direct result of the urban drift; the primary reason the Greater Banjul, Brikama area carry 60% of the population (African Development Bank, 2013). Similarly, motor vehicle activity remains on a fast growth trajectory (Aggarwal & Jain, 2016; Badami, 2004; Das, et. al, 2018). Sub-Sahara African (SSA) has seen a rapid rise in vehicle ownership because of a progressive increase in the importation of relatively low priced second hand autos from Europe and North America. The emission levels of the same second hand vehicles do not meet the standards in their originating countries. Therefore, poor emission coupled with inherent culture of poor maintenance by vehicle owners in SSA is the primary source of pollution in urban SSA (Amegah&Agyei-Mensah, 2017). Moreover, a report in 2018 indicated that The Gambia ranked 170 ($22.5million) in vehicle imports in the world (IndexMundi, 2018). Exxon Mobile (2013) projected that by 2040 the world population is likely to reach nine billion (Das et al., 2018). Therefore, energy demands around the world are expectedly projected to grow by 30 percent from 2016 to 2040 (Exxon Mobil, 2013).

In spite of that, the global air quality is reported to progressively get poorer mainly due to vehicular emissions as one of the major causes of pollution (Guo et al., 2016). The quality of air in sub-Saharan African (SSA) cities is growing poorer because of the quickly growingpopulationcoupled with the industrial expansion taking place in these parts of the world(Guo et al., 2016). Furthermore, SSA along with other developing countries reported a steep rise in fine particulate levels in the world (Amegah&Agyei-Mensah, 2017). A rise in the emissions is a direct result of a significant rise in population, urban, social and growth of the economy (Guo et al., 2016; Wu et al., 2017). Increasing fuel use by vehicles results in greenhouse gases like carbon dioxide (CO2), nitrous oxides (N2O), methane (CH4) and additional injurious pollutants like hydrocarbon (HC), particulate matters (PM), oxides of nitrogen (NOx) and sulfur dioxide (SO2) (Das et al., 2018). According to Netz, et al. (2007), in 2004, 23% of the CO2 emission in the world was contributed by the transport sector and 74 % of CO_2 emissions contributed by on-road vehicles. In addition, the increased emission is caused by old vehicles with poor maintenance records, high congested traffic, fuel contamination and bad roads (Das et al., 2018). Furthermore, Albeit Kirchstetter et al. (1999) posited that heavy-duty diesel vehicles (HDDV) are responsible causes significant air pollution problems. Road vehicles are also responsible for emissions of acid deposits, ozone layer reduction and climate change (Das et al., 2018).

Western and similar countries in the East enacted strong legislation for the primary reduction of vehicular emissions and enhancements to improved air quality (Zhang et al., 1995). However, vehicular emission in developing countries, including The Gambia has not received enough attention. In the case of the Gambia, there is a significant increase in vehicle registration over the last five years (African Development Bank, 2013) causing the increase in the number of vehicles and resultant increase in daily traffic numbers in the Gambia. Therefore, it is not arguable that increased number of vehicles cause major air pollution in the Greater Banjul Area.

A study by The Roads Transport Policy in May 2011, indicated that according to the Gambia Revenue Authority (GRA), approximately 33,500 vehicles were on the road in 2010. According to African Development Bank (2013), Gambia's rate of motorization was approximately 51 people per vehicle in 2011. In 2007 however, the projected fleet size is far lower than the record of 42,000 registered vehicles provided by the police data; and higher than the estimated fleet of some 15,556 vehicles in 2011 as per data collected from the Gambia Bureau of Statistics (GBoS) (African Development Bank, 2013). The road vehicles (excluding motorcycles) fleet growth rate was reported at an annual average 2.23 % and, approximately 73.0% of the motor vehicle fleet comprised light vehicles (car, van/station wagon, mini-bus). Table 1.0 illustrates the estimated vehicle type and numbers of the vehicle fleet in The Gambia (African Development Bank, 2013).

Table 1.0: Estimated Vehicle Type Fleet Numbers in The Gambia

This conceptual paper provides an overview of the global policies and practices in the management and control of vehicular pollution. The lessons learned will provide a road map for legislative and regulatory promulgation/consideration for a standardized air quality scheme for the key urban areas in The Gambia.This conceptual (perspective) paper aims to provide empirical evidence for the pioneering adoption of annual vehicular emission controls (test) in The Gambia. Air pollution poses significant health hazards as well as environmental risks (Franco et al., 2013).

