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Review paper

Developing Land-use Transport Model for Climate Change Mitigation and Adoption Planning in Nigeria

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ABSTRACT: The Paris Agreement aims to restrict human-caused climate change to less than 2°C, to adapt to climate risks, and to increase the world's ability to cope with climate change. Because cities account for a large amount of global greenhouse gas emissions, achieving this target will entail extraordinary reductions in greenhouse gas emissions as well as a thorough rethinking of the built environment. With the Paris Agreement's rapid transition to a more sustainable future in mind, this presents a significant challenge for urban land-use and transportation planning and the use of land-use transportation models (LUTM). Land-use and transportation modeling tools are essential for Nigerian cities to plan for a low-carbon, environmentally sustainable future, according to this study.

Recently developed urban integrated assessments, which include land use and transportation models with other environmental models of greenhouse gas emissions and climate hazards, show potential as platforms for evaluating the viability of urban policies in reaching the goals of the Paris Agreement. This research contends that land-use and transportation modeling tools are crucial for assisting in the development of a low-carbon, resilient future. An emerging field known as "urban integrated assessment," which integrates land-use, transportation, and other environmental models to calculate greenhouse gas emissions and climate hazards, has enormous potential for assessing city policies' ability to meet the Paris Agreement's climate change reduction targets. The article describes the problems that must be solved in order for the LUTM community to attain these goals. Adoption of new modeling approaches will be crucial in order to effectively portray rapid social and technical change and simultaneously assess the resilience and sustainability implications of various land-use and transportation plans. More complicated models for detailed design must be combined with smaller models for experimenting with various change situations. To allow these tools to be used by various stakeholders in order to explore urban futures and create radical urban transitions in multiple and interdependent urban sectors, multi-stakeholder approaches will be necessary.

Keywords: Urban modeling, transport, climate change, transitions, integrated assessment

INTRODUCTION

The Paris Agreement, signed in December 2015, entered into force on November 4, 2016. (United Nations Framework Convention on Climate Change, 2015). The accord is a global vow to "maintain efforts" to limit global warming to 1.5 degrees Celsius and 2 degrees Celsius over pre-industrial levels (ibid). Despite the fact that governments have committed to cut carbon dioxide (CO2) and other greenhouse gas (GHG) emissions, it is uncertain how the agreement will affect future policy and practice. Countries have made relatively limited progress in

lowering emissions since the inaugural United Nations Climate Change Conference in 1995. According to Rogelj et al. (2016), there must be "a significant increase or over-delivery on current [national GHG reduction promises] in order to retain a reasonable possibility of reaching the goal of keeping warming well below 2 degrees Celsius." More over 20% of the remaining carbon budget for the 2°C objective has been emitted since 2010.

Anderson (2015) discovered that in order to avoid a 2°C temperature rise (650Gt), CO2 emissions must be lowered by 10% per year by 2025, with this rate continuing until CO_2 is eliminated from the energy systems of developed countries by 2035. (ibid). The Paris Deal, a more ambitious EU proposal for a worldwide climate agreement, is on track to cut global emissions by 40% by 2030.

In order to develop effective climate change policies in the future, decision-makers and the general public must recognize the accords and understand what they represent in practice. According to Rockström et al. (2016), who suggested an ambitious plan to reduce emissions by half every decade in all sectors of the economy, rapid decarbonization may be done even with the use of "negative emission" technology to remove GHGs from the atmosphere.

The present federal government promises tabled at the Paris COP, according to Anderson (2015) and Rockström et al. (2016), would result in a warming of approximately 5°C, much above the level at which experts agree that climate change will become severe and unpredictable (2017). Along with the national government meeting that resulted in the Paris Agreement, 1000 city leaders from around the world convened to agree on local-level initiatives to decrease emissions and improve resilience (UCLG, 2015).

One of these was a solid promise to go above and beyond the international agreement's aims, while also exploring measures to assist the earth in adapting and recovering. CO2 emissions are concentrated in cities and urban areas, which serve as a focal point for mitigation initiatives. Cities, on the other hand, must be prepared to deal with a projected 2°C rise in global temperatures. Cities will play an important role in demonstrating options and learning from one another on an international scale to address climate change mitigation and adaptation difficulties (ICLEI, 2016). Reducing GHG emissions may result in additional benefits such as cleaner air, more green space, increased resilience, and a higher overall level of living (Stern, 2007).

Climate change policymakers have a wide range of issues in dealing with climate and mitigating its effects. The extent of adaptation is uncertain beyond 3°C of global warming, and its limits must be defined by cost studies (UNFCC, 2011). Cities require significantly more precise knowledge on the effects and tensions of policy decisions within their jurisdiction to assist them make decisions, whereas global policymakers require a broad understanding of the ramifications (Dawson, 2011). Without taking into account factors like as land use and transportation, the overall package of alternatives would be incomplete (Walsh et al., 2011; Revi et al., 2014).

Another consideration is that actions to reduce the risks of a warmer world have negative consequences in terms of GHG emissions, economic performance and social outcomes (Dawson, 2011); therefore, there are trade-offs to be made when considering adaptation and mitigation strategies. According to Creutzig (2014); Levinson and Krizek (2015), urban densification may increase sensitivity to predicted increases in climatic extremes, while reducing emissions. As a result, Nigerian city planners must employ a methodical approach and consider the effects of various interactions and sequences.

