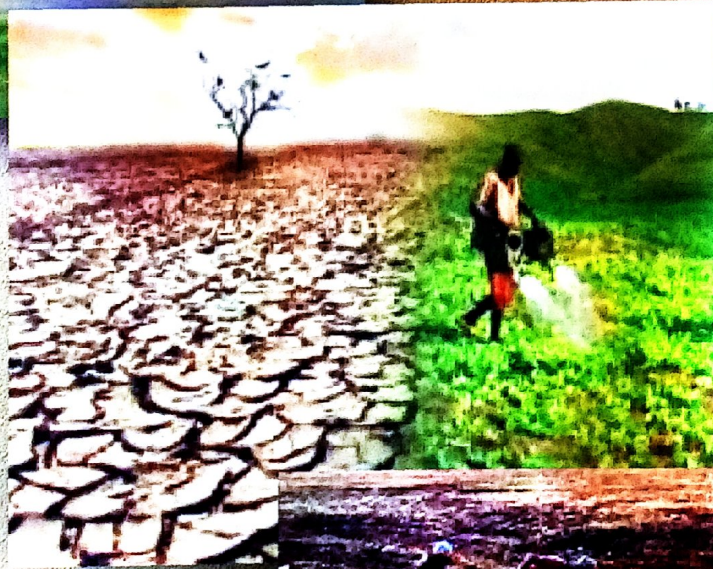
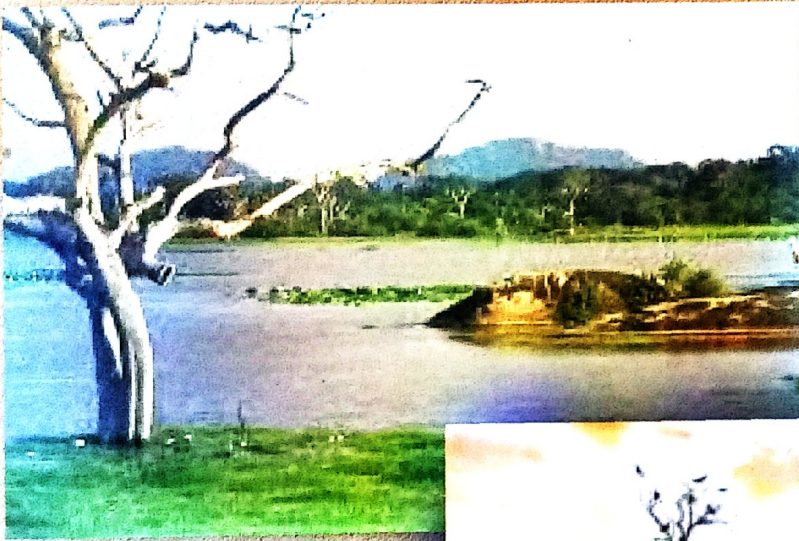


Water, Land and People in Climate Change



S. L. Tilakasiri

WATER, LAND AND PEOPLE IN CLIMATE CHANGE

Issues, Challenges and Perspectives

WATER, LAND AND PEOPLE IN CLIMATE CHANGE

Issues, Challenges and Perspectives

Editor

S L Tilakasiri



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**Dedicated to the People
Attempting to Make
The World a Livable Place**

PREFACE

The book **Water, Land and People in Climate Change** is a product of the efforts of Dr. S. L. Tilakasiri – an Afro-Asian researcher from Sri Lanka, who out of his concern for scholarship initiated this project. Increasing population numbers have from time immemorial been a critical issue of discourse in world history. Today we find that man has increased in numbers to its present estimated population of approximately 7.3 billion.

The increasing world population has placed pressure on: Water because Water is life; Land, for food production; Land and earth's crust, for exploration and exploitation for a continuously improving livelihood. The consequence of all of these is man's concern for its own survival and so the concept of sustainability and the discourse on climate change has become an issue of common concern. The editor-in-chief's desire to address the sustainability of man's increasing consumer culture necessitated this book project with contributions from people of different ethnic and country exposure and academic background.

The book has been divided into five parts of forty chapters. Part one discusses the issues and perspectives of climate change, from the spirituality point of view to that of salient determinants of several environmental changes, to the perspective of man's craving for pleasure and excessive consumption of goods and services.

Part two of the book focuses on the impacts of climate change on natural resources ranging from water (including ground water), through natural environments to forest resources, using a variety of modern techniques for their studies. Part three explores climate change and livelihood with emphasis on sustainability. Food and health security for man's survival are variously discussed. This part dovetails into part four that focuses on climate change and development, resources utilization efficiency, governance, irrigation, knowing numbers (census) to monitor growth and therefore plan better for development.

The last part of the book, on the way forward suggests ways of achieving man's desire for its continued existence on the surface of the earth. Ideas such as green energy, green marketing, greener organization and 'green' almost everything are examined. On a second thought, is man's original and traditional way of burials of the dead not 'green'?

This book covers the theoretical aspects and the issues involved in climate change, from different perspectives, especially from the view of developing economies. It is therefore a must read for scholars interested in developing economies, geographers, political scientists, planners and advocates of good governance. It is widely recommended for students in tertiary institutions, post graduate students, and policy makers.

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Bringing out a book of this nature on environmental issues has been a longtime ambition, since I was working as a researcher in the Research Department, People's Bank, Sri Lanka and conducting research with Swedish researchers on *Eco-development and Irrigated Agriculture in Sri Lanka*. Thanks to the University of Ilorin, Nigeria (*Better by Far University*) and the Department of Geography and Environmental Management of the University (*Better by Far Department*), for giving me the opportunity and made my dream come true. I am able to accomplish the ambition successfully with the kind supports from colleagues, professors and other members of staff in the Department who saw it as a worthwhile venture in the light of our common interests in the global and local environmental challenges of Climate Change

I sincerely appreciate Professor Abdulganiyu Ambali, the Vice-Chancellor – University of Ilorin, Nigeria, and Prof Is-haq O. Oloyede, the immediate past Vice-Chancellor of the University for providing a suitable and scholarly environment in the Department of Geography and Environmental Management, by appointing me as a staff. I have been fortunate in having the support from Professor M. O. Ibrahim, Director – Centre for International Education and Professor Ayodele Jimoh, Dean – Faculty of Social Sciences.

It was Professor L. T. Ajibade and Professor R. A. Olawepo who encouraged me to bring up the book, and without their intervention, this project might be difficult to accomplish.

During the preparation of this book many people offered advice and active support. I should mention with gratitude Emeritus Professor M. M. Karunanayake, *University of Sri Jayewardenepura, Sri Lanka* and Emeritus Professor C. M. Madduma Bandara, *University of Peradeniya, Sri Lanka* who supported me with valuable ideas, advice and moral support. I would also like to express my thanks to Professor J. F. Olarunfemi, Professor A. F. Adedayo and Professor H. M. Bandara, *University of Ilorin, Nigeria* for their support, continuous encouragements and comments. Thanks are due to Professor Jan Lundqvist of Stockholm International Water Institute, Sweden, Professor Ranghild Lund at University of Trondheim, Norway, Emeritus Professor Thomas Roswall at the Swedish International Development Cooperation Agency and Emeritus Professor Manfred Domroes at Mainz University, Germany for their useful comments and encouragements.

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Finally, I thank my wife Sriyani, children Sevvandi and Sahan for their understanding and support, and hope they are pleased with the outcome.

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BACKGROUND NOTE

Attempting to Make the Earth a Livable Place...

The term, *Climate Change* has today become everyone's buzz word. After being marginalized for decades, the issue of the environment in recent times is occupying a major part of Western political discourse. Leaders, Politicians, Officials, International Financial Organizations and Non-Governmental Organizations now constantly refer to the problems of the environment and Climate Change in their communication and try to go Green in everything (i.e. Green Energy, Green infrastructure, Green Marketing, Green Administration, Green Banking, etc.) as a solution to this crisis. Some still argue whether Climate Change is real or a myth? The reality of it has become a well-accepted fact and indeed a major challenge to everyone and all living organisms. Climate Change poses a serious threat especially to development in poor countries. We are now looking into a future of significant human-induced changes to our environment in general and to the climate in particular.