A Gambia development strategy and investment program indicated that the transport sector has the potential to support the productive capacity and long term expansion of the economy (Gambia, 2011). Hence, the "objective of the government to improve the transport sector's adaptation to climate change and mitigation of greenhouse gas emissions" (Gambia, 2011. p. 8). According to African Development Bank (2013), during the period 2003 to 2011, approximately 20% of the vehicles registered annually in The Gambia were imported second hand vehicles. Likewise, on average, cars in the national fleet of The Gambia were older than five years (Africa Development Bank, 2013).

Although The Gambia is reported to have a tax reduction policy for importing cleaner vehicles. The Gambia, has high tariffs based on the age of the car; but Gambia has no age restrictions for imported vehicles; and does not have a serious roadworthiness test mandates (Abdoun, 2018; Amegah&Agyei-Mensah, 2017). There is also a growing concern on Sulphur limits in gasoline. For example, the report for maximum Sulphur limits in gasoline in Northern and Western Africa in 2018, showed Tunisia and Morocco has the lowest sulfur limit (0-10ppm and 31-50ppm respectively). Meanwhile, other countries struggle to tighten diesel quality. The Gambia ranked among the highest with 501-3500 ppm, and maximum sulfur limits on diesel in Northern and Western Africa in 2018. The literature reviewed showed that The Gambia has among the highest Sulphur limits in gasoline with 2000-10000 ppm; while Morocco registered the lowest with 10-15ppm (Abdoun, 2018).

II. Literature review

In the years to come, road transportation is expected to continue as a significant contributor to air pollution (Wang et al., 2019), particularly in urban areas. Hence, this is one reason why major efforts have been made for the reduction of pollution; especially emissions caused by road transport vehicles. Moreover, these efforts include several such as new powertrains and vehicle technology enhancements, fuel refinement optimization of urban traffic management and the implementation of tighter emission standards (European Commission, 2011).

Global air quality is reported to be significantly worsening; primarily due to vehicular emission (Guo et al., 2016). In 2004 the world transportation sector was responsible for contributing 23% of the world's CO_2 emissions and 74% of on-road CO_2 emissions (Das et al., 2018). In addition, other reports indicate this to be closer to 26% of the global CO_2 emissions. Nevertheless, the increased emission is primarily due to old and poorly maintained vehicles, traffic congestion, fuel contamination and poor roads (Das et al., 2018). Although heavy-duty diesel vehicles (HDDV) are proportionally fewer, their emission contribution is considerably high. (Kirchstetter, 1999).

In an effort to control vehicular pollution, Prior to the year 2000, China, for example, effected standardization of emission and better fuel quality standards. Subsequently, the standards were made tighter every 3 to 5 years. In just less than 13 years, China 1; the equal of Euro 1, and China 5, the equal of Euro V standard was formulated (Das et al., 2018). In preventing pollution, China formulated an amendment of the emission standard together with punitive consequences to dissuade owner behavior from tampering emission standards (Zhang et al., 2014). Beijing undoubtedly pioneered in the control of on the road emission (Wu et al., 2011).

In 2017, China's Ministry of Environmental Protection came up with a remote sensor instrument for national regulation that inspects and measures high emitting diesel vehicles (Das et al., 2018; Yang et al., 2015). The Swedish have also succeeded in vehicle inspection and maintenance practices in Gothenburg, Sweden, and found to have surpassed even Los Angeles, California and Melbourne in emissions control (Zhang et al., 1995). In Nepal for example, the Department of Transportation Management (DoTM) is a singular organization that conducts vehicle emission tests in Nepal (Das et al., 2018). Vehicle inspection is an annual mandated requirement with the exception of commercial vehicles, which are mandated to test twice a year with six-month intervals. Moreover, the vehicles that pass the emission test are issued a green sticker. Nevertheless, to pass the emission test often requires a vehicle owner to carry out particular repairs (Das et al., 2018). Besides that, vehicles that fail the road-side emission tests are charged a nominal penalty for this failure. Approximately 33-40 percent of diesel vehicle emissions can be reduced after appropriate repairs (Faiz, Ale, &Nagarkoti, 2006). Therefore, vehicle maintenance policy is important for emission control.