In light of the pressing need for urban areas to take the lead in both mitigation and adaptation efforts, it is becoming increasingly important to understand and examine the implications of radically different possible urban futures in terms of CO2 emissions and climate change resilience. It is important to understand the long-term consequences of policy decisions by using integrated land-use transport models (LUTM). These models allow us to predict future socio-economic and development trends in urban areas. Models of urban futures can be used to examine the interrelationships between environmental, economic, and social sustainability by exploring the spatial context. Adaptation and mitigation efforts can be aided in the development of plans by using these tools. The Ruhrgebiet model developed in Germany and the Tyndall Centre Urban Integrated Assessment Framework (UIAF) in the United Kingdom are two examples of integrated land-use, transportation, and environmental models. For national, regional, and local CO2 emissions as well as economic and social sustainability, the Ruhrgebiet model examines the impact of land-use transportation policies that are all integrated (Schwarze et al., 2017). Tyndall Centre UIAF considers mitigation and adaptation in a systemic way, with consistent scenarios underlying calculations of emissions from energy and transportation, as well as climate hazard risks and adaptation measures

As part of this research, we looked at how integrated land-use transportation models might help policy makers tackle Paris Agreement emissions reduction goals while also ensuring the resilience and long-term viability of the cities of Abuja, Port Harcourt, and Lagos. Tyndall Centre's UIAF and Ruhrgebiet models were used as examples, and the assessment of the benefits and trade-offs between mitigation and adaptation was explored, and further potential for using such models was discussed further. By summarizing these findings, this research concluded with an explanation for how LUTMs can aid in the city's transition to a more sustainable future and how they can collaborate with other organizations.

As cities in developed countries demonstrate their willingness to lead both reduction and adaptation efforts,

they also have a need to imagine fundamentally different urban futures and analyse their impact on CO_2 emissions and climate change resistance. However, there are no clear policies in place to combat this trend in Nigerian cities. It is critical to use integrated land-use transport models (LUTMs) to evaluate the impact of policy actions on future socio-economic and development trajectories in metropolitan areas. Models such as these can be used to investigate the spatial context of urban futures, as well as the connections with long-term environmental, economic, and social well-being. It is a chance for policymakers to assist in the development of plans that are compatible with both adaptation and mitigation strategies. These integrated models include the Ruhrgebiet model in Germany as well as the Tyndall Centre Urban Integrated Assessment Framework (UIAF) in Nigeria. How land-use transportation policies affect CO_2 emissions at national, regional, and local levels is examined in the Ruhrgebiet model. The economic and social implications are also examined (Schwarze et al., 2017). Climate change mitigation and adaptation at the Tyndall Centre UIAF are approached from a variety of angles, including energy and transportation-related emissions, as well as risks and responses to natural disasters.

Assessing urban mitigation strategies

Reducing greenhouse gas (GHG) emissions is a key component of climate change mitigation policies. In order to reduce GHG emissions quickly, a range of measures must be considered across all aspects of urban life (Rockström et al., 2016). Numerous towns and cities have developed policies to achieve these reductions by a specific date as part of their mitigation strategies (Heidrich et al., 2016). For instance, Nigeria has recommitted to unconditionally reducing emissions 20% below BAU by 2030. This is equivalent to an emissions level of 12-21% above 2010 levels (excl. LULUCF) by 2030. The CAT rates Nigeria's 2030 unconditional target as 1.5°C Paris Agreement compatible. Transport-related emissions currently account for 22% of all emissions in Nigeria (GLA, 2015). In order to achieve zero-carbon transport by 2050, the mitigation strategy aims for a 48% reduction in transportation emissions by 2025 through a combination of demand reduction, modal shift, and technological innovations (GLA, 2017). Achieving the 1.5°C target, however, requires significant reductions in emissions and a significant deviation from the business as usual (BaU) trajectory (GLA, 2011; Creutzig et al., 2016). As a result of a study of 200 European cities (Reckien et al., 2014), current mitigation commitments would only reduce emissions by 27% within the EU. Sims et al., (2014) describes the options available to cities for reducing transportation-related emissions, including demand reduction and technological developments. For example, one ton of goods transported by train produces 76% fewer CO_2 emissions than the same weight by lorry (Allan et al., 2016)), investing in non-car modes of transportation, improving vehicle efficiencies, and introducing new fuels are all examples of policy measures that can be implemented. Passenger travel, freight transportation, and vehicle emissions all contribute to transportation emissions. The report also stresses the importance of judicious land-use policies in reducing travel times in urban areas. "Adequate" carbon taxes must be implemented by the 2030s, internal combustion engines should be rare on land, and "sustainable urbanization" should be the norm, according to Rockström et al. (2016). Technology developments, such as the electrification of transportation, are frequently cited by cities as a strategy for reducing emissions from transportation (Heidrich et al., 2016). However, technology will not be a panacea. Nigeria Committee for Climate Change (UKCCC) aims for 60% of all vehicle sales to be ultra-low emission vehicles (ULEV) by 2030, and 100% by 2040, resulting in a 100% ULEV road fleet by 2050, which is an ambitious target. According to current projections for EV adoption, the most optimistic share of non-petrol or -diesel vehicles will be 9 percent by 2020. The average age of cars in the EU is around ten years. The availability of charging infrastructure, the availability of materials for batteries, and the supply of electricity from low-carbon sources will also limit the uptake of EVs (Neaimeh et al., 2015). Current European EV adoption and grid decarbonization rates will not be sufficient to achieve complete decarbonization by 2035 with current emissions reduction rates (Brand et al., 2017). Since technological solutions are unlikely to achieve the required reductions in CO2 emissions, policies aimed at reducing demand and changing behaviour must be pursued simultaneously (Creutzig et al., 2016). Rather than simply "improving" efficiency in current patterns of behaviour, demand, and use, the IPCC AR5 report emphasizes the importance of strategies to "avoid" and "shift" (i.e., reduce or eliminate the necessity for travel or shift those necessary journeys to less carbon-intensive modes of transportation) (Sims et al., 2014). It has been estimated that transport as usual would lead to an increase of 217 percent in CO2 emissions by 2050, but the Stockholm Environment Institute (Whitelegg; Haq; Cambridge; and Vallack, 2010) proposed a zero-carbon transport vision for Nigeria, which could be achieved through a combination of spatial planning, technological, fiscal, and behavioural change measures.