The issues of global warming and/or climate change is one of the most important and current global environmental challenges. Climate change, whether human-induced or natural, majorly precipitates challenges to livelihood and the environment. Impacts related to climate change are evident across regions and in many sectors such as health, agriculture, water supply, transportation, energy and ecosystems. They are expected to become increasingly disruptive throughout this century and beyond. The empirical evidences gathered implicate climate change as having negative impacts on livelihood patterns across the globe.

It is now an accepted scientific phenomenon that the global climate is changing. The negative impacts of Climate Change are threatening to reverse, if not slow down the development efforts in many parts of the world, especially in the developing parts of the world. More and more people are now aware that the balance between nature and human development is breaking, natural resources are downsizing and disparities and inequities are increasing.

No doubt, development has brought about many benefits to societies, however, the kind of development from which we have reaped benefits are in most cases unsustainable. The desire to produce more goods for one's own consumption has intensified conflicts for control over limited resources, jeopardizing the environment as well as the present and future livelihoods of people. The world therefore needs to look harder at how to live and make the earth a livable place by mitigating and adapting to these on-going changes in the environment.

Man and his activities, which constitute a component of the environment, are closely interrelated with the other components' within the environment. It is a scientific

fact that human activities cause serious threats to the environment, a condition which in turn has endangered the environmental resources both on a short and a long-term basis. The environment has been a close friend of man in his timeless journey. Man has co-existed with the environment for thousands of years since the early civilization era by making use of the environment for his livelihoods in a more protective manner. However, during the last few decades of the 20th Century, enormous pressure has been on the environment, due to accelerated human activities causing greater environmental degradation and endangering man's future survival. With increasing rates of poverty and unemployment, it would appear that the average man, and also governments, politicians, planners and administrators have forgotten to remember the ways of nature; that the flood plains are the domain of rivers and that the coastlines are the domain of waves, and the like. Unfortunately, man has not developed the wisdom and learn to live outside paths of destruction induced by these elemental objects.

Man has been the prime source of environmental degradation as well its victim. Man and his environment are inseparably linked – all aspects of human life, well-being, sustainable living. The environment is directly linked with the stability and proper functioning of our surroundings. Unfortunately it has not been sufficiently recognized that many of our environmental challenges stem from a narrow, single purposed approach in public or private actions that affect the human environment; whether in agriculture, industries or urban development. There appears to be limited awareness among governments and the general public on the significance of these issues.

In terms of the degradation of the physical and biological environment of spaceship earth, man's existence has caused more irreversible damages than ever before. Studies have shown that man has with time tripled the production and consumption of consumable goods and food. This has created a monstrous and dominant technology driven culture that has led to an exponential increase in the level of resource utilization, both renewable and non-renewable.

The challenges that are facing man today are a product of the present global consumerism focused culture. This has been clearly illustrated through some of the subject titles selected by Toffler, a Sociologist in his book - *Future Shock* (1999), such as '*The Technological Engine*', '*Break with the Past*', '*Knowledge as Fuel*', '*The Throw-away Society*', '*The Paper Wedding Gown*', '*The Portable Play Ground*', '*The Rental Revolution*' and '*Life Style Factories*'. The improved modes of communication have played a significant role in shaping this culture to its present state and spreading to the most remote places in the Afro-Asian world and other developing countries. It is molding life styles suited to the consumerism tradition arising from what is produced, instead of what is needed.

The conceptual treatment of environmental problems by the dominant culture, has been to consider them as the necessary outcome of the consistent trade-off that man-kind is called upon to make when utilizing the limited natural resources to fulfill its unlimited needs. These problems have to be understood and their negative affects need to be mitigated.

The environmental crisis which is undermining physical and biological surroundings is a byproduct of the accelerated expansions of man's domination of the planet and his exploitation of natural resources. There are questions today about the triumph and benefits of technology and the dissociation between man and environment, it has brought about. This division is gradually undermining everyday life and leading to crisis between man and his environment. Some obvious symptoms of the change in the relationship between man and his environment are the poor management of water, land, soil and forest. The fallout is the various forms of pollution, uncontrolled urbanization, and destruction of existing life support systems and the crushing of traditional cultures.

During the last decades, many parts of the world recorded high levels of economic development and rapid levels of industrialization, urbanization and population growth. These have culminated into serious environmental degradation due to excessive exploitation of natural resources. Hence, different types of pollution such as soil, water and air are caused by intensive use of agro-chemicals, harmful substances, increased consumption, changes in consumption patterns and discharge of wastes amongst others.

Most of the developed countries are leading in the utilization of natural resources and consumption of goods and services. They are also having higher rate of industrialization, urbanization and, production and sale of destructive weapons. These countries have been primarily responsible for the environmental catastrophe which is being experienced lately. They sometimes use developing countries as dumping grounds for toxic wastes and other municipal wastes. Developing African countries, including Nigeria, have agreed to restrict importation of dangerous wastes into their countries. Similarly, the developing countries also contribute to global environmental degradation. For instance, deforestation in the Amazon and Asian Regions which leads not only to destruction of livelihoods but also displacement of people (especially indigenous groups). It should be noted that both the developed and developing countries across the world face the consequences of the current environment catastrophe. It is often the poorest people that are the hardest hit.

Future generations who are not in any way responsible for this crisis, also have to bare some effects. Further, in the inter-governmental collective efforts at finding solutions to this crisis, lack of interests on the part of certain powerful industrialized countries that made greater contribution to the problem, have disheartened others. Therefore, all countries need to work in a more responsible manner to get out of this common threat. Unless action is taken immediately to protect the environment by mitigating the adverse effects of human activities on it, as scientists have warned and forecasted, the earth will become an unsuitable and unsafe place for man and living organisms. Thus, actions of the present generation on the environment have become the major challenge for the people themselves. Hence, it has become a major focus of the agenda of states, organizations, scientists and intellectuals in taking actions in unison to find urgent and lasting solutions, so that the earth will remain a livable place for all living beings.

Climate change has become an international issue, thus several International

Summits: the Rio in 1992; Kyoto in 1997; Copenhagen in 2009; and Paris in 2015 came up to address the issues. The future emissions of greenhouse gases and aerosols will lead to significant change, including much more warming and sea level rise than what was experienced in the 20th Century. The 2015 Paris agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st Century. This will be achieved through three methods – reduce, re-use and re-cycle. In addition, solutions such as green growth, smart innovations, water resources management, clean energy (*such as biogas and solar*); climate resilient adaptation, combating deforestation, coastal zone management, sustainable innovation in waste management, building zero carbon economy and building eco-cities have been propounded.

Climate change is a global concern that requires collective action. The regions of Asia, Africa and Latin America are the most vulnerable to the impacts of climate change, though they have contributed the least to the problem. The question arises as to whether there is any common ground for cooperation among the countries of the South. What are the challenges of the countries of global South in terms of creating a concerted position in climate negotiations? How strong is the voice of the most vulnerable in the negotiation of issues related to climate change? What strategies and counter programmes are being proposed by the South? Are there strategies for tackling issues which are informed by Southern perspectives? How do these countries foster low carbon development pathways? What are the best climate change adaptation practices and how can they integrate into sectoral plans? How are these countries adapting climate change policies into their development and economic policies?

There are complex linkages between climate change, social and economic involvement in the Southern countries. These countries have to find ways to address climate change issues without compromising their economic growth and development. Therefore, it is imperative that Southern Countries form a forum to identify the challenges confronting them as well as their capacity to explore the impacts of climate change and coping strategies to overcome such challenges.

