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Integration of climate change mitigation and sustainable development planning: Lessons from a national planning process in Nigeria

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ABSTRACT

To limit global temperature increases to 'well below 2 °C', it is necessary that current national commitments to reduce emissions are increased, and these commitments are implemented. The identification of local development benefits from climate change mitigation is a possible motivating factor to achieve this. However, there is a lack of practical examples of how climate change mitigation and development priorities can be integrated in national planning processes, particularly in low- and middle-income countries. This work considers two questions *i) What are the factors that have to be considered when developing a plan integrating GHG reductions with local development goals?;* and *ii) How do you structure a process to reach a consensus about the plan itself?*. It does this by conceptualising the integration of climate mitigation and development benefits as a *policy intervention*. As a case study, a national planning process that integrated climate change mitigation with improvements to air quality and human health in Nigeria is conceptualised, *ex-post*, as an intervention theory model. The key factors identified include the importance of tailoring the planning process to the national context of how development priorities are identified and then used in the allocation of national budgets. In particular, assessments undertaken within the planning process, of emission reductions, and development of implementation pathways provided necessary information on how climate mitigation actions contribute to national development priorities. Additionally, the importance of structuring these assessments within a planning processes that also engaged key stakeholders to allow the information produced by the assessments to be informed, and acted upon, by those responsible for mitigation in each key sector is also highlighted. Finally, approaches for the use of intervention theory as a conceptual framework to design a planning process, *ex-ante*, are discussed, to further optimise the integration of development priorities into climate change planning.

1. Introduction

In 2015, almost all countries committed to limit global average temperature increases to 'well below 2 °C' (United Nations, 2015). Currently, the Nationally Determined Contributions (NDCs) submitted to achieve these goals are estimated to be consistent with between 3 and 4 °C of warming by 2100 (Jeffery et al., 2018). Therefore, countries need to increase their climate change mitigation ambition, as has been extensively discussed (IPCC, 2018; Robiou Du Pont et al., 2017; UNEP, 2019a). A second necessity is that the commitments countries make to reduce greenhouse gases (GHGs) are actually implemented. This is not guaranteed, because there is insufficient international funding available to support implementation in low- and middle-income countries (Pauw et al., 2019), and some climate change mitigation commitments lack the necessary detail and political and institutional buy-in to move from a target to concrete implementation (Pauw and Klein, 2020).

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The existence and identification of local benefits from climate change mitigation actions that align with a country's development priorities could facilitate increases in climate change mitigation ambition, because of the recognition that, by implementing actions that reduce GHGs, countries would simultaneously benefit locally from achieving these actions (CCAC SNAP, 2019). The identification of these benefits could also facilitate implementation of climate change mitigation commitments by building a broad coalition of support to implement climate change mitigation actions by demonstrating their relevance to different stakeholders locally (Gomez-Echeverri, 2018). There are a large range of sustainable development benefits that could be achieved from climate change mitigation actions, including improving human health, economic growth, energy access and security, biodiversity, etc. (Haines et al., 2017; Jakob and Steckel, 2016). Despite this, there is a lack of practical examples showing how countries can effectively develop and implement national action plans that mitigate climate change and simultaneously achieving local co-benefits. Available practical examples are generally from high-income countries (Workman et al., 2019) as opposed to low- and middle-income countries which have made a small historic contribution to global GHG emissions (UNEP, 2019a), and where there is the largest opportunity for local development benefits to motivate and facilitate actions to reduce GHGs (Kuylenstierna et al., 2020). In addition, a large number of climate change commitments do not take into account the political and institutional priorities in a particular country, that determine the local development priorities, limiting their chances of being implemented (Pauw and Klein, 2020; Röser et al., 2020).

The potential for the integration of climate change mitigation and development priorities to increase climate change mitigation ambition and implementation, and the limited way in which this integration currently occurs in the majority of climate change planning processes raises two questions, *i) What are the factors that have to be considered when developing a plan integrating GHG reductions with local development goals?;* and *ii) How do you structure a process to reach a consensus about the plan itself?*

In this paper we provide insights on these two questions by framing the integration of climate change mitigation and development priorities as a policy intervention. Specifically, we analyse the development of a national action plan that integrates climate change mitigation and air pollution abatement in Nigeria. In this context, the 'intervention' encompasses all elements of the planning process that contributed to the development, endorsement and initial implementation of the plan. The analysis unfolds in two steps, corresponding to the two questions above. Firstly, we construct, *ex-post*, an intervention theory model of the development of the plan. In doing so, we aim to address the first research question to identify the critical causalities, and key linkages between different components of the policy intervention that were necessary for the development of this plan. Then, we address the second question, discussing the steps that were taken to make this process work to highlight the critical issues, and how the process could be improved. Finally, we reflect on how intervention theory could be applied proactively in the design and implementation of a policy intervention (i.e. *ex-ante*) as an organisational tool to structure similar processes to more effectively develop integrated plans that simultaneously achieve climate change mitigation and local development priorities.

In June 2019, following a three-year process, Nigeria's Federal Executive Council endorsed Nigeria's National Action Plan to reduce Short-Lived Climate Pollutants (hereafter abbreviated to 'National SLCP Plan'). Short-Lived Climate Pollutants (SLCPs) are a subset of pollutants that directly contribute to both climate change and air pollution, and its associated health impacts. SLCPs include methane, tropospheric ozone, black carbon, and hydrofluorocarbons (UNEP/WMO, 2011). The National SLCP Plan in Nigeria integrates climate change mitigation and air pollution reductions because i) it aims to reduce emissions of SLCPs which directly contribute to both issues, and ii) the mitigation measures included to reduce SLCPs also reduce co-emitted GHGs and other air pollutants. The plan includes 22 mitigation measures targeting 8 major SLCP source sectors in Nigeria (Table S1). The full implementation of Nigeria's National SLCP Plan has the potential to reduce black carbon and methane emissions by 83% and 61% in 2030 compared to a baseline scenario, respectively. Additionally, the implementation of these 22 measures would also be effective at reducing other air pollutants, and would reduce carbon dioxide emissions by 14% in 2030, contributing to Nigeria achieving its international climate change commitments (Nigeria Federal Ministry of Environment, 2019). The National SLCP Planning process in Nigeria was conducted with support the Climate and Clean Air Coalition (CCAC) Supporting National Action & Planning to reduce SLCPs (SNAP) initiative (CCAC, 2021). The SNAP initiative aims to support national governments to plan and increase action to reduce SLCPs, improve air quality and mitigate climate change.