The government of China through subsidies and tax breaks, improved electric vehicles (EV) purchase, energy savings reduces vehicular pollution. Yellow-label vehicles were phased out in China through a scrappage program that provided proper subsidies/incentives (Das et al., 2018; Yang et al., 2015). Hence, through this program, Beijing was able to remove the older vehicles from the national fleet (Wu et al., 2011). Equally, Europe offers huge subsidies and significant tax breaks to encourage electric vehicle sales. In countries such as Norway for example, the excise tax reduction ranged from 39% to 67%; meanwhile in Halland, France and England excise tax was reduced from 10% to 40% (EuropeanCommission, 2017). Hence, many countries have made provisions to raise electric vehicle sales by removing customs and sales taxes for the purchase of these cars (Das et al., 2018).

The rising danger of global warming and climate change, which is primarily attributed to increasing greenhouse gases, has brought carbonomics as focal point of research. Although Kyoto Protocol recognized six types of green gases, CO_2 emission is by far the most substantial because it contributes up to 70% in excess of atmospheric concentration, contrasting methane (CH_4) and nitrous oxide (N_2O) with about 24% and 6% contributions, respectively. CO_2 has an extensive life cycle with an atmospheric lifetime estimated of 200 years as against CH_4, with an estimated atmospheric lifetime of 10 years (Solarin, 2014). Human activities are responsible for annual releases of nearly 30 Billion tons of CO_2 into the atmosphere (Houghton, 2003; Iwata and Okada, 2014;Safaai et al., 2011). Besides that, the significant rise in energy consumption occurs in lower developed countries, which are also responsible for much of the growth of emissions and are projected to surpass the Organization for Economic Co-operation and Development. (OECD) as the top contributor to global CO_2 fossil fuel emissions. This recent trend has led to the call for CO_2 reduction in developing countries, which has been hitherto a subject among developed countries (OECD, 2007; OPEC, 2011).

Likewise, African nations are experiencing rising emissions of up to 70% increase, which was 265.7 million tons in 1971 and 927.5 million tons in 2009 (EIA, 2011). The African ecosystems singularly contribute 40% of fire emissions, typically from the burning of the savannah. Nevertheless, Africa's contribution is less than 4% of the global fossil fuel emissions, the continent's role in the global carbon cycle is progressively being recognized as a matter of concern (Solarin, 2014). South Africa is presently the 8th largest per capita emitter and 11th biggest emitter of CO_2 in the world. Globally, among nations, Egypt ranks high with rapid growth in greenhouse gas (GHG) emission. Nevertheless, Africa receives scant attention from global policymakers mainly due to the absence of studies on African countries (Solarin, 2014).

The Gambian Nationally Appropriate Mitigation Actions (NAMA, 2011) listed eight priority areas (Gambia, 2011). "The Low Carbon Development Strategy (LCDS) is meant to fill the void presented by the non-availability of a climate change policy and strategy which leads to the ad-hoc to no implementation of sustainable Climate Change Convention in the Gambia." (Gambia, 2011. p. 13). According to the 2019 Environmental Performance Index, The Gambia ranked 156thout of 180 countries. As of 2020, The Gambia has no emission control scheme in place. According to Amegah&Agyei-Mensah (2017), imposing higher vehicle importation standards helps reduce the ownership of old vehicles and controlling the air pollution that emanates from these vehicles. Ghana, Cote d'Ivoire, Gabon, The Gambia, Eritrea, Lesotho, Niger and Mozambique have placed restrictions against the importation of over-aged vehicles above five years either by way of legislating a ban on importing or imposing stiff import taxes and levies (Amegah&Agyei-Mensah, 2017). These measures, however, have been found to not be effective in Ghana and Gambia (Amegah&Agyei-Mensah, 2017).

This paper aims to examine the institutionalization of vehicle emission control regime for The Gambia; and how this is possible by regulation for on-road vehicle emissions inspection. Therefore, the Institutional Theory is appropriate to support the present research framework. According to Sirmon, Hitt, and Ireland (2007), Institutional Theory postulate the survival of firms/agencies is contingent on their ability to conform to institutional requirements. Besides that, Institutional Theory focuses on the relationship between organizations/agencies with formal or informal institutions (Oliver, 1991).