Furthermore, development programmes should focus with vision and accountability on ecosystem approaches and integrate reforms to climate risks. An integrated approach with good governance would build sustainable programmes, which are based on the considerable body of knowledge that already exists with local people, especially with regards to attitudes, adaptation and mitigation to climate changes. Their long standing and time-tested experiences should be taken into account.

This publication on **Water, Land and People in Climate Change** presents important discussions of the Climate Change and related issues at global and local levels, particularly in the context of Afro-Asian Countries. The book represents a collective effort among a large number of scholars from different universities and other organizations, and it addresses a wide range of issues on climate change including past, present and future. It also contains some papers on livelihoods which include water resources, natural hazards,

human health, food security, transportation, governance and sustainable development as well as urbanization.

Part I, *Issues and Perspectives of Climate Change*, consists of six chapters. Climate change and/or global warming is a global phenomenon. It does not appear like war, terrorism, and espy, but it disguises itself and serves as a major determinant of several environmental changes because it precipitates challenges to livelihood and environment. Chapter one (1) provides an overview and background of discussions of the subject by reviewing the past, present and future of climate as well as the way forward. Chapter two (2) explores some thoughtful challenges of climate change on future development of Mankind. Chapter three (3) points out that the root causes of climate change is our craving for pleasure which results in excessive consumption of goods and services, the hallmark of our modern consumer society. Chapter four (4) provides some notes on public environmental relations and its perceptions with nature. It also discusses the spiritual dimensions of what and where nature is in the Anthropocene. Chapter five (5) provides an overview of the UNFCCC climate change strategies by identifying divergent opinions and the need. This chapter also identifies the disparaging arguments by the developing and developed worlds. Chapter six (6) explains the concepts, the primary causal factors and the indicators of changes in world climate.

The focus of Part II, *Climate Change and Natural Environment*, is presented in chapters seven (7) to thirteen (13) where variability and changes in climatic elements and their roles on environment, natural hazards, groundwater re-charge, water and forest resources are discussed. While chapter seven (7) presents the impacts of global climate change on water resources in Africa and the positions of African leaders in the global climate discourse, chapter eight (8) examines the influence of climate on groundwater re-charge in a part of Nigeria. Currently, it is widely known that high temperature and extreme rainfall events are very critical within the tropics. Chapter nine (9) measures the Land Surface Temperature (LST) variation in the Kesbewa Urban Council (KUC) area, Sri Lanka using thermal infrared (TIR) images to assess the role of various forms of green spaces, specifically urban and peri-urban agriculture and forestry (UPAF), on UHI.

Studies have shown that at the global level, the growing forest stock has been decreasing slightly with some regional differences and the forest is established to be good in carbon sequestration, but the amount of carbon released into the environment is greater than what the available forests could sink. Chapter ten (10) gives a global perspective of climate change on forest resources. As observed by the author, the changes in climate can result in excessive rainfall leading to flooding which can accentuate erosion and eventual submergence of human landscape. Chapter eleven (11) elaborates climate change as the main driver of the myriads of natural hazards that are being witnessed in the human landscape. Chapter twelve (12) which examines spatio-temporal patterns of climate variability in Sri Lanka reveals that the seasonal pattern has produced water surplus as well as water deficit areas.

The various environmental challenges confronting the world today would have been mitigated at an earliest stage if nations of the world had taken into account the effective and focused environmental monitoring programmes that are mainstreamed into national policies. Chapter thirteen (13) considers the basics of environmental monitoring and control as well as a brief review of some environmental monitoring and control programmes implemented in Nigeria, USA, Canada and some International Organizations. It also identifies adaptive management cycle as an effective approach in designing and implementing environmental monitoring and control programmes that are sustainable.

Food security is an important issue as it does not only affect people's livelihood but also affects national economic development and social stability. In Part III, *Climate Change and Livelihood*, chapters fourteen (14) to seventeen (17) present explanations for lack of food security, agriculture and urban water supply. Chapter fourteen (14) examines Nigerian agriculture within the context of environmental and sustainable development, while chapter fifteen (15) and sixteen (16) examine the impacts of climatic variability on food security and urban agriculture by exploring the current situation in the world with a special focus on Nigeria. All sectors of Nigeria's socio-economic development including the natural ecosystems, are vulnerable to climate change. The emergence of push cart water vendors, otherwise called Small Water Enterprises (SWE) in cities is a sign of the inefficient piped water supply system and a resilient strategy in climate change. Chapter seventeen (17) studies the characteristics of water vendors in the Sahelian city of Sokoto Nigeria with a view to offering solutions for sustainable urban water supply provision.

Understanding the effect of the changing climatic elements is very paramount because of its negative consequences, particularly on human health and migration. Chapter eighteen (18) and nineteen (19) examine the impacts of climatic variability and change on human health, particularly on perception of hyperthermia and malaria prevalence in Nigeria, while the global evidence and theory of the impacts of climate change on human migration as well as its impacts on poor rural women are presented in chapters twenty (20) and twenty-one (21) respectively.

The Part IV, *Climate Change and Development*, consists of nine (9) chapters. Chapter twenty-two (22) examines irrigation as a means to ensure sustainable agricultural production and food security under dry conditions that have been brought by climate change. The change in climate is one of the realities that is now and would continue to affect our lives in coming years. Chapter twenty-three (23) presents engineering and technological responses as resource efficiency in the fight against the climate. Obviously, less privileged marginalized people and poor countries are exposed to and vulnerable to all types of climate-related shocks, such as, human health, natural disasters and crop failure from reduced rainfall. The change in the climate conditions is one of the several important determinants of health dynamics of individuals and groups in human society. While chapter twenty-four (24) examines the impact of climate change on incidence of poverty in developing countries drawing instances from countries like China, Malawi, Uganda, Ecuador, and Bangladesh among others, chapter twenty-five (25) assesses the global issues

and challenges of climate change on human health.

Exponential growth of earth's human population and consequent development of lands and increasing energy demands are causing a doubling of carbon dioxide in the global atmosphere leading to climate variability and change. Consequently, the developing world will continue to face severe climatic risks in light of climate change. Chapter twenty-six (26) analyses the role of transportation sector in Greenhouse Gas (GHG) emission, in particular, Nigeria towards mitigating GHG emission from transportation and the implications of these on global greenhouse emission control programmes, while chapter twenty-seven (27) presents the governance of climate change in a city of Nigeria with a view of studying any observable changes and assessing urban strategies and policies on climate change adaptation and mitigation.

Climate plays a key role particularly in the tourism industry, which is one of the largest and fastest growing economic sectors. The impact of climate change on tourism is discussed in chapter twenty-eight (28), while chapter twenty-nine (29) examines population growth and displacement in reaction to climate change in Africa. Census organization in Nigeria, has been faced with lots of problems; in particular, the problem of omission of communities and the listing of settlements especially during the demarcation of Enumeration Area (EA) has been considered a major issue in previous censuses. Chapter thirty (30) attempts to explain the ways out of improving acceptability in the next census in Nigeria.

The last Part of this book, *Way Forward: Towards Sustainable and Livable Futures*, comprises ten (10) chapters. Chapter thirty-one (31) presents a paper on resilience to climate change in sustainable cities and chapter thirty-two (32) discusses drainage infrastructure as of vital importance, in a built environment where it is needed in the management of storm runoff and waste water. Studies have shown that transport such as traffic accidents, environmental noise, air pollution and greenhouse gas emissions has serious negative impacts, thus contributing to global warming. As climate change is projected to increase the intensity of extreme weather events and with serious negative implications on the transportation sector, particularly in the developing world, chapter thirty-three (33) focuses on the need for the transport community to develop approaches and solutions that simultaneously minimizes the impacts of climate through a strategy that builds, rebuilds, operates and maintains transport infrastructure.