The process for the development of Nigeria's National SLCP Plan provides a useful case study of how climate change mitigation and local development priorities can be linked because exposure to air pollution is the largest environmental health risk globally making it a development priority for many countries. This includes Nigeria, which experiences an estimated 114 thousand premature deaths due to air pollution in 2017, of which 70 thousand were infant (< 5 years) deaths (Stanaway et al., 2018). In addition, there is a large overlap between the sources of the emissions causing climate change (GHGs and SLCPs) and air pollution (Crippa et al., 2018). This overlap means that there is a substantial opportunity to design and implement strategies that simultaneously improve air quality and human health locally while mitigating climate change (e.g. Nakarmi et al., 2020; Stohl et al., 2015; UNEP, 2019b).

2. Intervention theory framework for assessment of policy interventions

Intervention theory has been widely applied to evaluate different programmes (Chen, 2005; Vedung, 2017; Weiss, 1998); enhance understanding of complex problems (Rogers, 2008), including applications to understand how integrated climate and development interventions can be successfully implemented; or to evaluate the implementation process (Linnér et al., 2012). As outlined in Linnér et al. (2012), an intervention theory analysis *'describes how policies or measures are supposed to be implemented and function'*, and *'focus[es] on identifying presuppositions on why, under which circumstances and for whom the intervention works as well as the intervention logic, that describe how the elements of the intervention fits together'*. An intervention theory model comprises three elements: i) the change model, which describes the causal processes by which the goal of a programme is achieved, i.e. *how* an intervention is intended to achieve its goal, ii) the action model, which describes the actions that need to be taken to achieve the necessary changes, i.e. *what* is done to achieve the goal, and iii) the context, which details the information relevant to what circumstances the change and action model are assumed to be effective in achieving their goal (Chen, 2005).

In this study, intervention theory is applied *ex-post* to conceptualise as a policy intervention a planning process that aims to integrate climate change mitigation with key development benefits (air pollution mitigation). The 'intervention' encompasses all elements of the planning process undertaken in Nigeria. The aim of this conceptualisation of the planning process is to examine the key factors that led to the development, endorsement and inception of the implementation of Nigeria's National SLCP Plan. The intervention theory model of Nigeria's National SLCP Planning process was developed based on the reports that documented the planning process and stakeholder workshops (Nigeria Federal Ministry of Environment, 2019) (see Supplementary Information).

The context includes the mechanisms by which development priorities can be taken forward in Nigeria, including the institutional and political context, how development priorities are identified and funded from national budgets, as well as relationships and responsibilities of different Ministries, Departments and Agencies (MDAs), existing

regulations, plans, strategies and activities relevant for reducing SLCPs. Also included is the physical and social context, i.e. the major activities that emit SLCPs, GHGs and air pollutants in Nigeria. The change model was developed to define the key 'components' of the intervention, required to achieve the overall goal of the process, which is to reduce SLCPs, improve air quality and mitigate climate change. For each component identified in the change model, the direct outputs and the outcomes that resulted from one or a combination of individual components to achieve the overall goal were identified to illustrate the causal chain by which the components of the intervention achieved the goal. The Action model outlines the specific activities that were undertaken for each of component.

The intervention theory model for the planning process to develop Nigeria's National SLCP Plan is shown in Fig. 1. Within this conceptualisation of the planning process in Nigeria, the change model identifies five key outcomes from six components of the intervention that contribute to achieving the goal of reducing emissions of SLCPs, improving air quality and mitigating climate change. The main outcome, the development of a National SLCP Plan, is achieved by agreeing among all relevant stakeholders on the priority mitigation measures, and a concrete set of actions to implement them. The six components are broadly consistent with those identified as being effective for the development of national actions plans related to a varied set of environmental issues, including climate change mitigation (CDKN, 2016) and adaptation (UNDP et al., 2011), air quality management planning (Gulia et al., 2015; RTI International, 2016), sub-national environmental planning (Grafakos et al., 2019; WHO, 2014), and disaster risk reduction (Stults, 2017). The disaggregation of the planning process into the three elements of the intervention theory model (context, change model and action model) provides insight into the two key research questions in this work, which are discussed in the following sections. Firstly, the key factors that were important in the development of the plan were how the six components linked to the specific context of development planning and national budget allocation in Nigeria (Section 3). Of particular importance are the two assessments that underpinned the development of the National SLCP Plan, to provide information and evidence as to how actions to reduce SLCPs could achieve Nigeria's stated development priorities. Secondly, the specific links between the six components of the intervention theory model, and the actions undertaken within each component, that structured the planning process towards reaching consensus across stakeholders in Nigeria are highlighted (Section 4).

