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Research Article

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Climate Rationale Development the Case of Evidence and Climate Data in Analyzing Historical and Projected Climate Trends and Impacts for Project Development

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Abstract

A proper climate rationale is grounded in evidence and climate data, is crucial for developing effective projects by demonstrating the link between climate change impacts and proposed solutions. Analyzing historical and projected climate trends helps in understanding vulnerabilities, justifying interventions, and ensuring that projects are both relevant and impactful. Detailed projections of future climate, typically the modified outputs of computationally intensive global climate models, receive the lion's share of attention by those involved in adaptation planning. The natural complement to climate change projections, and the focus of this research, are climate indicators, which we define as information on observed climate trends, conditions, and impacts often associated with socioeconomic consequences. Climate indicators have been used for broadly communicating about climate change and are increasingly used to provide quick, reliable access to information on observed patterns of change in physical and ecological systems as well as risks to human health and well-being. Weather and climate information encompasses a diverse range of data sets, methods and tools. To unpack the issues in the utility of weather and climate information for decision-making, it is necessary to understand what type of information is relevant and the underpinning technical and scientific challenges associated with the production of such information. This section summarizes the range of globally and regionally available weather and climate information, but first provides pertinent background on key concepts of weather and climate. A climate rationale provides the scientific underpinning for evidence-based climate action decision-making, and development of the theory of change for activities related to climate finance. It ensures that the set of causal linkages between climate and climate impacts and between action and societal benefits is fully grounded in the best available climate data and science concerning the most relevant climatic factors.

The climate rationale is the cornerstone of justifying a climate change project's necessity and its effectiveness in addressing core impacts and threats. It essentially explains the "why" behind the initiative, linking specific climate threats faced by a community or region to proposed solutions for mitigation or adaptation. Desk research and literature review was undertaken via review of existing climate information by gathering and analyzing existing climate data, including historical records, climate models, and scientific literature related to the project's location and sector. The desk review enabled assessment of projected climate impacts by investigating climate models and projections to understand potential future climate scenarios and their impacts on the project's environment and target population. Further data gathered enhanced comprehension of climate vulnerabilities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks. Scientific Literature mostly from reviewing studies on climate change impacts relevant to the project's context informed the conceptual framework as illustrated below. By following this comprehensive research methodology, environmental sustainability managers and scientists can create a strong climate rationale that effectively addresses climate change risks, promotes resilience, and contributes to sustainable development. Justification of Project Choices by explaining the rationale for chosen adaptation options especially by clearly articulate why specific adaptation measures were selected and how they address the identified climate risks and vulnerabilities. In addition, the study proposed for formulation of climate risk management plans that clearly outline specific actions to manage the identified climate risks and ensure the project's long-term sustainability. A comprehensive EIA & SEA Environmental Management Plan would ensure that proper monitoring and evaluation establishes a monitoring and evaluation framework to track the project's progress in addressing climate risks and adapting to a changing climate.

Keywords: Climate, Climate Indicators, Ecological Systems, Climate Rationale, EIA, SEA Environmental Management Plan.

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Introduction

A proper climate rationale is grounded in evidence and climate data, is crucial for developing effective projects by demonstrating the link between climate change impacts and proposed solutions. Analyzing historical and projected climate trends helps in understanding vulnerabilities, justifying interventions, and ensuring that projects are both relevant and impactful.

Detailed projections of future climate, typically the modified outputs of computationally intensive global climate models, receive the lion's share of attention by those involved in adaptation planning. A great deal of emphasis goes into risk management decisions where adaptation practitioners try and answer difficult questions about how the future may unfold. This makes sense, as climate projections can provide information about a range of potential climate impacts well into the future, as well as the type and magnitude of key uncertainties about those impacts. Such work is critically important because, by some estimates, adaptation can reduce the cost of climate impacts by more than half [1].