Climate change adaptation and mitigation are presented in the remaining chapters of this book. Green energy from natural pigments and green marketing are seen as ways of mitigating the adverse effects of climate change. Chapter thirty-four (34) presents an overview of application of natural pigments in the photovoltaic devise, particularly the usage of natural pigments in dye sensitized solar cells (DSSCs). While creating a "Greener" Organization as a call for Green Human Resource Management for climate change mitigation is presented in chapter thirty-five (35), reasons for the adoption of green marketing by business firms, application of traditional marketing mix elements to green

marketing, and the golden rules of green marketing as antidotes to climate change are explained in chapter thirty-six (36).

Finally, climate is a fundamental element of the environment and a change will consequently cause a change in the entire environment, affecting other elements of the environment. Thus, explanations of the vulnerability and adaptation of farmers to climate change in Ikara Local Government Area of Kaduna State, Nigeria is presented in chapter thirty-seven (37), while chapter thirty-eight (38) discusses environmental mitigation strategies for pollution and climate change challenge in Nigeria. Implications of government policies on climate change are discussed in chapter thirty-nine (39) and the last chapter examines the effectiveness of the principle of integration of sustainable development to combating climate change.

The completion of this book would not have been possible without the direct and indirect efforts of a great number of individuals. Putting all these papers together was by no means an easy task. Even so, we are still aware that there are topics which we may have missed. The complexion of this book's contribution is more Afro-Asian than our 'global' theme deserves. Nevertheless, we want to pay tribute to the authors for their knowledge, experience and skills. It was a privilege to work with them.

S. L. Tilakasiri

Chapter 26

THE ROLE OF TRANSPORTATION IN GREENHOUSE GAS EMISSION AND MITIGATION STRATEGIES FOR REDUCING EMISSION FROM TRANSPORTATION

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Introduction

Transportation is an integral part of modern economy, which increasingly relies on a mobile workforce, distributed production and transportation of goods and passengers which are essentially enabled by vehicle technology, fuels and transportation infrastructure (Onokala, 2011). The relationship between transportation and the environment is paradoxical in nature. On one hand, while transportation support increasing mobility demands for passengers and freight, on the other side, the same transport activities due to the growing levels of motorization and congestion is imposing grave dangers on the environment through sustained increase in greenhouse emission (Jean-Paul and Claude, 2013). All forms of transportation are closely dependent on the usage of several forms and sources of energy. The relationship between transport and energy is a direct one, but subject to different interpretations since it concerns different transport modes, each having a specific performance level. There is often a compromise between speed and energy consumption, related to the desired economic returns. Passengers and high value goods can be transported by economies of scale, mainly those achieved by maritime transportation are linked to low levels of energy consumption per unit of mass being transported, but at a

low speed. Comparatively, air freight has high energy consumption levels, linked to high speed services. Almost all transportation modes depend on the internal combustion engine, for the majority of internal combustion engines, gasoline (C_8H_{18} ; four strokes Otto-cycle engines) serves as fuel, but other sources like methane (CH_4 ; gas turbines), diesel (mostly trucks) and kerosene (turbofans of jet planes) are used. These technologies of transportation system generally have been linked to greenhouse gas emission because they rely heavily on the combustion of hydrocarbons from vehicle engine. This chapter therefore examines the concept of greenhouse, the various ways transportation has influences the greenhouse gas emission, strategies for minimizing emission from transportation.

The Concept of Greenhouse

The greenhouse effect is real and helps to regulate the temperature of our planet. It is essential for life on Earth and is one of Earth's natural processes. Result of heatabsorption by greenhouse gases (GHG called because they effectively 'trap' heat in the lower atmosphere) in atmosphere and re-radiation downward of some of that heat (CO_2 ; CH_4 ; Nitrous Oxide; Sulphur Hexafluoride; Hydro fluorocarbons and Per fluorocarbons). A Green House Gas (GHG) is a gas in the atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases in earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide and ozone. Without greenhouse gases, the average temperature of Earth's surface would be about $15^\circ C$ ($27^\circ F$) colder than the present average of $14^\circ C$ ($57^\circ F$), (Jean-Paul and Claude, 2013). Figure 1 shows countries of the world and their contributions to global carbon emission.

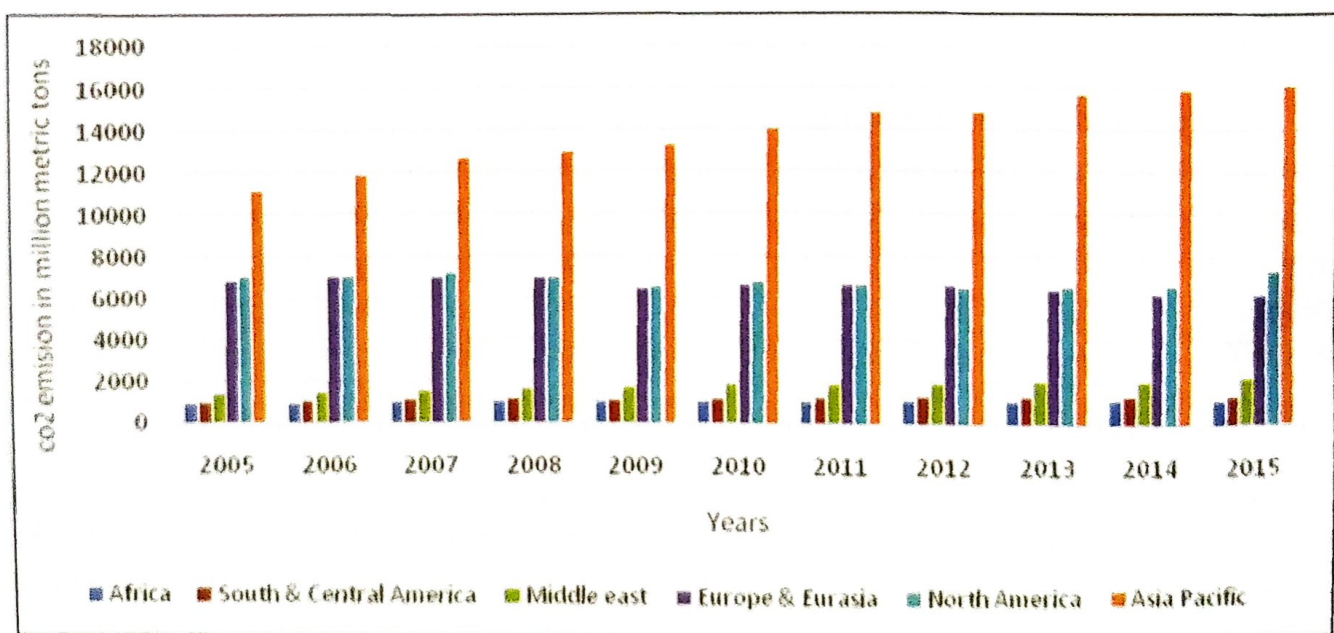


Figure 1: World Regional CO_2 Gas Emission between 2005 and 2015.

Source: <http://www.statista.com/statistics/205966/world-carbon-dioxide-emissions-by-region>.

Figure 1 shows that Asia Continent's contribution to the global emission is constantly high for past 11 years, followed by America. China is not only the highest contributor to the CO₂ emission in Asia but also worldwide, this is followed by America. The least contributor of global emission is Africa. There seems to be a strong relationship between global gas emission and the level of industrialization of different regions.

Transport Activities and Dimensions of Environmental Impacts

Transportation activities whether at land, air or water based support increasing mobility demands for passengers and freight within the local, regional and national setting. Due to the growing levels of motorization and traffic congestion in cities, the transportation sector is becoming increasingly linked to the greenhouse emissions (OECD, 1988, as reported in Jean-Paul and Claude, 2013). The most important impacts of transport on the environment relate to climate change, air quality, noise, water quality, soil quality, biodiversity and landtake (*ibid*).