3. Key factors in integration of climate change mitigation and development priorities

3.1. Context of development in Nigeria is key to an effective intervention

The Intervention Theory model summarised in Fig. 1 highlights how the change and action models of the Nigerian National SLCP Planning process are undertaken within a specific context. To link climate change mitigation to specific development goals, the most important element of context in Nigeria for the development, high-level political endorsement, and implementation of an action plan was the mechanisms by

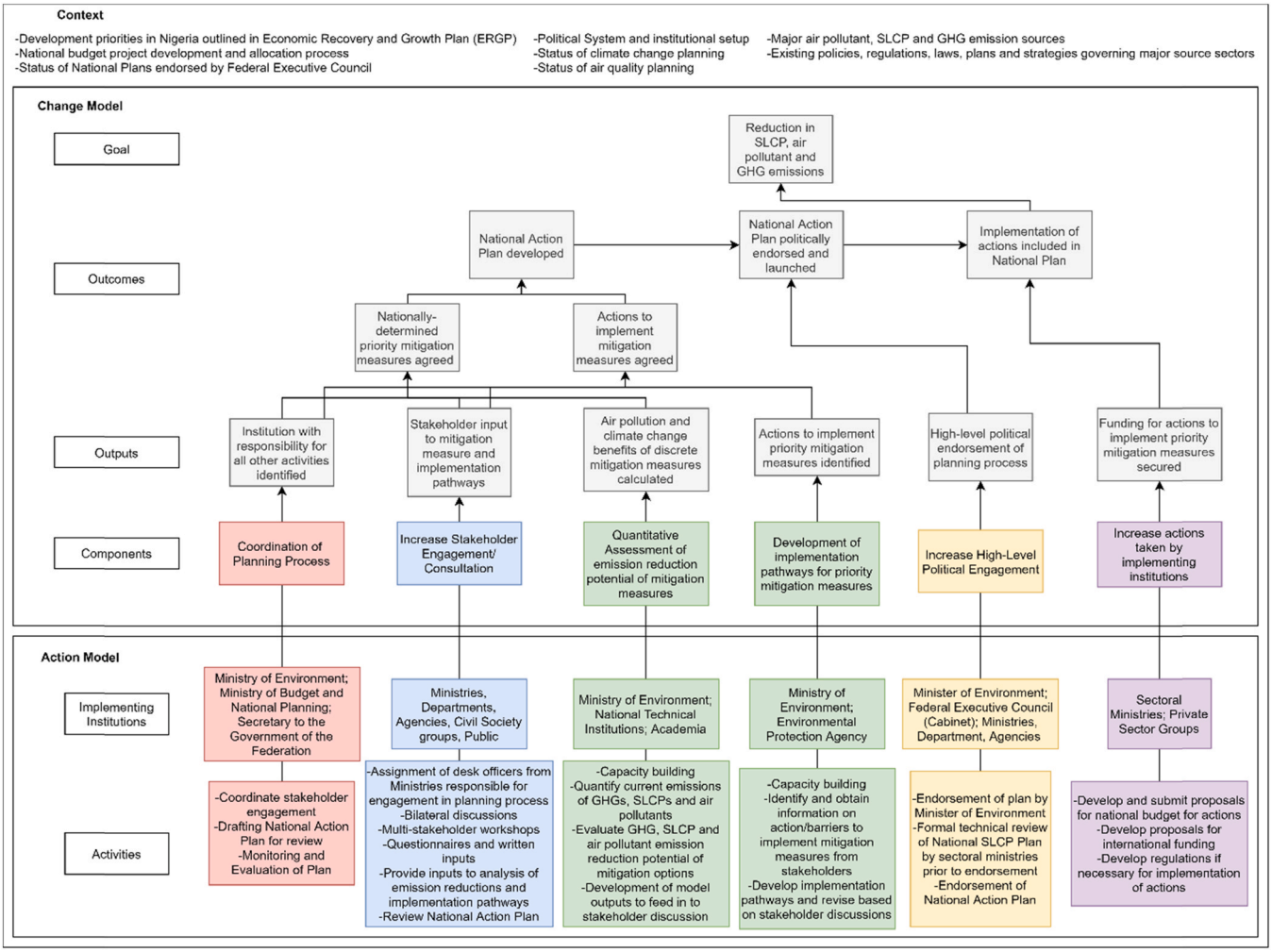

Fig. 1. Intervention Theory model for national short-lived climate pollutant planning process in Nigeria.

which development priorities are identified, prioritised, and funded. The development priorities of the Nigerian Government are outlined in the Economic Recovery and Growth Plan (ERGP, Nigeria's National Development Plan), and fall under six categories, i) Economic Growth, ii) Competitiveness of the Economy, iii) Employment Generation, iv) Access to Quality and Affordable Education and Healthcare, v) Social Welfare Improvement and Poverty Reduction, and vi) Strong Local Content (Nigeria Ministry of Budget and National Planning, 2017). When MDAs in Nigeria submit national annual budget requests, submissions are evaluated against the national development priorities in ERGP as criteria for national budget funding (Adeniran et al., 2017; Ekeocha, 2012; Nigeria Ministry of Budget and National Planning, 2017; Sam-Tsokwa and Ngara, 2016; SPARC, 2016). Therefore, a key context to consider when developing a plan to link climate change and air pollution mitigation in Nigeria is to ensure that the plan directly contributes to the ERGP priorities to maximise chances of national budget being allocated to it.

The second element of context that was important to take into account for development planning and budgeting in Nigeria, including in the National SLCP Planning process is the effect of high-level political endorsement of plans and strategies. In Nigeria, the highest level of endorsement of a national plan or strategy is by the Federal Executive Council, chaired by the President, the highest decision-making body in Nigeria. The endorsement of Nigeria's National SLCP Plan by the Federal Executive Council does not guarantee its implementation. The practical effect of endorsement is that it strengthens the case for funding when MDAs submit proposals to the national budget for specific projects that contribute to the implementation of this endorsed national plan. In the context of Nigeria's National SLCP Plan, the endorsement provides an incentive for sectoral MDAs to submit budget proposals that directly contribute to implementing the 22 priority mitigation measures included in the National SLCP Plan. Therefore, a policy intervention designed to integrate climate and development priorities, and to receive national budget allocation, in Nigeria should respond to the need to provide information on how specific actions contribute to the 6 criteria outlined in Nigeria's ERGP. It should also engage MDAs as key stakeholders able to submit national budget requests for projects that contribute to the implementation of the priority mitigation measures.