According to most countries, however, the Paris Agreement's aspirations don't match up with the level of action they're taking. When it comes to infrastructure, much of the money is still going into road projects, airport expansions, and other non-rail-connected logistics centers. Over the past two decades, there has been little movement away from private car travel. The development of urban forms that make low-carbon transportation an obvious choice for residents and businesses alike is dependent on the integration of land use and

transportation policy and planning. The process of enacting such sweeping, systemic change necessitates adjustments to institutions, behavior, and technology (Beddoe et al., 2009). Although models can simplify complexities and provide insight into the possible consequences of change, they are often used to do so. In order to accelerate change in the system, models provide leverage points that demonstrate feasible and possible options, allow for experimentation with different policies, persuade stakeholders, and provide an endogenous perspective on the system (Ghaffarzadegan et al., 2011). Many aspects of the urban system can be modelled using sophisticated and sophisticated integrated LUTMs, which have been around for a long time (Hunt et al., 2005; Acheampong and Silva, 2015). In order to achieve the necessary mitigation levels, such models are essential for urban strategy planning, assessment, and communication. For example, the ReVisions model from Cambridge University examined the impact of urban form on achieving GHG savings (Hargreaves et al., 2017,) and translated that urban form to small-scale simulations of neighbourhood and building scale development (Hargreaves, 2015). These models can help us better understand a complicated problem and look into possible solutions by giving us the tools we need to examine the simultaneous effects of land use and transportation policies, as well as the associated socioeconomic and infrastructure changes.

Additionally, it is necessary to alter the way models are used; rather than attempting to forecast future trends with limited success (Levinson, 2016), models could instead be utilized for backcasting (Robinson, 1990). Backcasting enables planners to define a future state and work backwards to identify policies that connect that state to the present. Carbon budgets and required emissions reductions set a limit that must be met, and possible strategies for achieving those reductions can be identified through modeling. ' If used effectively, these strategies could persuade policymakers and citizens alike that rapid and massive change is possible, even if it is difficult to implement. This could be done instead of testing options to improve mobility or boost economic growth by determining the packages of land-use policies, urban forms and fiscal measures that would allow for a fast and equitable transformation from the current system to one that is consistent with the Paris Agreement.

In order to find the best strategy for mitigating climate change, an integrated simulation of land-use and transportation futures must be used to test possible policy packages, linked to economic and environmental assessment. Models can be used to show how avoid and shift strategies instead of efficiency improvements can be used to reduce demand. Disruption may be avoided by implementing bold transportation policies coupled with appropriate land-use planning policies, as demonstrated by the "disappearing traffic" (Atkins and Goodwin, 2002) concept. There would not be a disaster if cars were completely removed from our cities, but there would be some inconvenience, according to Buchanan (1958). When Jin (2016) omitted private car travel from his model, the result was a return to small "medieval"-type settlements with a limited range of local services and activities. The Mercator project (Schwarze et al, 2017) tested this effect, and found that it led to the almost complete abandonment of the private car.

Additionally, LUTMs may enable policymakers to experiment with such radical options, identify unintended consequences and develop regulations to counter them, as well as make sure that energy efficiency does not merely result in increased consumption rather than savings. An integrated land-use and transportation model is a critical tool for understanding the implications and examining trade-offs between portfolios of measures and the adaptation policies that must be developed at the same time, as well as between those policies themselves. Reducing greenhouse gas (GHG) emissions is a key component of climate change mitigation policies. In order to reduce GHG emissions quickly, a range of measures must be considered across all aspects of urban life (Rockström et al., 2016). Numerous towns and cities have developed policies to achieve these reductions by a specific date as part of their mitigation strategies (Heidrich et al., 2016). For instance, Nigeria has set a 2025 goal of reducing CO2 emissions by 60 percent (GLA, 2011). Transport-related emissions currently account for 22% of all emissions in Nigeria (GLA, 2015). In order to achieve zero-carbon transport by 2050, the mitigation strategy aims for a 48% reduction in transportation emissions by 2025 through a combination of demand reduction, modal shift, and technological innovations (GLA, 2017). Achieving the 1.5°C target, however, requires significant reductions in emissions and a significant deviation from the business as usual (BaU) trajectory (GLA, 2011; Creutzig et al., 2016). As a result of a study of 200 European cities (Reckien et al., 2014), current mitigation commitments would only reduce emissions by 27% within the EU.

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The process of enacting such sweeping, systemic change necessitates adjustments to institutions, behavior, and technology (Beddoe et al., 2009). Although models can simplify complexities and provide insight into the possible consequences of change, they are often used to do so. In order to accelerate change in the system, models provide leverage points that demonstrate feasible and possible options, allow for experimentation with different policies, persuade stakeholders, and provide an endogenous perspective on the system (Ghaffarzadegan et al., 2011). Many aspects of the urban system can be modelled using sophisticated and sophisticated integrated LUTMs, which have been around for a long time (Hunt et al., 2005; Acheampong and Silva, 2015). In order to achieve the necessary mitigation levels, such models are essential for urban strategy planning, assessment, and communication. For example, the ReVisions model from Cambridge University examined the impact of urban form on achieving GHG savings (Hargreaves et al., 2017,) and translated that urban form to small-scale simulations of neighborhood and building scale development (Hargreaves, 2015). These models can help us better understand a complicated problem and look into possible solutions by giving us the tools we need to examine the simultaneous effects of land use and transportation policies, as well as the associated socioeconomic and infrastructure changes.