Transport Influence on Climate change

The activities of the transport industry release several million tons of gases each year into the atmosphere. These include lead (Pb), carbon monoxide (CO), carbon dioxide (CO₂; not a pollutant), methane (CH₄), nitrogen oxides (NO_x), nitrous oxide (N₂O), chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), silicon tetrafluoride (SF₆), benzene and volatile components (BTX), heavy metals (zinc, chrome, copper and cadmium) and particulate matters (ash, dust). Transportation as a human activity has had a great effect of the greenhouse gas emission like carbon dioxide (CO₂), methane (CH₄) and nitrogen oxide (N₂O). Over the past three decades, carbon dioxide emissions from transportation related activities have risen faster than those from other sectors and are projected to rise more rapidly in the future (Onokala 2011). Currently, carbon dioxide (CO₂) represent the largest proportion of Green House Emission (CGHs) covered by the Kyoto protocol. From 1990-2004, the carbon dioxide emission from the world's transportation has risen by 29 per cent in industrialized countries and 61 per cent in other countries in transition (IEA, 2006). In Nigeria, according to Earth's Trend (2003) as reported in Onokala (2011), the transportation sector contributed 36 per cent of the total carbon dioxide emission arising from anthropogenic activities, while IEA (2006), reports that the transport sector in Nigeria contributed 42.9 per cent of the total CO₂ emission due to anthropogenic activities. This means that the contribution of CO₂ emissions by the transport sector in Nigeria is on the increase. The gaseous chemical is greatly contributing to the global climate change through the following environmental impacts

Transport and Soil quality

The environmental impact of transportation on soil consists of soil erosion and soil contamination. Coastal transport facilities have significant impacts on soil erosion.

Shipping activities are modifying the scale and scope of wave actions leading to serious damage in confined channels such as river banks. The removal of earth's surface for highway construction or loosening surface grades for port and airport developments have led to important loss of fertile and productive soils. Soil contamination can occur through the use of toxic materials by the transport industry. Fuel and oil spills from motor vehicles are washed on road sides and enter the soil. Chemicals used for the preservation of railroad ties may enter into the soil. Hazardous materials and heavy metals have been found in areas contiguous to railroads, ports and airports.

Transport and Biodiversity

Transportation also influences natural vegetation. The need for construction materials and the development of land-based transportation has led to deforestation. Many transport routes have required drained land, thus reducing wetland areas and driving-out water plant species. The need to maintain road and rail right-of-way or to stabilize slope along transport facilities has resulted in restricting growth of certain plants or has produced changes in plants with the introduction of new species different from those which originally grew in the areas. Many animal species are becoming extinct as a result of changes in their natural habitats and reduction of ranges.

Transport and Landtakes

Transportation facilities have an impact on the urban landscape. The development of port and airport infrastructure is significant features of the urban and peri-urban built environment. Social and economic cohesion can be severed when new transport facilities such as elevated train and highway structures cut across an existing urban community. Arteries or transport terminals can define urban borders and produce segregation. Major transport facilities can affect the quality of urban life by creating physical barriers, increasing noise levels, generating odors, reducing urban aesthetic and affecting the built heritage.

Transport and Impacts on Water Bodies

Transportation contributes significantly to the pollution of the hydrosphere in various ways ranging from air pollution fallouts to the construction and maintenance of infrastructure such as roads, railways and ports. In some areas transportation may account for up to 25 per cent of nitrogen fallouts in water. It is estimated that acid rains may account for more than 75 per cent of the growth of acidity of lakes, (Jean-Paul and Claude, 2013). Since fallouts are a continuous accumulation and occur over a longer period than most water pollution sources, the most notable and destructive fallouts are sulfuric and nitric acids that may alter the pH of water if they are present in sufficient concentrations. Several northeastern United States and eastern Canadian lakes have seen their entire fish population destroyed as a result of increased acidity levels. It also includes damage to forests like reduced photosynthesis (sparse foliage) and acidified soils (limited nutrients). Nitrous oxides may affect the ecological balance of marine life by favoring algae blooms. Other fallouts such

as HC/VOC and lead are poisonous and may disrupt marine life if they accumulate in the aquatic food chain. A long term accumulation of air pollution fallouts of various natures will contaminate and disrupt whole aquatic ecosystems.

Oil products residuals carried by tankers are the major source of marine discharges. It is estimated that for every million tons of oil carried, one ton is spilled through washouts. From 1989 to 1992, 105 accidental oil spills by tankers were accounted worldwide, totaling 991,000 tons of oil being spilled. Annually, an average of 1.1 million tons of oil comes from discharges and 400,000 tons are spilled (Jean-Paul and Claude, 2013). The Exxon Valdez oil spill is a well-known example of such an occurrence.

Since road infrastructure (parking lots, roads, drainage systems) occupy a significant land surface in developed countries, it is the major source of runoffs. For instance, while highways occupy 5-8 per cent of the urban catchment area, it contributes for as much as 50 per cent of the total suspended solids, 16 per cent of the total HC and 75 per cent of the total metal inputs to a receiving stream. Runoffs from infrastructure will alter the turbidity and the oxygen level of water (warm water holds less oxygen), and contaminate the food chain. It may increase the eutrophication process of several lakes. During early springtime, nearly all the salt accumulated will be released in the hydrographic system where it will contaminate ground water and interfere with the growth of plants and the reproduction cycle of aquatic life. Infrastructure runoffs collected by the sewage system of urban areas often converge at evacuation points and contaminate whole hydrographic systems at high concentrations. Jean-Paul and Claude (2013), noted that most cities have 30 to 70 per cent of their surface occupied by roads and parking space. They thus represent important sources of runoffs. Several transportation infrastructures have important territorial handholds. When a transportation infrastructure is built over a hydrological environment like a river, wetland or a coastal area, disruption occurs. The maintenance of transportation infrastructure, particularly harbor and waterways (dredging) also, have a significant impact.

Air Pollutants Emitted by Transport System

Many pollutants identified as being closely related to transportation, for example carbon monoxide emission (which is the result of the incomplete combustion of hydrocarbons) accounted for about 70 to 90 per cent by transportation system. Carbon monoxide is present near major traffic intensive arterials in urban areas. Since carbon monoxide is not chemically stable, direct global effects are strongly limited. Indirectly, carbon monoxide contributes to the formation of greenhouse gases as a catalyst. Energy production and transportation still remain the main contributors to CO₂ even in United Kingdom (Taiwo, 2006). Table 1 shows emission generated in U.K. by different sources in percentage as observed in the table, energy is the main source followed by Transport sector.

Table 1: UK's CO₂ Emission by Sources.

Sources	Years							
	1995	2000	2003	2004	2005	2006	2007	2008
Transport	18.56	20.11	21.05	21.22	21.42	21.62	21.78	22.34
Energy Supply	41.21	38.28	36.75	39.03	38.68	38.97	39.64	39.53
Business	18.39	18.68	18.79	17.04	16.68	16.65	16.37	16.19
Residential	13.52	14.70	15.77	15.58	15.84	15.25	14.71	14.25
Other	8.32	8.23	7.63	7.12	7.38	7.52	7.50	7.69

Source: University of Newcastle (2013).

Nitrogen Oxide (NO or NO₂) a by-product of combustion accounts for about 45 to 50 per cent of total greenhouse emissions. Nitrogen Oxides are not very harmful to humans (particularly NO), but when released from an internal combustion engine, high concentrations are often toxic. Nitrogen Oxides are known to be associated with several global effects and have increased at a rate of 0.2 per cent annually over the last decades. They are a catalyst for ozone, a component of acid rain and a component of smog. Depositions of Nitrogen Oxides influence the nitrate cycle, particularly in water where it influences algae blooms. Hydrocarbons (HC) are a group of chemical compound composed of carbon and hydrogen. They are mostly the result of the incomplete combustion of gasoline. They include methane (CH₄), gasoline (C₈H₁₈) and diesel vapors, benzene (C₆H₆), formaldehyde (CH₂O), butadiene (C₄H₆) and acetaldehyde (CH₃CHO). Transportation accounts from 40 to 50 per cent of total emissions of HC/VOC. They can be emitted by incomplete combustion (70%), during refueling (10%) or by evaporation from storage units (20%), particularly gas tanks. All HC/VOC have several global effects. They are components of smog, catalysts for ozone and components of acid rain.