3.2. *Assessments provide key information to support integration of climate change and development planning*

Within the change model, two of the components undertook specific assessments that provided key information that allowed the planning process to respond directly to the context of integrated climate and development planning in Nigeria described in Section 3.1. These two components included a quantitative assessment of the emission reduction potential of mitigation measures, and the development of implementation pathways for priority mitigation measures. Both assessments provided information and evidence as to how different policies and measures designed to mitigate climate change and improve air quality could contribute to achieving Nigeria's development priorities, as defined by the six criteria in ERGP.

An emission reduction assessment (described in Supplementary Information) evaluated the effectiveness of different mitigation measures in reducing SLCP, air pollutant and GHG emissions. Quantitative assessments of emission reductions are routinely undertaken within planning processes, e.g. GHG mitigation assessments within climate change planning (Federal Republic of Nigeria, 2020). However, GHG mitigation assessments typically focus only on greenhouse gases, whereas the analysis conducted within the National SLCP Planning Process quantified emissions of greenhouse gases (carbon dioxide, methane), short-lived climate pollutants (methane, black carbon), and other air pollutants that contribute to local health impacts (nitrogen dioxides, sulphur dioxides, volatile organic compounds, organic carbon and fine particulate matter) (see Supplementary Information and Kuylenstierna et al., 2020).

The assessment of this expanded set of pollutants in Nigeria demonstrates the strong link between climate change mitigation and local air pollution. Firstly, emissions of SLCPs, GHGs and air pollutants were shown to share many common emission sources, such as households, transport, agriculture and waste (Supplementary Information). Without further interventions, these emissions were projected to substantially increase into the future, exacerbating local air pollution and its health impacts, as well as increasing Nigeria's contribution to global climate change (Table S3, Fig. S1). Secondly, the assessment showed that specific mitigation measures identified during the planning process can be effective at simultaneously reducing air pollution and mitigating climate change. Implementation of all of the 22 mitigation measures included in the National SLCP Plan (shown in Table 1) were estimated to result in substantial reductions in emissions of all air pollutants, SLCPs and GHGs (Table S4). Therefore, the emission reduction assessment showed how the mitigation actions identified contributed to improving air quality in Nigeria, which would directly improve the health of the population through a reduction in the incidence of respiratory, cardiovascular diseases and other negative health outcomes (Anenberg et al., 2018; Malley et al., 2017). Improving human health is the fifth criteria in Nigeria's national development priorities included in ERGP, and therefore this assessment provides information as to how these mitigation actions can contribute to Nigeria's development priorities (Section 3.1).

Secondly, the assessment of implementation pathways further expanded the information available on how the mitigation measures in the plan link to Nigeria's national development priorities. They aimed to develop a common understanding of the actions required to implement each mitigation measure by synthesising inputs from different MDAs responsible for mitigation in each sector, and provide the basis for the development of indicators to monitor and evaluate the implementation of the Plan. The MDAs who were engaged to provide inputs are listed in Table S1, and the questionnaire used to guide their inputs shown in Table S5. Inputs from MDAs were synthesised into a consistent set of implementation pathways by i) developing a value chain for each mitigation measure to characterise the system that the measure targets, ii) identifying the actions within the value chain to implement the mitigation measure, iii) developing a logical framework analysis to assess how actions contribute to achieving the emission reduction goal, and iv) identifying indicators to monitor and evaluate the measure's implementation (Supplementary Information). These outputs are shown for all available mitigation measures in Figs. S2-S17 and Tables S6-S13, and a summary of the actions identified to implement each measure is shown in Table 1.

The identification of implementation pathways for each mitigation measure relied on the engagement of the responsible MDAs and could be developed for 10 of the mitigation measures. Each implementation pathway identified between 4 and 10 actions to contribute to the implementation of the mitigation measures in Nigeria, as well as those stakeholders needed to achieve each action. These showed substantial similarity in the types of actions identified. The main types of actions identified related to research to understand how the mitigation measures could be implemented in Nigeria; data collection and monitoring systems; training and capacity building; communication and dissemination of best practice; regulation and enforcement; and private sector engagement (Table 1).

The necessary actions identified in the implementation pathways provide the basis for the development of project proposals to submit for consideration for an allocation of funds for national budget to fund the implementation of the National SLCP Plan. They show how specific actions to implement a mitigation measure can contribute to the ERGP development priorities. For example, the implementation of some mitigation measures includes the establishment of public-private partnerships, e.g. for vehicle testing, composting of organic waste, anaerobic digesters for manure, which can provide employment and economic opportunities (Criteria 1, 3 and 5 in Nigeria's ERGP (Section 3.1)).

Table 1
Summary of mitigation measures and actions identified to implement them (N.A.: Sufficient inputs were not available to develop implementation pathways).