III. Research Design andMethod

Based on the literature review the conceptual framework in Figure 1 was developed. The conceptual framework explains therelationship between emissions testing and emission control of road transport vehicles resulting in good environmental performance.

Figure 1:

The vehicle emission testing concept is new to The Gambia. There is paucity of research on the pollutant emissions and the activity that causes them. As a great start, vehicle emission testing would evaluate the condition of the vehicle; especially for the second hand vehicle imported from around the world which have failed their vehicle safety or emission standard and brought in to the third world countries like the Gambia. As such, on the road vehicle emissions inspection is one way that to curb the sub-standard vehicles from the roads in the Gambia. Besides, that regulatory bodies in Gambia must play an active role to fight against importation of sub-standard vehicles which pollute the Gambian air and lowers the quality of life of the people.

Measuring the constructs of the proposed conceptual framework is most attainable through the use of a quantitative methodology. A quantitative methodology provides a research design that allow for collection of data through survey method (questionnaire) [1].The design of the present research would use regression analyze measuring both the structural model (model A) and measurement model (Model B). Through PLS-SEM data analysis software the researcher may test the hypotheses following establishment of composite reliability and validity.

IV. Results and Discussion

According to WHO (2011), outdoor air pollution causes approximately 1.3 million deaths annually globally. Empirical evidence has established a source apportionment study that road transport is singularly responsible for vehicular emission pollutants (Franco et al., 2013; Maykut, Lewtas, Kim, & Larson, 2003). Moreover, in decades to come, road transport is highly probable to cause major contribution to air pollution, especially in urban dwellings. Hence, it is a good reason for significant efforts to be taken globally for the reduction of pollution caused by vehicular emission. These efforts include new powertrains and vehicle technology improvements, optimized fuel refinements of urban traffic management and the application of tighter emission standards. (Franco et al., 2013).

Exponential growth in urbanization and aggregate rise of car exhaust gas emissions on the roads is a grave threat to air quality, principally in urban areas (Neeft, Makkee, &Moulijn, 1996; Yang, Wang, Shao, &Muncrief, 2015). Moreover, the small-scale processes, burning of wood and coal in open fires and stoves and the use of engines for transport purposes, are most common in densely populated areas. As such, it is not surprising that these are held mainly responsible for the high concentrations of pollutants found in urban environments (Menkvelde et al., 2002). Modern-day air concentrations of pollutants are CO, HC, NO, and particulates are higher in urban than in rural areas, because of urban traffics emissions of these compounds (Amegah&Agyei-Mensah, 2017; Wang et al., 2019). In a comparative study of the possible effect of air pollution on cancer mortality incidence in the rural and urban areas, Neeft et al. (1996) found that high emissions concentrations may be responsible for adverse health issues such as decreased lung function or lung cancer. Nevertheless, cancer mortality in cities appears to be significantly higher compared to rural areas (Neeft, Makkee, &Moulijn, 1996).

In the 1970s, The United States of America and Europe pioneer in the first introduction of Automotive Regulations Standards (Neeft, Makkee, &Moulijn, 1996). These pioneering standards were first functional and purposefully applicable to light-duty passenger cars. These standards began with expression in grams of regulated compounds per mile and were easily met by passenger cars because they were not stringent prior. However, in the years that followed post the 1970s, these standard regulations became tighter, which led to the development of the three-way catalyst (Neeft, Makkee, &Moulijn, 1996). A growing number of countries had developed diesel emission standards based on the emission standards for the European Commission (EC), USA or Japan. However, they are less strict than the USA Federal emission standards. California, for example, has the most stringent standards in the world (CONCAWE, 1994).