Particulates include various solids in suspension in the atmosphere such as smoke, soot, and dust and results of the incomplete combustion of fossil fuels, notably coal. Transportation accounts for around 25 per cent of total emissions of particulates. Diesel engines are the main emitters. Other important sources are thermal power plants using coal. Mixture of solid and liquid fog and smoke particles formed through the accumulation of carbon monoxide, ozone, HC/VOC, nitrogen oxides, sulfur oxide, water, particulates, and other chemical pollutants. Photochemical smog are those with a higher concentration of ozone and HC/VOC. Several large cities (like Los Angeles, Tokyo and Mexico) have serious smog problems to the point that emissions reduction policies are established. Smog impairs visibility considerably and causes different annoyances (odors, irritations, etc.). Because of its components, smog is highly associated with acid rains and greenhouse effects. Lead is a toxic metal mainly used as an anti-knock agent in gasoline (Lead tetraethyl – Pb (C₂H₅)₄) and in batteries (lead dioxide as an anode and lead as a cathode). Until recently, lead tetraethyl was a main source of atmospheric lead emissions in developing countries. This contribution has dropped in absolute numbers but still accounts for 30 to 40 per cent

of total emissions. Batteries are now an important source of lead for transportation, but a very limited amount of this lead is carried through the atmosphere (see water pollution). Extremely poisonous metal. When accumulated in the atmosphere Lead can also be transported in the atmosphere over wide distances.

Odors are the subjective perception of the sense of smell. They exist in different "shapes" of odors perceived as pleasant, neutral, or unpleasant. Diesel and gasoline engines are the major sources of odors accounted for by transportation. Carbon dioxide composes 0.04 per cent of the atmosphere, whenever there is combustion (oxidation) of fossil fuels, there is an emission of carbon dioxide. Important temperature regulator for the atmosphere, keeping it at +15°C instead of -15°C if carbon dioxide was absent. Transportation accounts for around 30 per cent of total carbon dioxide emissions in developed countries (15% worldwide). About 66 per cent of carbon dioxide emissions from transportation come from the combustion of gasoline, 16 per cent from diesel fuel and 15 per cent from jet fuel. Carbon dioxide emissions by transportation have the following modal breakdown: cars (43%), light trucks (20%), heavy trucks (14%), airplanes (14%), rail and marine (7%) and non-oil based (2%). Growing quantities of carbon dioxide in the atmosphere are assumed to be linked with the greenhouse effect.

Sulfur dioxide is a heavy, colorless gas with a strong odor. It is the result of the combustion of fossil fuels like coal and hydrocarbons. Transportation accounts for around 5 per cent of total sulfur dioxide emissions. Sulfur dioxide has a counter effect on greenhouse gases by blocking radiation. This effect is significant enough to be included in climatic models. Ozone is a pale blue gas with a strong odor and a powerful oxidant. It is the most common photochemical oxidant. Ozone is created naturally in the high atmosphere when an oxygen molecule is broken apart by ultraviolet radiation and combines with another oxygen molecule. Ozone is also the result of the action of light over a mixture of HC/VOC and nitrogen oxides in the lower atmosphere. It is thus directly linked with transport emissions, notably in urban areas. Ozone is poisonous, hampers breathing and irritates the eyes and the respiratory system at concentrations higher than 0.15 ppm. The normal/natural concentration is around 0.01 ppm at ground levels.

Sulfuric acid is a corrosive, oily colorless liquid, which forms when sulfur oxides and water vapors are mixed. The level of formation of acid (sulfuric and nitric) is influenced by the level of exposition to sun light. It may also exist in dry form, which is called acid deposition. When dissolved in water, sulfuric and nitric acids lower the pH (higher concentrations of hydrogen ions). The standard pH of fresh water ranges between 6.5 and 7.5. Since transportation accounts for 5 per cent of sulfur dioxide emissions, 45 per cent of nitrogen oxides emissions and for 40 per cent of HC/HOV emissions, sources may range from 10 to 30 per cent of acid rains, depending on regions. This figure is of 25 per cent in Western Europe (Jean-Paul and Claude, 2013). CFCs are colorless and poison-less gases (or liquids). They are very stable, non-flammable and non-toxic components and they have been widely used as dispersing agents (aerosols) or as refrigerants (notably Freon, R-12). For transportation, motor vehicle air-conditioning systems are the main source and

account for about 20 per cent of all CFCs emissions. In fact, during its life cycle, an air-conditioning system will release 100 per cent of its CFCs in the atmosphere. With recent legislations, CFCs emissions have considerably subsided in developed countries but not in developing countries. Because of its chemical properties (stable and non-toxic), CFCs have no noticed effects on living organisms. Current concentrations of CFCs in the atmosphere reach about 0.35 ppm (all types of CFCs) but the most widely used type, R12, has 20,000 times more infrared absorbency than carbon dioxide. Thus one ton of Freon will have the same greenhouse effect than 2,000 tons of carbon dioxide. CFCs reduce the concentration of stratospheric ozone, which absorbs harmful ultraviolet rays. CFCs may stay in the atmosphere from 70 to 200 years, due to their extremely stable properties. They are a long term component of the atmosphere. CFCs emitted in the 1990s are likely to damage the ozone layer for 200 years (*ibid*). Even though transportation contributes significantly to the emission of air pollutants new technologies (catalytic converters) and policies have reduced emissions significantly, notably in the United States.

Noise Pollution Emitted by Transport System

Road Transportation Noise: Road accounts for approximately 70 per cent of total noise emissions by transportation. It must be noted that different road transportation modes have different scales of noise emissions. Main sources of noise come from the engine and the friction of the wheels over the road surface. Further, travel speed and the intensity of traffic are directly linked with its intensity of noise. For instance, one truck moving at 90 km/hr makes as much noise as 28 cars moving at the same speed. Ambient noise is a frequent result of road transportation in urban areas. The addition of all the noise generated by cars, trucks and buses creates a permanent ambient noise (ranging from 45 to 65 db) that impairs the quality of life in urban areas and thus the property values of residences. Nearby road arterials, ambient noise is replaced by direct noise and vibrations. The acoustics created by the surrounding environment (hills, buildings, trees, open space, etc.) alleviate or worsen local conditions. Noise level grows arithmetically with speed. For instance a car traveling at 20 km/hr emits 55 db of rolling noise, at 40 km/hr 65 db, at 80 km/hr 75 db and at 100 km/hr 80 db. Available evidence underlines that around 45 per cent of the population in developed countries live in high levels of noise intensity (over 55 db) generated by road transportation. Along major highway arterials in inter-urban areas, noise emissions are likely to alter the living environment of wildlife species, (Jean-Paul and Claude, 2013).

Rail Transportation Noise: Rail accounts for 10 per cent of total noise emissions by transportation. Noise comes from the engine (mostly diesel), the friction of wheels over the rails, and whistle blowing. Furthermore, when trains are moving at high speed, acoustic noise becomes more important than other sources. Depending of the train aerodynamics, noise emissions are from 50 to 80 times the logarithm of train speed and become significant at speeds higher than 200 km/hr. When rail / truck transshipment is involved, the convergence of trucks towards rail yards provides an additional source of noise

related to rail transportation activities. Around 3 per cent of the population may be exposed to high noise levels from rail transportation in OECD countries. The level of exposure is obviously related to the importance and location of rail transportation infrastructure. The most important noise impacts of rail operations are in urban areas where the majority transshipment functions are performed. Furthermore, rail terminals are often located in the central and high density areas of cities.