No.	Measure	Actions needed to implement
1	Renewal of urban bus fleet in Lagos	N.A.
2	Adoption of CNG buses in Nigeria	N.A.
3	Introduction of low Sulphur diesel and petrol	1. Testing and verification of Sulphur fuel content on imported fuels 2. Adopt regulations and timeline for Sulphur content for domestic production 3. Provide technical assistance to ensure refineries can produce low Sulphur fuel 4. Implement testing of Sulphur content of domestically produced fuels
4	Elimination of high emitting vehicles	1. Enforce ban on 2-stroke engines 2. Inspection of imported vehicles to enforce Euro III standards 3. Implement sticker system to show vehicle emission compliance 4. Establish NESREA accredited vehicle testing centres 5. Develop operation guidelines for privately run testing centres 6. Identify and procure emission testing equipment 7. Build Capacity of testing centre staff 8. Develop database for vehicle emissions 9. Raise public awareness of vehicle testing through media 10. Develop pilot project testing centres in Abuja
5	Reduction of vehicle journeys by car through transport model shift	N.A.
6	Increase in population using modern fuels for cooking (LPG, electricity)	N.A.
7	Replacement of traditional biomass cookstoves with efficient improved biomass stoves	N.A.
8	Elimination of kerosene lamps	N.A.
9	Elimination of gas flaring	N.A.
10	Fugitive emissions/leakages Control	N.A.
11	Methane leakage reduction (Natural Gas)	1. Implement pilot measurement campaign for methane emissions at selected sites 2. Develop best practice guidelines for Advanced Leak Detection and Repair (A-LDAR) 3. Regulate oil and gas production to legislate for best practice at oil and gas facilities 4. Implement A-LDAR to enforce regulations 5. Develop independent monitoring and reporting of methane emissions
12	Improved energy efficiency in industry	N.A.
13	Reduction of methane emissions and open burning of waste at open dumpsites through adoption of biogas digesters	1. Expand 'blue bin' pilot project to raise awareness and encourage waste separation at source 2. Establish material recovery facility to separate waste for recycling, composting and landfill 3. Train agencies on controlled landfill management including separation, recycling, composting and landfill 4. Develop public, private partnership for composting of organic waste 5. Develop standard operation procedures and guidelines for composting operators 6. Develop and implement controlled landfill management 7. Train formal and informal landfill workers/scavengers in separation and best practices
14	Septic sludge collection	1. Develop financial incentives to encourage adoption of septic tanks in areas not connected to sewer lines 2. Develop public private partnership for collection and transport of septic sludge 3. Design, operate and maintain septic sludge collection facility 4. Identify funding for manufacture and operation of biodigesters through public private partnership 5. Develop and run tracking system for septic sludge operators
15	Sewerage Systems and Municipal wastewater treatment plants	1. Build database of sewer lines in Federal Capital Territory 2. Install sensors on sewer lines for monitoring and maintenance and real-time fault detection 3. Train staff on monitoring and maintenance of sewer lines 4. Expand sewer lines to whole city of Abuja 5. Identify funding to finance upgrade and monitoring of sewer lines 6. Fund and install Omni Processor at treatment plant to produce electricity and dry ash fertiliser
16	Increased adoption of intermittent aeration of rice paddies (Alternate wetting and drying technique (AWD))	1. Assessment of regions where AWD is suitable alternative 2. Integration of AWD into sustainable rice platform (containing international standards and protocols to be adopted) and produce standard operating manual 3. Develop pilot project to demonstrate effectiveness of AWD technology 4. Raise awareness and train stakeholders in AWD practice (alongside other techniques such as urea deep placement) 5. Build capacity of Ministry of Agriculture staff on emission inventory development 6. Ensure availability of equipment (e.g. water tubes) to implement AWD 7. Implement monitoring system to assess farms using AWD
17	Reduce open-field burning of crop residues.	1. Develop standard operating manual in conservation agriculture 2. Increase awareness raising and training on alternative uses of crop residues (e.g. briquettes for fuel/feed) 3. Awareness raising and training on conservation agriculture practices with minimum tillage 4. Enforce existing state-level policies to control burning where necessary 5. Develop regulations to control waste burning in states where needed 6. Develop public private partnership model for investment

(*continued on next page*)

Table 1 (*continued*)

No.	Measure	Actions needed to implement
		7. Ensure availability of briquetting equipment 8. Ensure provision of necessary farm inputs at affordable prices 9. Establish routine monitoring to ensure conservation agriculture implemented
18	Anaerobic Digestion (AD)	1. Develop incentives for clusters of farmers to invest in AD 2. Ensure production and distribution of AD that are affordable 3. Training of field officers in use of AD 4. Training of technicians in installation of AD 5. Expand access to finance purchase of biodigesters
19	Reduce enteric fermentation methane emissions	1. Increase research on animal husbandry 2. Increase research on artificial insemination 3. Develop and implement livestock census 4. Increase training of field extension officers on best animal husbandry practices 5. Increase training of animal husbandry technicians on artificial insemination 6. Develop regulations on best animal husbandry practices 7. Implement enforcement process for regulations
20	Expansion of electricity coverage	N.A.
21	Increase renewable electricity production	N.A.
22	Elimination of HFC Consumption.	N.A.

4. Structing the planning process to facilitate engagement across stakeholders

As outlined in the change model in Fig. 1, the two assessments were not sufficient on their own to result in a plan that could be endorsed at a high-political level by Nigeria's Federal Executive Council and acted upon by those MDAs responsible for the targeted emission sources. The agreement on the priority mitigation actions and the actions that could be taken to implement them also required a planning process with coordination and stakeholder engagement components. In terms of linking the SLCP planning process to national development priorities, these two components aimed to ensure that all relevant stakeholders (listed in Table S1) were involved in the development of the two assessments and were in a position to act on the information generated. Hence, the specific coordination and stakeholder engagement activities, i.e. the action model show in Fig. 1, provided the structure of the planning process to provide consensus on the contents of the plan itself.

Regarding coordination, implementing institutions who undertook the coordination were key to obtaining consensus on the contents of the plan, its endorsement, and its implementation. The Federal Ministry of Environment coordinated the development of the plan, but its endorsement and implementation were coordinated between three institutions: the Federal Ministry of Environment, the Ministry of Budget and National Planning, and the Office of the Secretary to the Federation. This allowed the institution responsible for the national budget appropriation process, and the one responsible for reporting to the highest Federal decision-making bodies in Nigeria (the Federal Executive Council and the Presidency) to engage in the overall coordination of the implementation of the plan. Practically, this meant that after the high-level endorsement of the plan by the Federal Executive Council, the Ministry of Budget and National Planning highlighted to the different Nigerian MDAs that submitting national budget proposals that contributed to achieving this plan would have a high chance of success. In addition, they outlined why implementing this plan contributed to Nigeria's development goals, and the specific process for developing and submitting project proposals related to the National SLCP Plan for national budget consideration as highlighted in the Implementation Strategy Meeting report (included in Supplementary Information).