The natural complement to climate change projections, and the focus of this research, are climate indicators, which we define as information on observed climate trends, conditions, and impacts often associated with socioeconomic consequences. This definition includes direct measures of climate (e.g., temperature, precipitation), non-direct measures (e.g., plant phenology or wildfire disturbance) and even societal measures (e.g., heat-related mortality, heating and cooling degree days) useful for displaying the influence of changing climate over time at various appropriate spatial scales. In addition to being important in their own right as climate continues to change, climate indicators will provide increasingly important evidence for shifting baseline climate conditions that could be used in proactive adaptation decision-making [2-4].

Climate indicators have been used for broadly communicating about climate change and are increasingly used to provide quick, reliable access to information on observed patterns of change in physical and ecological systems as well as risks to human health and well-being. Internationally and in the U.S., there are several examples of regional and national climate indicator compilations that conveniently develop, compile, and document indicators based on a variety of data sources [5-12].

Background Information

Weather and climate information encompasses a diverse range of data sets, methods and tools. To unpack the issues in the utility of weather and climate information for decision-making, it is necessary to understand what type of information is relevant and the underpinning technical and scientific challenges associated with the production of such information. This section summarizes the range of globally and regionally available weather and climate information, but first provides pertinent background on key concepts of weather and climate.

Weather and climate are fundamentally different. Definitions vary, but 'weather' is often defined as the state of the atmosphere at a point in time, while 'climate' is the statistical distribution of weather aggregated over a period of time [13, 14].

Historical observations help us understand past and present-day climate risks. Observations from paleoclimate proxy data sets (e.g. from ice cores and tree ring data) and directly measured observational data sets provide data at different temporal and spatial resolutions. For example, three observational data sets are used in the Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report (AR5) to develop a time series of global mean annual temperatures from 1850 to the present day [15]. Other examples of observational data sets include satellite-based rainfall data and tropical cyclone data [16, 17].

Dissemination of climate information has improved in recent times. With an increasing volume of climate data, online data portals are becoming an important mode of communication [18]. Producing information from raw data requires post-processing expertise and appropriate analytical tools. Users in this space are therefore mostly limited to researchers and impact assessment modellers. However, climate information is increasingly being translated into more usable formats for other users, such as through agro-advisories for farmers, and is also being disseminated through innovative communication channels for more widespread uptake [19].

Literature Review

A climate rationale provides the scientific underpinning for evidence-based climate action decision-making, and development of the theory of change for activities related to climate finance. It ensures that the set of causal linkages between climate and climate impacts and between action and societal benefits is fully grounded in the best available climate data and science concerning the most relevant climatic factors (GCF 2022).

The interventions aimed at tackling climate change must be founded on a robust and comprehensive climate rationale. Such a rationale ensures that the proposed solution effectively addresses the specific challenges posed by climate change. Moreover, a strong climate rationale has become a prerequisite for accessing climate finance from international funding bodies. By basing interventions on a well-founded climate rationale, it is possible to enhance their efficacy and ensure that they align with the criteria established by those funding bodies.

The climate rationale is the cornerstone of justifying a climate change project's necessity and its effectiveness in addressing core impacts and threats. It essentially explains the "why" behind the initiative, linking specific climate threats faced by a community or region to proposed solutions for mitigation or adaptation [20].

Challenges related to developing a climate rationale are elaborated as follows according to The Building Approaches to Fund Local Solutions with Climate Evidence (BASE) and Adaptation Research Alliance (ARA) studies in 2022 identified several technical, social, and capacity-related challenges faced by local actors in developing countries when developing a climate rationale: Gaps in data and information due to a lack of localized data, which is crucial for accurately assessing climate impacts and risks. This is compounded by difficulties in accessing decentralized data, language barriers in communicating data,

and limited historical data availability. Complexity of climate modelling mostly in developing accurate climate models and scenarios is inherently complex, requiring advanced technical expertise and resources that may be lacking in some developing countries.

Varying capacity and resources due to the diverse contexts in different countries and institutions have varying levels of capacity and resources to generate and utilize climate information. This disparity can hinder the effective development and application of climate rationale. Limited understanding of climate impacts as a result of insufficient understanding of how climate drivers and associated risks specifically affect local community livelihoods, which impedes the development of targeted and effective climate strategies. Inadequate investment in climate information systems orchestrated by a general lack of public and private investment in climate information systems and high-quality data infrastructure, which further exacerbates the difficulties in developing a comprehensive climate rationale.