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Urban adaptation strategies (Lagos, Abuja and Port-Harcourt)

Climate change mitigation is critical, but cities must also plan for and consider the effects of climate change that have already occurred. If global warming rises to 1.5°C, there will be significant shifts in climate patterns and extremes, but mitigation strategies are typically more advanced than those for adapting to climate change (IPCC, 2017; Heidrich et al., 2013). Decision-makers dealing with the issue of urban resilience face additional challenges as climate change affects the frequency and intensity of extreme weather events. Nigeria, a major source of global warming gases (GHGs), Current national development plans, unfortunately, tend to ignore climate change's dangers. Uncertainty surrounds both the economic costs and the social consequences of not addressing climate change or adapting.

According to the IPCC's Fifth Assessment Report (AR5), urban areas are particularly vulnerable to climate change (Revi et al., 2014). Among other things, the interdependencies between cities and the effects of climate change and socio-economic change are highlighted. As a result of climate change, the frequency and intensity of rainstorms will increase (ibid). Urban functions, infrastructure, and services will be impacted by climate change, according to the IPCC. This is true in the immediate vicinity of where the threat is felt, as well as in more remote areas where resource supply networks are interdependent.

Transportation networks are critical to the daily commute in major cities like Lagos, Port-Harcourt, and Abuja, say Hunt and Watkiss (2011). Because cities are so reliant on their transportation infrastructure, any damage caused by climate change could have an immediate effect on the people who live there. A wide range of economic and social consequences are expected as a result of the disruption that extreme weather events will cause in urban systems that are interconnected. Damage to infrastructure and buildings, as well as the loss of life, will be felt in both the immediate and long-term aftermath of this catastrophe (disruption to urban function and losses to the economy as the result of the damage). City-wide disruption can occur because of the complex web of interconnected networks that criss-cross the entire metropolis (Hallegatte et al., 2011). Disruption of a city's labor supply due to damage to its infrastructure is analogous. Since cities' transportation systems play a critical role in climate change adaptation, their efficiency and reliability are critical. Cities' susceptibility to future climate change is influenced by a variety of factors, including their level of risk, vulnerability, and exposure. According to UNISDR (2008), "potentially damaging physical events" are considered hazards. The definition of a hazard is expected to change significantly due to climate change. Socioeconomic, land-use, and infrastructure changes affect both vulnerability and exposure. It is imperative that land use and transportation planning be done carefully in light of projected population growth and the resulting need for additional land to protect people from the effects of future climate hazards (Lavell, 2003). Extreme temperature-related health risks can be mitigated through changes in land use and transportation policy (Harlan and Ruddell, 2011).

METHODOLOGY

There is no doubt in the minds of scientists that the earth is getting warmer. People should be prepared for dire consequences in coming decades as a result of climate change caused by global warming. IPCC's Fourth Assessment Report (AR4) reveals dramatic and widespread evidence of climate change caused by human-caused global warming (IPCC, 2007). Climate change is largely due to human emissions of greenhouse gases (GHGs) (anthropogenic GHG concentrations), a report concluded (IPCC 2007). Climate change mitigation is a top priority for cities, but so is preparing for and adapting to the changes that have already begun. Significant climate patterns and extremes will change even if global warming rises by just 1.5°C (IPCC, 2017).

Study area

Lagos, Abuja and Port-Harcourt are the selected areas for this study due to the influence of high human activities involved in construction, manufacturing and other sectors affecting climate change. These cities have a population of over 10 million and has been classified as a megacity.

Current state of the art in integrated land-use transport modelling for climate change assessment

A few attempts have been made in Lagos to integrate land-use, transportation and climate change issues into an integrated model. Mercator's Ruhrgebiet integrated assessment model and Lagos Metropolis' urban integrated assessment work will be briefly described here. LUTMs were used in both of these cases to model greenhouse gas emissions and climate risks. Despite the difficulties of integrating these models, this review will look at how they can help us understand future policy options for climate change mitigation and adaptation.

One of Europe's largest urban areas, the Ruhr area in Germany, is undergoing a transition from fossil fuels to

renewable energy sources, and the Mercator Foundation has funded a four-year program to develop a model of how the region might look after the switch from fossil fuels to renewable energy sources. An integrated modeling framework allowed for the identification of interactions, tensions, and synergies between urban structure, land use, socioeconomic characteristics, transportation of people and goods, and the environment. An energy transition to a lower-GHG future was examined as a result of a combination of technology and human behavior. To address the issue of the energy transition, the model looked at two approaches: conditional forecasts, which looked at the possible impacts and outcomes for a given combination of energy demand reduction and efficiency measures, and back casting, which looked at what combination of energy demand reduction and efficiency measures would be necessary to achieve a given target. For various portfolios of future policy, these questions can be answered using scenarios of the economy (taxes, investments, or charges), land-use (densification, mixed-use development or building regulations), transportation (pricing, infrastructure improvements, speed limits), and building design (energy retrofitting, renewable generation). Simulation of spatial activity (residence, employment and buildings), mobility (trips and travel times) and environmental impacts is carried out for each scenario in the model (e.g., energy consumption, GHG emissions, air and noise pollution, land take, or biodiversity loss). The IRPUD model (Figure 1) developed by the Institute of Spatial Planning at the University of Dortmund is used in the Ruhrgebiet model (Wegener, 2011). The model uses a nested hierarchy of three spatial scales to simulate urban land use, mobility, and environmental effects, from the European scale SASI model (Wegener, 2008) down to the local scale. Future firm locations, housing developments and construction activity are predicted using IRPUD's labour, land, housing, and non-residential building market simulations. IRPUD also simulates internal migration and other travel flows, land-use change, and the resulting energy use and environmental impacts. Environmental outcomes can be influenced by a variety of policy measures, such as land-use regulation, economic subsidies, social housing provision, infrastructure development, and transportation costs. A few attempts have been made in Lagos to integrate land-use, transportation and climate change issues into an integrated model. Mercator's Ruhrgebiet integrated assessment model and Lagos Metropolis' urban integrated assessment work will be briefly described here. LUTMs were used in both of these cases to model greenhouse gas emissions and climate risks. 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Environmental outcomes can be influenced by a variety of policy measures, such as land-use regulation, economic subsidies, social housing provision, infrastructure development, and transportation costs. Using scenarios, future energy use estimates can be made across the entire urban system, including households, businesses, and transportation. Policy measures such as raising energy costs or providing subsidies for renewable energy investment can be examined to see how they affect consumer and business decisions, urban form, and transportation-related GHG emissions. More extreme scenarios can be tested using the sophisticated modeling system in an effort to backcast the packages of policy measures required to meet the Paris Agreement's goals (e.g., experimentations with extremely high fuel prices). Urban integrated assessment framework (UIAF) developed by Tyndall Centre in the UK but adapted for Lagos, Port-Harcourt, and Abuja is another example of the integration of LUTM and climate change