The coordination of the implementation of the National SLCP Plan was enhanced by the other components of the intervention. The emission reduction and implementation pathways assessments provided the basis for monitoring implementation of the 22 mitigation measures as well as enabling the future revision and updating of the Plan. Firstly, the emission assessment, because it was developed by a national team, can be updated over time as new data becomes available, to assess emission trends for each sector and determine whether they align with the pathways in the Plan. Secondly, the indicators allow progress to be assessed, not only in relation to achieving the Plan's overarching goal, but also in relation to key outputs and outcomes of the activities identified as necessary for its achievement (Table 1 and Supplementary Information). Tracking the output and outcome indicators over time allows the Federal Ministry of Environment and other MDAs to identify to what extent the actions to implement a measure are being achieved, whether the emission reductions expected are resulting from implementing these activities, and whether the local development benefits from implementing the national SLCP plan are being realised. This tracking can identify if more effort is required to effectively implement existing activities, whether additional activities are needed or if some activities are no longer necessary to facilitate implementation.

In addition to coordination, the second component that helped reach consensus on the content of the plan was active engagement of key stakeholders who are needed for its implementation (Fig. 1). The engagement of stakeholders attempted to achieve two outcomes. Firstly, it attempted to allow stakeholders to inform the plan and align it with their agendas, so that the measures to mitigate climate change and improve air quality also contributed to achieving the stakeholder's priorities, and would therefore receive their agreement. Secondly, it aimed to ensure that all key stakeholders had the information developed during the planning process so that it could be acted upon, e.g. to develop proposals for national budget submissions. This information includes the outputs from the two assessments undertaken, the technical assessment of emission reductions and implementation pathways for priority measures (Section 3.1).

The stakeholder engagement was facilitated initially by the Federal Ministry of Environment requesting that each MDA assign a desk officer responsible for engagement with the planning process, allowing them to be called upon to provide input at different stages. The emission reduction assessment provided quantitative information, relevant to MDAs. It included not only GHGs, but also local air pollutants directly degrading air quality and impacting the health of Nigerians. The contribution of an emission source to the problems of air quality and climate change were quantified (Fig. S1), as was the contribution that a particular sector could make to solving these problems (Table S4). Therefore, the data made available in the process was able to create arguments that could be put forward to stakeholders and convince them to engage in the National SLCP Planning process during bilateral discussions and multilateral meetings explaining the extent to which the MDAs could contribute to mitigating climate change and improving air quality locally (Nigeria Federal Ministry of Environment, 2019).

Stakeholder engagement also improved the robustness and acceptability of the results of both assessments to the policy making process and provided information on the linkages between climate change mitigation and development as detailed in Section 3.1. The national team developing the quantitative assessment of emission reductions could request national data from the desk officers in each MDA to inform the development of the emission reduction assessment. This resulted in national data being used, where possible, to characterise emissions of

SLCPs, air pollutants and GHGs. For example, for the transport sector, data on the number of vehicles was taken from National Bureau of Statistics, and Lagos State Vehicle Registration data, while data on oil production and refining was taken from the Nigerian National Petroleum Corporation Annual Statistical Bulletin (Table S2, note: where national data could not be identified, default international data was used). In addition, when priority mitigation measures were defined, MDAs were consulted in the definition of the mitigation measures, the level of ambition and the timeline for implementation. In many cases, the mitigation measures aligned with other plans and strategies, e.g. priorities outlined in the 'Sustainable Energy 4 All' strategies on increasing the number of households cooking using Liquified Petroleum Gas (LPG) (Nigeria Federal Ministry of Environment, 2019). That the quantitative modelling underpinning the planning was owned, run and understood by experts in the country, and used a high degree of national data, was critical to its acceptance and political impact.

Ultimately, the engagement of stakeholders also contributed to the high-level political endorsement of the plan. Prior to this endorsement, the National SLCP Plan document was submitted to all Ministries for a technical review, to ensure that it did not conflict with the priorities of each MDA (Nigeria Federal Ministry of Environment, 2019). As the National SLCP Plan had been developed with the active participation of stakeholders from each MDA, in bilateral discussions with the Federal Ministry of Environment, during multilateral 'peer-review' workshops and through submission of written comments, the National SLCP Plan carefully aligned with the priorities of each MDA. This allowed the validation by technical reviewers within each MDA of the National SLCP Plan, and its subsequent endorsement by the Ministers at the Federal Executive Council.

Finally, there is one factor not captured in the intervention theory model that was important in structing the planning process to reach consensus about the plan. The sequencing of the interventions and activities was important for the National SLCP Plan development (Fig. 2), in addition to the components and activities within the overall intervention (Fig. 1). For example, stakeholder engagement was not just a one-off event, but started early in the process and occurred continuously throughout the development, endorsement and initial implementation of the National SLCP Plan, as shown in Fig. 2. Also, relatively early in the process, the quantitative information on SLCP emission sources, and the emission reduction potential of mitigation measures was made available. This provided the basis for the development of a first draft of the National SLCP Plan by the coordination team, for early discussions with stakeholders, which contained quantitative information on their contribution to the issues of climate change and air quality and its health impacts, as well as practical options for how they could reduce this contribution. Having this draft National SLCP Plan provided the basis for detailed, specific discussions with different MDAs about what it was possible for them to endorse in a National SLCP Plan, and what actions could be taken by the MDAs to implement these actions, i.e. two of the outcomes shown in Fig. 1 (Nigeria Federal Ministry of Environment, 2019).

5. Opportunity for designing climate and development policy interventions through *ex-ante* intervention theory framework

This application of intervention theory to conceptualise a policy intervention designed to integrate climate change mitigation with development priorities (in this case, air pollution mitigation) was undertaken *ex-post*, following the three-year national planning process. As outlined above, the application showed that linking the integrated climate change and air pollution mitigation plan to the development priorities in Nigeria, and how these priorities are used to allocate national budget, was a key factor in the development, endorsement, and initial implementation of the plan. This was facilitated by the development of assessments to provide evidence and information showing how climate change and air pollution mitigation actions contributed to Nigeria's development priorities, and a structured coordination and stakeholder engagement process to reach agreement on the priority actions that could be implemented.