Air Transportation Noise: Air transportation accounts for 20 per cent of total noise emissions by transportation, (Ogunmodede, 2004). As air transportation took a growing importance in inter-city transportation and that jet engines were predominantly used, noise emissions have increased significantly to the point of becoming a major concern near airports. Noise comes from the jet engine, the aerodynamic friction and ground craft operations. Even if the turbofan is the least noisy jet propulsion technology available, aircrafts are an acute source of noise in several urban areas. Noise from aircraft operation is known to have direct impact on property values around airports. This effect is distributed along major approach and takeoff lanes. The establishment of heavily used flight paths between major cities creates noise corridors where ambient noise is almost prevalent. This is particularly noted when those corridors are over densely populated areas.

The environmental impact of aviation occurs because aircraft engines emit heat, noise, particulates and gases which contribute to climate change and global dimming. Despite emission reductions from automobiles and more fuel-efficient and less polluting turbofan and turboprop engines, the rapid growth of air travel in recent years contributes to an increase in total pollution attributable to aviation. From 1992 to 2005, passenger kilometers increased 5.2 per cent per year. And in the European Union, greenhouse gas emissions from aviation increased by 87 per cent between 1990 and 2006, (Jean-Paul and Claude, 2013). There is an ongoing debate about possible taxation of air travel and the inclusion of aviation in an emissions trading scheme, with a view to ensuring that the total external costs of aviation are taken into account.

Transportation Emission and its Impacts in Nigeria

Transport is a known source of many air pollutants in most Nigerian cities. An EIA study carried out by Mechedec Construction (Nigeria) Ltd on behalf of Lagos Urban Transport Project (LUTP) in 1996 provided a description of atmospheric emissions of pollutants from three sources: stationary, mobile and industry. The profile of metropolitan Lagos by type and source reveals that road traffic is the major source of air pollution in the state. The reason for this is not far-fetched 60 per cent of all the activities are carried out using motor vehicles. Table 2 shows the estimated atmospheric emission from different sources, mt per year.

Table 2: Estimated Atmospheric Emission from Different Sources, Mt Per Year.

Source	Particulates	Sulphur Dioxide	Nitrous Oxide	Carbon Monoxides	VOCS
Stationary power plant	2	10	23	5	2
Industry/ Commercial	205	7290	4811	467	29
Domestic	6049	8618	7794	986	513
Mobile	-	-	-	-	-
Road Vehicles	4084	3378	29700	308840	52741
Rail Movement	1	4	3	3	2
Aircraft	27	33	297	1794	1137
Marine	6	460	139	21	70
Total	41118	3876	30139	310618	53950

Source: Mechelec Construction (Nigeria Ltd., 1996).

As observed in Table 3, air pollutants in Lagos state include Nitrogen Oxides, (NO, NO₂), SO, particulate matter, other atmospheric pollutants like dust generated during maintenance works through material handling, vehicle movements on loosely surfaced roads, transportation of uncovered construction materials like sand and exhaust emissions from static equipment made their respective significant contributions to the level of pollutants in the air. However, the volume and composition of vehicle emission depends on a variety of factors including like vehicle age, level of engine maintenance, road condition and engine temperature.

Transport as a major contribution to pollution in urban environment. According to Filani (2000), transport is believed to be one of the major defilers of the environment. Its effects on the health and people, community values and environmental ecology to say the least are deplorable. The effects manifest in the form of atmospheric pollution, noise pollution and degrading aesthetics" (Ogunmodede 2004). Urban traffic is characterized by many poorly maintained and sometimes unserviceable vehicles. These vehicles produced carbon-monoxide, unburnt hydrocarbons, nitrogen oxides and aldehydes. The automobiles are considered as the major source of more that 50 per cent of the pollution in Nigerian urban environment (Ogunsanya, 1985). In a similar way, while Ameyan (2002) reveals that road transport contributes more than 60 per cent of the emission with the exception of sulphur oxide and particular matter in the 1960s. The reason given by Ameyan (2002) why Nigeria is more polluted more than the industrialized countries include the fact that:

- i. Many vehicles are in poor conditions, following economic downturn of the 1980s, a barrage of vehicles which are unable to meet emission standards in Europe and elsewhere have flooded the country.
- ii. The use of low quality fuels.
- iii. More vehicles are concentrated in few large cities (Ogunmodede 2004).

The contributions of the transport sector to the total pollution in Nigeria are as shown in Table 3:

Table 3: Percentage Contribution of the Transport Sector to the Man-made Emission in Nigeria, 1998).

Emission Types	Nigeria	Lagos State	The United Kingdom	The Netherlands
CO ₂	40.81	45.65	N/A	N/A
CO	82.80	86.58	85	70
NO _x	58.60	61.31	45	54
SO ₂	97.74	26.91	5	N/A
VOC	21.97	98.77	N/A	N/A
N ₂ O	77.06	40.40	N/A	N/A
PM	77.02	83.41	N/A	N/A
Pb	97.76	100.00	N/A	N/A

Source: Obioh *et al.* (1994) was cited in Ogunmodede (2004).

Transport is responsible for most of the lead concentration which appear in the blood stream of most urban dwellers. Undoubtedly, transport related air pollution have been found to be more acute over congested urban streets where pollutants may produce conditions that are harmful to human health (Hoyle and Knowles, 1998).

Transport Environmental Pollution and Human Health

The various transport emissions have serious consequences on human health. For example, sulphur dioxide effect on man is the result of irritation by gas itself and product form in the atmosphere. 95 per cent of the inhaled high concentration of SO₂ is absorbed in the upper part of the respiratory system. It acts as an irritant and increase symptoms for patient and bronchitis, emphysema, chronic lung diseases and pulmonary fibrosis. Carbon monoxide has a unique mechanism of action differing from other air pollutants. Most common air pollutants irritate the respiratory tract but CO passes directly through the lung into the blood stream. In the bleed stream, CO shows a high affinity for the hemoglobin in the blood leading to brain damage, impaired perception and asphyxiation or in a lower doses weakness, fatigue, headaches and nausea. Allowable concentrations of CO is 100 mg/m³ for 15 min, 60 mg/m³ for 30 mg/m³ I hour, 10mg/m³ for 8 hours (Okolo, 2006).

Toxic air pollutants are associated with cancer, cardiovascular, respiratory and neurological diseases. Carbon monoxide (CO) when inhale affects bloodstream, reduces the availability of oxygen and can be extremely harmful to public health. An emission of nitrogen dioxide (NO₂) from transportation sources reduces lung function, affects the respiratory immune defense system and increases the risk of respiratory problems. The physical and chemical properties of particulates are associated with health risks such as respiratory problems, skin irritations, eyes inflammations, blood clotting and various types of allergies.

Oxides of nitrogen cause eye irritation, respiratory tract diseases, lung damage, decreased pulmonary functions and hearing stress. Allowed limits of concentration is 400 ug/m³ for 1 hour 150 ug/m³ for 24 hours. Nitric oxide in large concentration will react with haemoglobin in a similar way as carbon monoxide, thus resulting in oxygen deprivation effects. Symptoms of acute poisoning often expressed by people in traffic jams include headache, loss of vision, decrease muscular coordination and nausea.

Lead is another pollutant, which constitutes health hazards, forty percent of the gasoline used contains lead and the blood lead level in some studies is found to be 30 ug/dl. According to Okolo (2006), an action plan formulated between Nigeria and her West African neighbors in November 2001 is to the effect that leaded gasoline will be phased out by 2004.

Arising from the health implication of the air pollution is that of the economics of it. It is believed that the cost of air pollution in Lagos would have increased medical costs such as medicines and hospital visits and on productivity losses. It is a common occurrence that people who are sick lose days from work and mothers who stay at home to take care of the children who get sick. The pleasant news is that Nigeria no longer import, produce or market leaded fuel since December 2004. The cost of air pollution in terms of damage to human health, vegetation, and buildings and of reduced visibility is perceived as a serious problem in many developing country cities. World Bank (2002) report confirms that air quality is poorer than in most developed cities of equivalent size. The adverse effects of air pollution often fall disproportionately on the poor, compounding the impacts from other environmental problem in developing countries such as lack of clean water and sanitation.