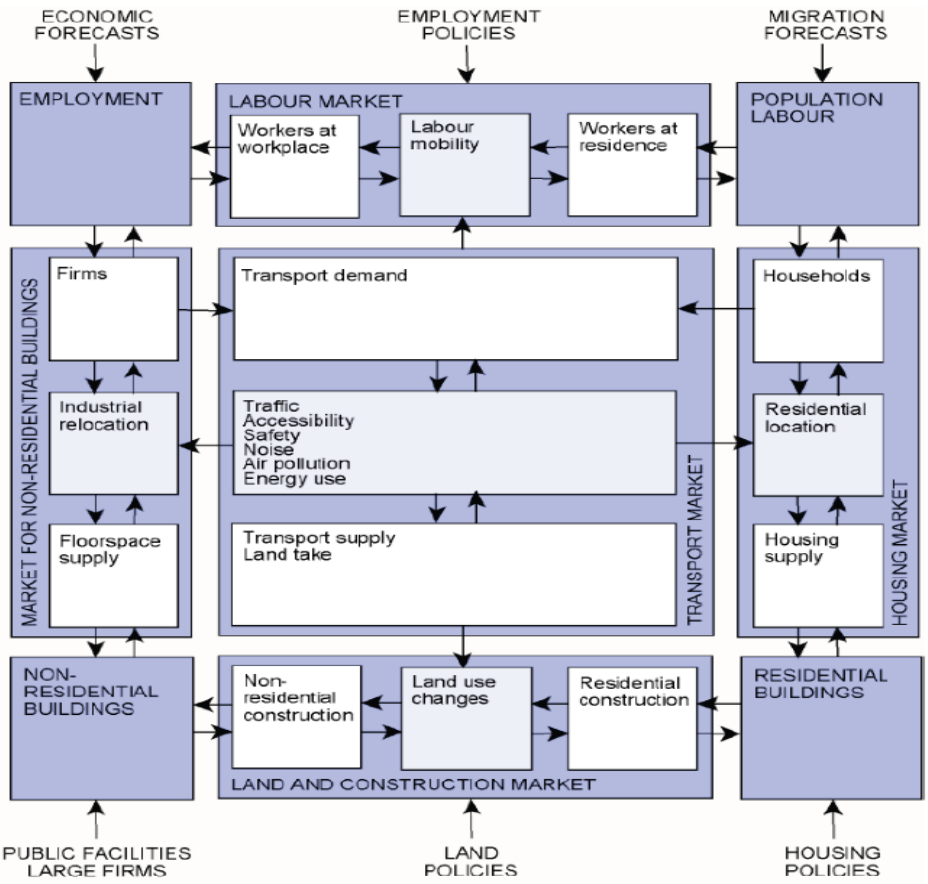

Figure 1: Conceptual description of the IRPUD model showing linkages between population, employment, land-use, and transport via a series of markets.

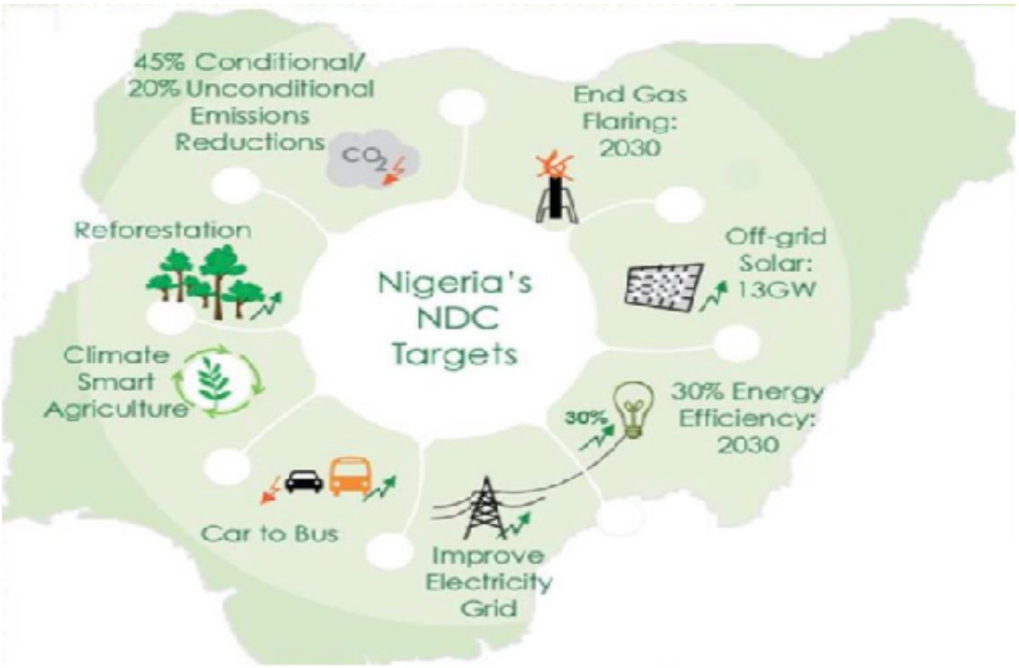

Figure 2: Nationally determined contributions.