The context within which development planning takes place, i.e. the priorities of Nigeria's Economic Recovery and Growth Plan, and budget appropriation process, are country-specific. However, the key factor of developing assessments that link a specific issue(s), in this case climate change and air pollution mitigation, to specific development planning and budget appropriation processes in Nigeria, could also be applied in other countries and to other issues. Similarly, the way in which the coordination of the planning process was structured could also be applied to other planning processes to strengthen the link between climate change, and development planning, and national development planning and budget allocation. For example, the engagement of Ministries of Budget and Planning, alongside the Ministry of Environment, in the coordination of the plan, and the sequencing of stakeholder engagement to ensure stakeholder are engaged throughout the process (Fig. 2), could also be applied to other planning process. In seeking to generalise the lessons from the development of Nigeria's National SLCP Plan to other countries, or development goals other than air quality, one

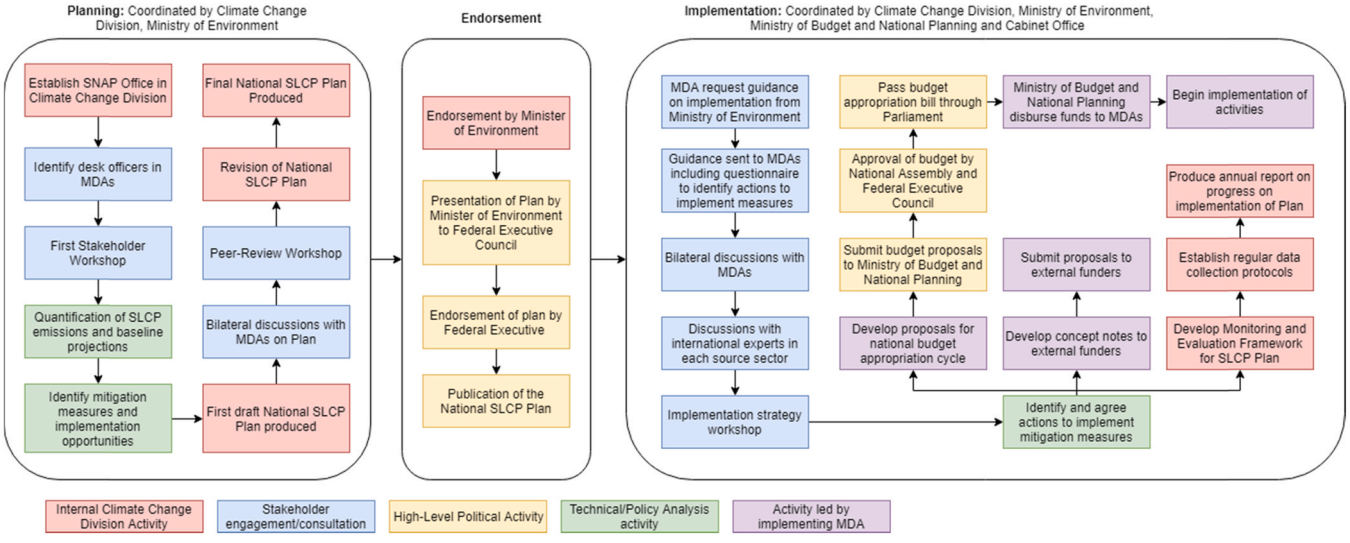

Fig. 2. Sequencing of activities in Nigeria's national SLCP planning process.

key improvement could be the *ex-ante* application of intervention theory. Applying intervention theory *ex-ante* in designing policy interventions to link climate change mitigation and development benefits could contribute to the development of tailored interventions for particular countries or development issues, increasing the chances of achieving the intended goal. Firstly, the interventions required to achieve the Paris Agreement targets, alleviate air pollution, or other complex issues are transformative interventions within a country involving multiple stakeholders. The intervention theory conceptualisation of the planning process provides a framework that, once established, can facilitate regular monitoring of the process. This monitoring can be done both to assess the effectiveness of different interventions in achieving established goals and targets, but also to review whether the goals and objectives of the interventions also need to change (Amanatidou et al., 2014; Patton, 1994), as shown in Fig. 1, and supplementary information. In the context of interventions to achieve climate change mitigation and development priorities simultaneously in low- and middle-income countries, the ability of the intervention theory model to facilitate the review and revision of all aspects of the policy or process is advantageous due to the high frequency with which political priorities change, and also strong socioeconomic trends driving changes in the relative magnitude of emissions from different source sectors (O'Neill et al., 2017).

In addition, some of the limitations of the planning process in Nigeria could have been amended at the outset of the national planning process through the development of an intervention theory analysis of the policy intervention *ex-ante*. A key limitation of the National SLCP Planning process was varying levels of engagement of key MDAs, resulting in more progress being made in some sectors than others. This is reflected in the development of implementation pathways for only 10 of the 22 priority mitigation measures to date (Table 1), as they relied on the provision of inputs from the implementing MDAs responsible for the particular sector. While the reasons for the differing levels of engagement of different MDAs are difficult to disentangle, the development of an intervention theory model for the planning process could pinpoint the activities and strategies to widen engagement (see below).

Other limitations of the National SLCP Planning process in Nigeria included the development of the implementation pathways after, rather than in parallel to, the technical assessment of emission reductions (Fig. 2). This meant that the implementation pathways were informed by the emission reduction assessment, i.e. implementation pathways were developed for priority mitigation measures that had been previously identified. Therefore, the identification of implementation pathways did not inform the identification of priority measures, which may have resulted in a less than optimal ranking of the priority that should be assigned to measures. This is because a detailed understanding of the implementation pathway can help to identify barriers to progress and hence affect the prioritisation process. The development of an intervention theory model at the beginning of the planning process to examine the interventions and links to achieving the overall goal of the policy intervention would have identified the link between the emission reduction assessment and the ease by which implementation pathways could be followed. This would have strengthened the planning process, as the understanding of the actions needed to implement a measure, their time scale, their likelihood of success, and their importance to the overall level of implementation of the mitigation measure, gained from the development of implementation pathways, could contribute to determine the level of ambition of a particular mitigation measure in the emission reduction assessment.