Strategies for Minimizing Emission from Transportation

The number of transport vehicles around the world today is quite high and each one is a potential source of air pollution especially in large urban cities. The amount of pollution that are produced together can create a very big problems, this therefore create the necessity to evolve mitigating measures to reduce the impact of transport emission on the green house emission. Some of these measures include:

I Mandatory use of catalytic converters. A catalytic converter is a device used to reduce the toxicity of the emissions from an internal combustion engines. Today it has wide application areas in order to reduce emission from car engines, trucks, trains, buses and other engine-equipped machines. The catalytic converters performs three way simultaneous tasks of (reducing nitrogen oxides to nitrogen and oxygen: $2\text{NO}_x + \text{O}_2 \rightarrow x\text{N}_2$, oxidation of carbon monoxide to carbon dioxide: $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$ and oxidation of unburnt non-methane hydrocarbons (HC) to carbon dioxide and water: $\text{C}_x\text{H}_y + n\text{O}_2 \rightarrow x\text{C} + m\text{H}_2\text{O}$. These three reactions occur most efficiently when the catalytic converter receives exhaust from an engine running at the stoichiometric point of 14.7 parts oxygen to 1 part fuel. When there is more oxygen than required, then the system is said to be running lean and

the system is in oxidizing condition. In that case, the converter's two oxidizing reactions (oxidation of CO and Hydrocarbons) are favored, at the expense of the reducing reaction. When there is excessive fuel, then engine is running rich. The reduction of NOx is favored at the expense of CO and HC oxidation.

II Rigorous inspection and maintenance of the vehicles: it is indeed very important for the engine of a vehicle to be in a very good condition as this will ensure that the pollutants emitted to the environment from such vehicle is very limited as the engine operates on a very effective and efficient level.

III Introduction of alternative fuels with environmentally friendly emissions: with the rising emission from transport at alarming rates, nine European cities: Amsterdam, Barcelona, Hamburg, London, Luxemburg, Madrid, Porto, Stockholm and Stuttgart have committed themselves to Clean Urban Transport for Europe (CUTE). Demonstration project in introducing fuel cell powered city buses. With hydrogen- based fuel cell technology, vehicle emission will tend to zero. A combination of this "cleaner" alternative with petrol will reduce pollutants. The Nigerian government has launched the alternative fuel project in 2005. Table 4 shows the relative advantages and disadvantages of some alternative fuels.

Table 4: The Relative Advantages and Disadvantages of Some Alternative Fuels.

Alternative Fuel	Advantages	Disadvantages
Natural Gas	<ul style="list-style-type: none"> • Low Nox emission compared to advanced diesel engines • Very low emission compared to diesel • Zero sulphate and SO₂ emission 	<ul style="list-style-type: none"> • More complex refueling system • 4-times larger tank requirements • Reduced engine efficiency • Increased methane emission
Alcohol	<ul style="list-style-type: none"> • High octate number • Low Nox emission • Zero sulphate & SO₂ emission • Low evaporative loses 	<ul style="list-style-type: none"> • Cold start problem • Increased odor • More corrosive than hydrocarbons • Larger fuel tank • Safety and handling problems
Dimethyl Ether	<ul style="list-style-type: none"> • Little modification to diesel engine requirements • Very low particle emission • Zero sulphate & SO₂ Emission • Low engine noise • Low NOx levels without after treatment 	<ul style="list-style-type: none"> • Low viscosity • The injection system need to be developed
Biodiesel	<ul style="list-style-type: none"> • High octate number • Good lubricity • Zero sulphate& SO₂ emission • Particulate of low toxicity (same mass emission) 	<ul style="list-style-type: none"> • There are corrosion properties • Low heating value • Higher freezing points • Increase NOx emission and • Increased odour

Source: Okolo (2006).

IV Developing Vehicle Emission Standard: for the preparation of an emission projection, it is important to make use of the experience and results of existing and new initiatives within international conventions. At the European level a comprehensive package of policy measures to reduce such emission have been initiated through the European Climate Change Programme (ECCP). Each of the 25 EU members states have also put in place its own domestic actions that built on the ECCP measures or compliment them. The ECCP is a multi-stakeholders consultative prices that has brought together all relevant players such as the commission national experts, industry and NGO community. Stakeholders' involvement is an essential element of the ECCP because it enables the programme to draw a broad spectrum of expertise and help builds consensus, thereby facilitating the implementation of the resulting policies and measures. Developing nations like Nigeria could walk the same route by developing that will enhance clean air and clean environment. There is need to establish a national ceiling for at least four pollutants: Sulphur dioxide (SO₂), Nitrogen Oxide (NO_x), Volatile Organic Compounds (VOC) and Carbon Monoxide (CO), causing acidification, eutrophication and tropospheric ozone formation. The deposition of acidifying pollutants (SO₂ & NO_x) onto vegetation, surface waters, soils, buildings and monuments reduces the alkalinity of Lakes Rivers and has serious effects on biological life. Acidification also makes many forests vulnerable to drought, diseases and harmful insects. Nitrogen supply to the soil is critical for plant nutrients. However, plants vary in their needs for nitrogen. The deposition of NO_x from the atmosphere leads to changes in terrestrial and water ecosystems, thereby altering vegetation and biodiversity.

Table 5: European Emission Standards (in gramme per kilometer).

Year	1970	1972	1976	1980	1984	1988	1992	1996	2000	2005	2010
CO ₂	N/A	-	-	-	-	-	-	200	180	140	120
CO	N/A	60	25	21	15	7	2.72	22	2	1	-
HC	N/A	15	8	7	5	2.5	0.97	0.5	0.02	0.1	-
NO _x	N/A	-	-	-	-	-	-	-	0.25	0.08	-

Source: Okolo (2006).

To put in place a National Emission Standard (NES), certain legislation must exists. However, the first step towards this goal should be to establish a technical committee that will examine the technical feasibility of attaining whatever limit values which they will set, taking into consideration the followings

- Determination of different limit values for emissions by petrol and diesel cars using the EU standard as a guide (that tax incentive be granted to car importers and manufacturers to encourage compliance with whatever new limits that are developed before the set date for full implementation) of carbon monoxide, of unburnt hydrocarbons, of nitrogen oxides, and specifically for diesel engines, limits values for particulate pollutants.

- Determination of the range of vehicles affected by the emission standards and possible and possible need for differential standards with terminal dates.
- Determination of the necessary technologies needed for the successful launching and compliance with the standard. For example, actions needed in order to guarantee the availability of the following on the market: monitoring equipment and spare parts, good quality unleaded petrol, suitable lubricants etc.
- Determinations of incentives that will encourage stakeholders comply with these emission standards.
- Determination of the costs and benefits of a significant reduction in the fuel consumption of cars and analysis of the instrument available to achieve this and
- Determination of the nature of enlightenment campaign needed.

V. While in many cases technologies are available to control emissions, the main obstacles are lack of economic ability and the political will to do so. It is also imperative for government to discourage as much as possible the importation of old technology such as used cars from overseas (*Tokunbo* cars). Because, presently the average ages of *Tokunbo* cars that ply Nigeria roads are about 15 years old. Furthermore, there will the need to put in a place a system for close cooperation and coordination amongst inter-agency stakeholders, an administrative body empower to deal with the various aspects urban area in relation to transportation, the motor vehicle and public education as a road transport users may be instituted.

Conclusion

This chapter has discussed the concept of greenhouse, the influence of transportation on climate change, transportation emission and its impacts in Nigeria and strategies for minimizing emission from transportation. The need to raise awareness about the role of transportation in Green House Gas Emission is an important and urgent task for the transportation planners and geographers, it is only then that the mitigation strategies itemized above can be successfully implemented.

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