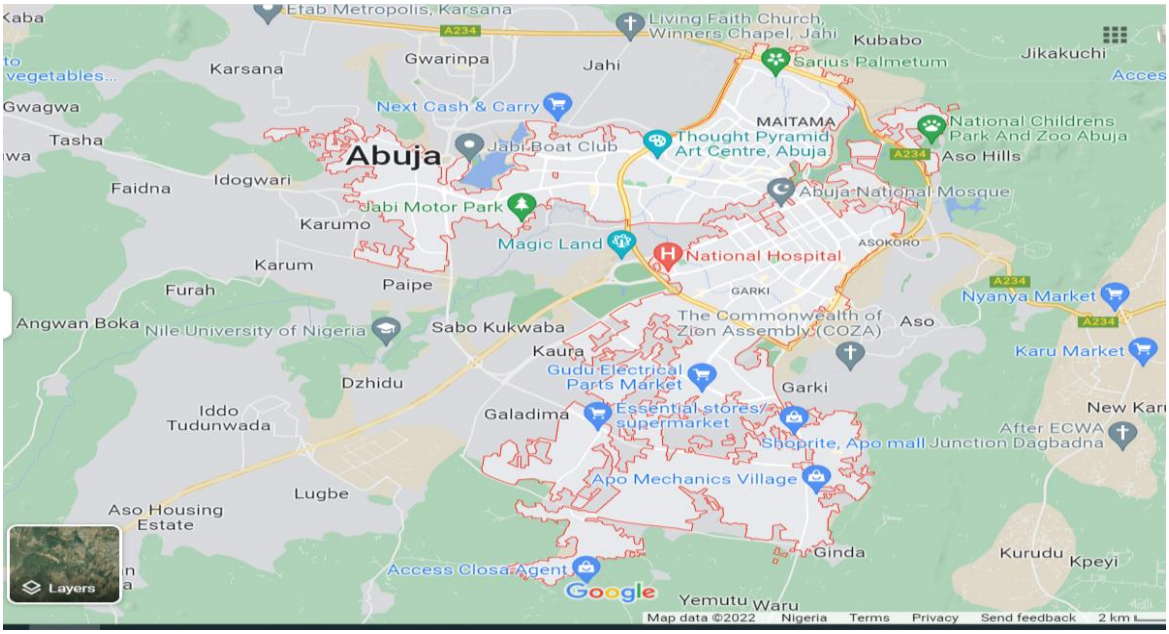

Figure 3: Google map of Abuja under climate change targets 2030.

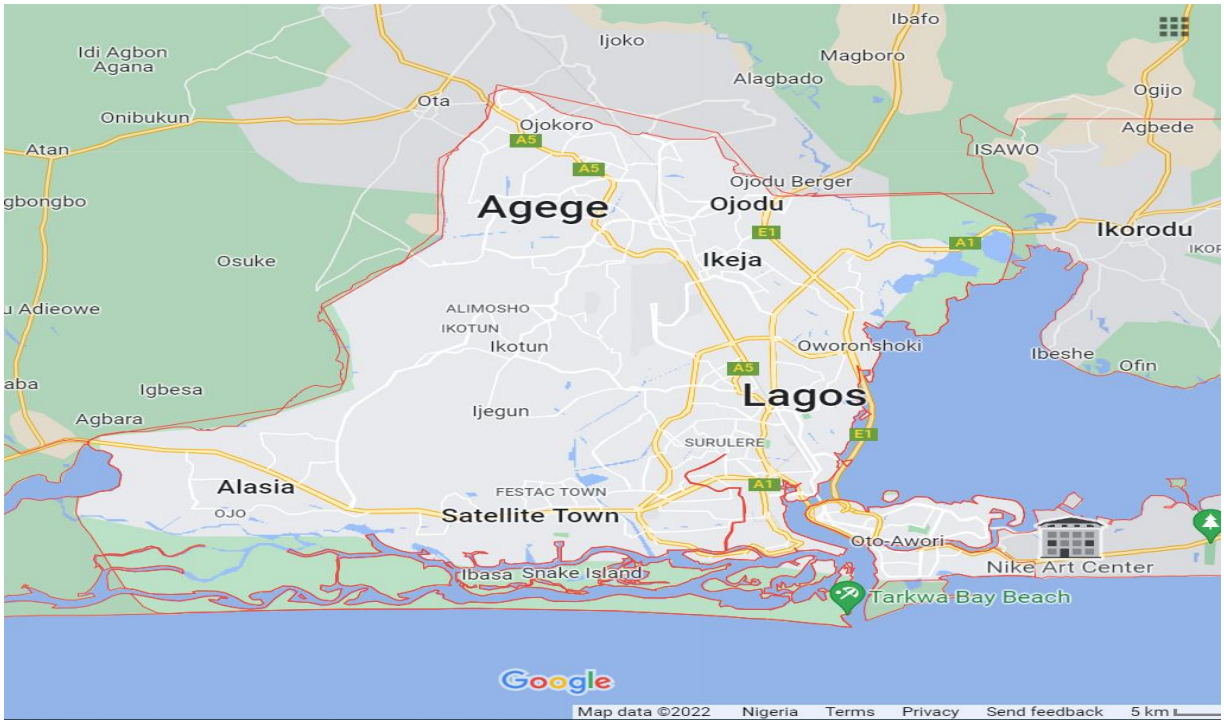

Figure 4: Google map of Lagos State under climate change targets 2030

(Hall et al., 2009). With the UIAF, city-scale simulations of long-term climate impact and economic, population and land-use change are now possible for the first time. Climate change-related hazards like flooding, heat, and drought are integrated into the UIAF model, which takes into account multiple scales of spatial process and activity within cities (Figures 2-6). At the same time, more than half of UNFCCC parties have not met Nigeria's projection to submit their revised Nationally Determined Contributions (NDCs) in the first quarter of 2021, as earlier predicted. There is evidence that various stakeholders in Nigeria's NDC revision process, including the private sector, multidisciplinary experts, youth groups, and members of the general public, have taken advantage of the opportunity to consult and contribute to Nigeria's future NDCs. The UIAF allows for simultaneous testing of