Finally, the development of an intervention theory model *ex-ante* could contribute to expanding the range of development benefits, and possible trade-offs, that are identified and assessed in the planning process. Air pollution is closely linked to climate change due to common emission sources, but there are many other links between climate mitigation and development impacts that could have been identified. The identification of further benefits from the implementation of the 22 mitigation measures identified in the National SLCP Plan, or an analogous climate or clean air plan, could increase the ambition and engagement of MDAs by demonstrating how they contribute to achieving goals within their area of responsibility, such as job creation potential. It is clear that implementing the 22 mitigation measures in Nigeria's National SLCP Plan will directly contribute to achieving multiple sustainable development goals (SDGs), in addition to mitigating climate change mitigation (SDG 13.2) and air pollution (SDG 3.9). The potential SDG benefits of implementing SLCP mitigation measures (including many included in Nigeria's National SLCP Plan) have previously been identified (Haines et al., 2017), but these were not systematically evaluated as part of this process. In addition, possible trade-offs within the planning process were evaluated, though limited to trade-offs in the emissions of GHGs, SLCPs and air pollutants from the implementation of particular mitigation measures. For example, measure 20, the expansion of national electricity coverage was modelled to reduce the use of diesel generators for electricity generation (Table 1). This results in a decrease in the emissions of black carbon and other pollutants for which diesel combustion is a major source, and relatively small increases in SO_2 and CH_4 emissions from increased electricity demand. In this case, the increase in emissions was more than compensated for by the implementation of other mitigation measures that target the major sources of these pollutants. However, as for development benefits, broader trade-offs from the implementation of the 22 mitigation measures, e.g. on different population groups, were not considered in the planning process, and could be explored in future analyses.

Further information about the development implications of implementing mitigation measures could be used within the National SLCP Planning process to prioritise mitigation measures, engage a wider range of stakeholders, and provide further justification of the value of implementing mitigation measures in the budget allocation process. Both the emission reduction assessment and development of implementation pathways could be expanded to consider broader development implications, and the quantitative assessment could include quantification of other development benefits. For example, the implementation of Measures 14 and 15 (Table 1), to expand and improve the wastewater treatment system to reduce methane emissions, could also improve human health through improved water and sanitation systems. These health benefits can be quantified using standard health impact assessment methods (Stanaway et al., 2018). Additionally, the implementation pathways identify specific actions that are needed to implement the mitigation measure, and the analysis of the development implications of these actions could allow to identify those pathways to implement mitigation measures with the largest number of development benefits, and minimal trade-offs (ICAT, 2020).

6. Conclusions and relevance to climate change planning processes

The need for more transparent, effective, and implementable climate change plans has been highlighted (Pauw and Klein, 2020), as has the potential to align climate change mitigation with national development priorities to increase ambition and implementation of climate change mitigation (Linnér et al., 2012; Shindell et al., 2017; United Nations, 2015). Many countries also lack formal air quality strategies or plans (UNEP, 2015). Nigeria is one of seven countries within the Climate and Clean Air Coalition Supporting National Action & Planning (CCAC SNAP) initiative to have developed and endorsed a National SLCP Plan or Strategy (Bangladesh Department of Environment, 2018; Colombia Ministry of Environment, 2018; Cote d'Ivoire Ministry of Environment, 2019; INECC, 2019; Ministry of Environment of the Maldives, 2019; Togo Ministry of Environment, 2020), providing a process and tangible output that could be used to enhance and integrate climate change and air quality planning processes.

The planning process in Nigeria, conceptualised as an intervention theory model, highlights the importance of specific assessments to

provide information and evidence tailored to the specific national development priorities, and to the national budget allocation process. Secondly, the Nigerian case study highlights the necessity that these assessments are undertaken alongside specific coordination and stakeholder engagement components of a planning process that allows the information provided by the assessments to be used to reach consensus, and endorsement of the contents of the plan.

In Nigeria, the planning process within which these key elements were undertaken was an independent planning process designed to develop Nigeria's National SLCP Action Plan. However, most countries have existing climate change planning processes into which these elements could be integrated to increase the integration of development priorities with climate change mitigation. The Paris Agreement states that the achievement of the long-term temperature targets should be done in the context of sustainable development and the right to health (United Nations, 2015), but most countries have not integrated sustainable development priorities into their climate change commitments (Pauw et al., 2016). Therefore, as countries progress with climate change planning and reporting, the insights from this analysis emphasise the utility of integrating development benefits such as improving air quality within this process to increase mitigation ambition, and to engage stakeholders in the development of a realistic plan for implementation. Specifically, climate change mitigation assessments are commonly undertaken, and air pollutants, and other development priorities could be integrated into them to demonstrate how climate change mitigation can contribute to national development priorities (CCAC SNAP, 2019). Based on the Nigeria example, undertaking these integrated assessments within a process that engages all relevant stakeholders in the development and dissemination of this information, increases the probability that climate change mitigation measures move forward to implementation. Intervention theory can be a useful conceptual framework with which to develop and design a process that includes specific components which aim to achieve these goals.

CRediT authorship contribution statement

Christopher S. Malley: Conceptualization, Methodology, Formal Analysis, Writing – original draft. **David Omotosho:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Project Administration. **Bala Bappa:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Project administration. **Asmau Jibril:** Conceptualization, Methodology, Project administration. **Peter Tarfa:** Conceptualization, Methodology, Project administration. **Mikael Roman:** Conceptualization, Methodology, Formal analysis, Writing – original draft. **W. Kevin Hicks:** Conceptualization, Writing – review & editing. **Johan C.I. Kuylenstierna:** Conceptualization, Methodology, Writing – review & editing. **Candela de la Sota Sandez:** Writing – review & editing. **Elsa N. Lefèvre:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2021.08.022.

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