Recognizing on the road pollution as one of the primary means to improve the air quality, China formulated and effected an action plan to mitigate air pollution (CHINE 2013). "The emission standard for HDDV for China 5 stage were 4.0 g/kWh CO, 0.55 g/kWh HC, 2.8 g/kWh NOx, and 0.03 g/kWh PM (Das et al., 2018). In India, the government recently set up Bharat Stage (BS)-IV norms for vehicle emissions control. The maximum permissible limits for HDDV were 1.5 g/kmhr CO, 0.96 g/kmhr HC, 3.5 g/kmhr NOx and 0.02 g/kmhr PM. However, BS III norms were 2.1 g/kmhr CO, 1.6 g/kmhr HC, 5.0 g/kmhr NOx and 0.10 g/kmhr PM" (Daset al., 2018. p. 77). Likewise, European nations similarly formulated strict emission standards that tightened standards for heavy-duty vehicles (Das et al., 2018). The emission standards for NOx for Euro I, Euro II, Euro III, Euro IV, Euro V and Euro VI were 8 g/km, 7 g/km, 5 g/km, 3.5 g/km, 2.0 g/km and 0.4 g/km respectively (Vestreng et al., 2009). Similarly, in United States, in 2016, the emission standards for heavy-duty highway vehicles (Spark-Ignition) were 0.195-0.230 g/mi NMHC, 0.2-0.4 g/mi NOx, 0.02 g/mi PM, and 7.3-8.1 g/mi CO depending upon the vehicle weight (USEPA, 2016).

On the other hand, SSA and other advancing regions were reported to have the highest fine particle levels in the world (Brauer et al., 2012). PM2.5 concentrations in SSA cities has been estimated at around 100 mg/m3 compared to <20 mg/m3 in most European and North American cities (Brauer et al., 2012). Despite that, a rapidly growing population in SSA cities led to increased vehicle ownership, a rise in the use of solid fuels for cooking and heating, and poor waste management practices. Hence, such poor situations coupled with increased industrial emissions and unpaved roads in several neighborhoods caused severe urban air pollution in SSA (Amegah&Agyei-Mensah, 2017). Notwithstanding, the introduction of vehicle emission standards in Africa has proven arduous due to the undeveloped institutional and monitoring systems (Abdoun, 2018).

V. Conclusion

"There is a clear lack of urgency from SSA governments in addressing the deteriorating urban air quality situation in the region which is possibly due to the absence of (1) reliable data on air pollution levels due to weak and non-existent air quality monitoring networks in countries, and (2) local evidence on the environmental and human health impact of air pollution, and the magnitude of the associated health risk." (Amegah&Agyei-Mensah, 2017. p. 739). Therefore, this paper is groundbreaking for The Gambia as African nations' emission control become more important for much-needed attention in this era of rapid urbanization and high dependence on auto vehicles. Nonetheless, the paper provides some empirical bases for government of The Gambia to consider instituting and annual vehicle emission test standard. The paper provides much-needed knowledge for The Gambia government on the standardization criterion for on-road vehicle emission. Hence, providing a rationale for research in the environmental management in The Gambia. Furthermore, this paper provides support for the government of The Gambia. to give greater focus in the aspects of environmental management and sustainability. The government efforts in the future will not only protect the environment but will ensure better lifestyles and vehicles management in The Gambia.

Table 1.0: Estimated Vehicle Type Fleet Numbers in The Gambia

Vehicle Type	**Number**	**%**
Cars	20,896	62.4
Van/Station Wagons	2,902	8.7
Minibus 12-22 pax	474	1.4
Bus > 22 pax	2,618	7.8
Good Vehicles	1,626	4.8
Others	2,397	7.2
Government/Diplomatic	2,587	7.7

Total	33,500	100

Source: [2]

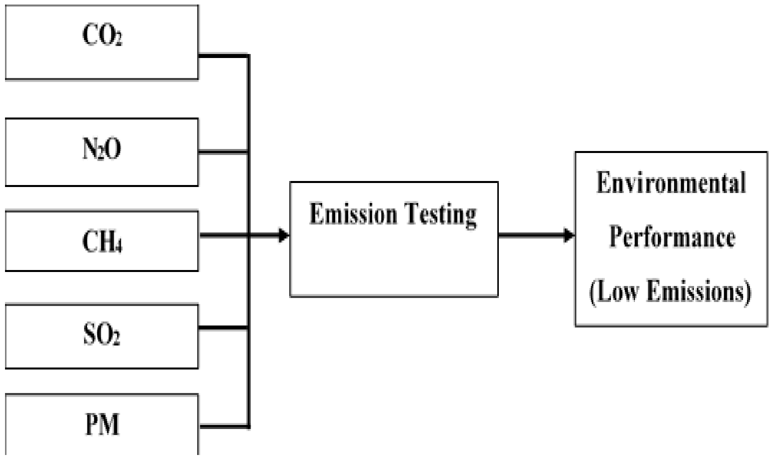

Figure 1. Research Framework; Underpinned by Institutional Theory

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