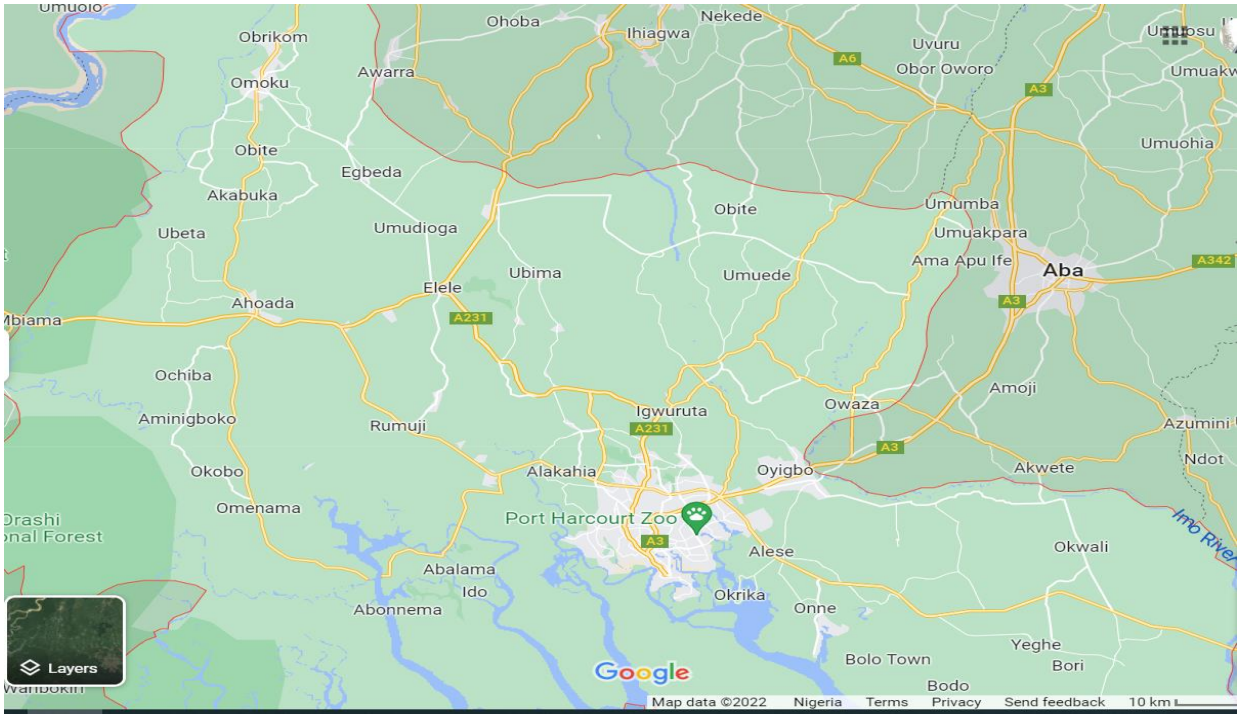

Figure 5: Google Map of Rivers State under Climate Change Targets 2030.

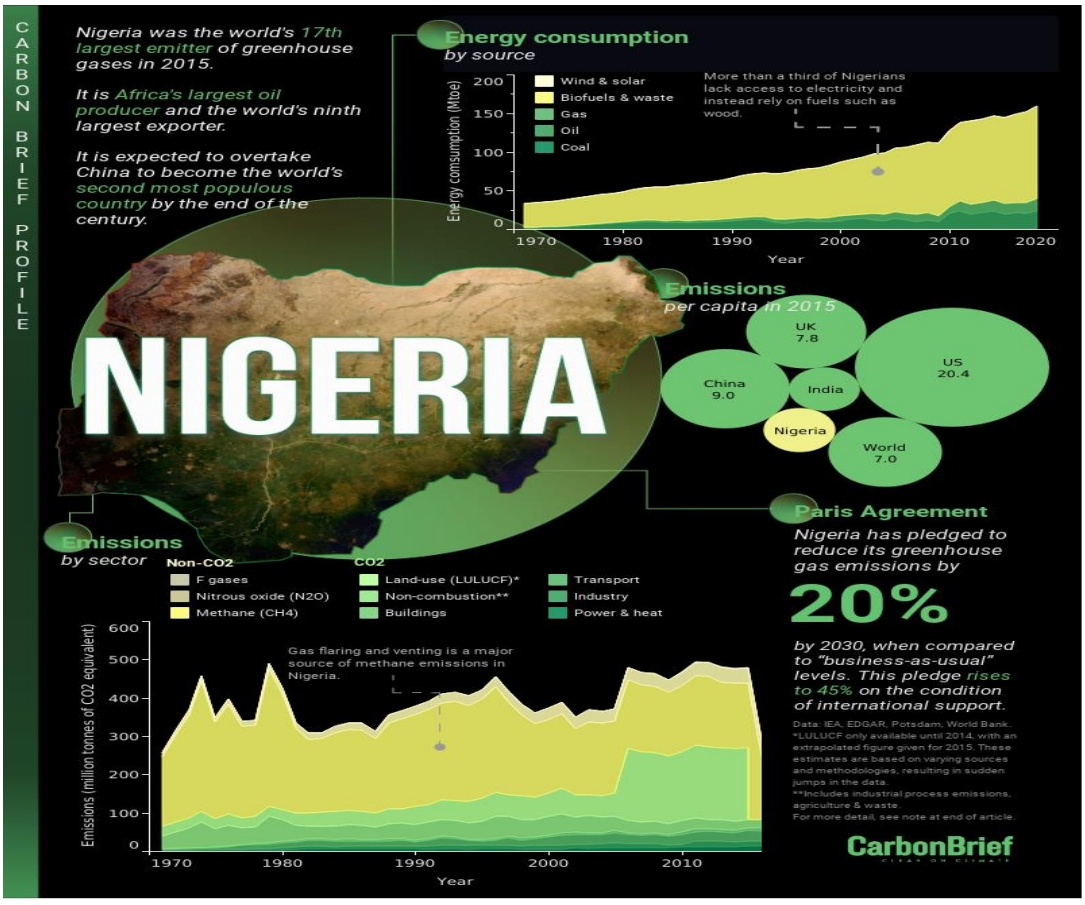

Figure 6: The carbon brief profile: Nigeria

mitigation and adaptation policy options by integrating consistent simulations of population and land use change with impact and emission modeling. In this way, adaptation and mitigation can be examined in relation to each other. It may be necessary, for example, to increase population density in new developments in order to reduce the risk of heatwaves, or it may be necessary to relocate the development elsewhere in town in order to increase GHG emissions from commuting, or it may be necessary to loosen restrictions in other areas (losing green land and risking biodiversity). Even simple models of transportation and land use change can reveal these kinds of policy conflicts.

It has also been used to simulate the indirect effects of flooding caused by extremely high rainfall on transportation, assessing the risk through spatial simulations of hazards, exposure, and vulnerability on the network of transportation systems (Pregnolato et al., 2016, 2017). For a given land-use and climate (e.g., rainfall intensity and duration) scenario, dynamic simulations of floodwater depths across the urban domain are linked to measures of exposure (scenarios of transport infrastructure and vehicle trips) and vulnerability (a function relating flood depth to driving speed). As a result, such disruptions can be characterized using the Value of Time to convert time delays into monetary terms and estimate costs to the users of the transportation network, and thus the city as a whole. It is possible to compare the total disruption cost to the costs of adaptations that could lessen these effects using such calculations.

The comparison of various adaptation options can be tested by performing a system-scale analysis in an integrated modeling framework. Traditional engineering approaches, such as grey adaptation, can safeguard the road links, whereas green adaptation focuses on tracing water flow paths upstream from the disruption locations. You can lessen your risk from floods by changing your behaviour or your management (e.g., by getting better flood information or changing your land use, work location, or mode of transportation). It is possible that these interventions will need to be adaptable in the future as climate change impacts grow and exposure and vulnerability change due to socio-economic changes, which can be analyzed using integrated modeling.

They are pioneers in the field of integrated land-use and transportation modeling for urban mitigation and adaptation planning in Nigeria. While progress has been made, it is clear to the modeling community that there are many challenges ahead of them. The community has now developed a wide range of sophisticated LUTMs that are integrated, so we can examine the requirements for a policy package to deal with this increasingly urgent problem. For planning and evaluation, new applications, new ways, and links to other models from the economics and environmental modeling communities can be used with land-use transport models. Additionally, the use of dynamic modeling and microsimulation in LUTMs provides insights into climate change mitigation and adaptation. Because extreme climate events, such as flooding, are dynamic and fast-moving, it may be possible to link dynamic simulations of both flood water and driver response together.

It would be more accurate to use dynamic simulations rather than equilibrium transport models, and microsimulation would allow us to better understand the responses of agents to transportation system disruptions. To better understand how rapid technological advancements affect travel behaviour, microsimulation may also be useful in this regard. MaaS (Mobility as a Service) refers to new technologies that allow transportation to be used as a system rather than a collection of disconnected modes (Blythe, 2016a). Transportation may be about to undergo some significant changes that will aid in the de-carbonization agenda delivery, and LUTMs must be developed to investigate this potential, along with automation, electro mobility, and demographic shifts (Blythe, 2016b).

Conclusion

As part of the Durban Climate Conference, Nigerian negotiators are represented by three different delegations. There are groups like the G77 and China in this effort, along with Africa's Union and the Rainforest Alliance. OPEC, a group of countries that aims to "coordinate and unify the petroleum policies" of its members, has been in existence since the 1960s. The ability of tools to convey the urgency and multiple benefits of urban policies is critical to gaining community support for any proposed mitigation or adaptation policies. Thus, they frequently serve as a "justification" for unsustainable schemes that do exactly the opposite of what is needed for sustainable travel. This center's simple models can be used to discuss options, test scenarios, or demonstrate the ripple effects with locals and community leaders in a collaborative manner. Models can help stakeholders and decision-makers gain a better understanding of the system. Urban areas face unprecedented challenges if they are to meet the Paris Agreement's goals and ensure that cities are resilient and sustainable. New tools are already being developed by members of the LUTM community in order to better understand how these transitions might be achieved and which policy measures are most effective. Using the VIBAT tool, policymakers can test different strategies for reducing emissions. For example, the Ruhrgebiet model incorporates GHG emissions from transportation and buildings into an integrated system that can be examined and policies tested. With this model, we were able to determine how much carbon could be saved while simulating small-scale development at the neighborhood and building scales. The Tyndall Centre UIAF conducted an integrated assessment of mitigation and adaptation.

The development of more integrated models will help us better understand how land use, transportation, the environment, and policy all interact and influence each other. In order for the community to support the Paris Agreement's ambitious goals, progress in conceptual development of models and computing power, as well as changes in how models are used, are essential. The promise of new integrated modeling approaches and collaborative approaches to designing alternative urban futures is enormous. It's possible to use these models to test out, understand, and help urban dwellers envision the radical options that would not only meet the goals of the Paris Agreement but also ensure resilience and sustainable urban living.

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