Linking responses to climate impacts where effective climate change projects must explicitly connect proposed solutions to specific observed or projected climate impacts. This requires detailed knowledge of how climate change affects local conditions and how proposed interventions address these effects.

Data access and technical challenges mostly in the developing countries, especially Small Island Developing States (SIDS) and LDCs, frequently face difficulties accessing high- resolution climate data at the project level. Downscaling global climate models to local scales and interpreting this data into actionable insights involves significant technical expertise [21].

Integrating scientific and local knowledge in order to formulate robust climate rationale should incorporate not only scientific data but also local and traditional knowledge. This approach ensures that the social, economic, and cultural consequences of climate change are considered, enhancing the relevance and effectiveness of the proposed interventions [22].

Alignment with policies and capacity constraints where there has to be a coherent demonstration of proper alignment with both national and international climate policies adds complexity to the proposal process. Additionally, developing countries often struggle with financial tracking and mobilizing climate finance due to limited capacity [21, 22].

Conceptual Framework

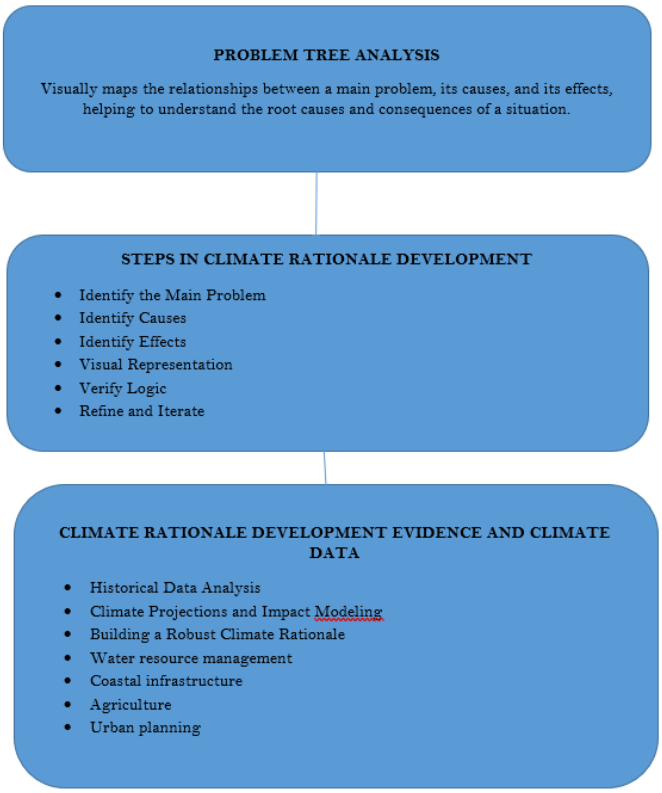

Figure 1: An illustration of CLIMATE RATIONALE DEVELOPMENT problem tree analysis & scientific tools of evidence and climate data, (Lydia Nyawira Mburia, 2025)

Research Methodology (Methods & Materials)

This chapter outlines the research methodology adopted to examine the Climate Rationale Development the Case of Evidence and Climate Data in Analyzing Historical and Projected Climate Trends and Impacts for Project Development. The study employed a mixed-methods design (quantitative and qualitative) to capture both measurable data and deeper insights. A descriptive and explanatory survey design was applied to elaborate climate rationale development.

The target population comprised of climate scientists and environmental sustainability experts drawn from Africa Group of Negotiators Experts Support. A purposive and stratified random sampling technique was used. Purposive sampling Africa Group of Negotiators Experts Support who hold immense experience, while stratified random sampling ensured representation across organizational levels at AGNES.

The study sampled 100 respondents that encapsulated 50 environmental sustainability experts, 25 climate change policymakers, and 25 community representatives), determined using Yamane's formula for population sampling.

Data was collected through structured questionnaires, key informant interviews, and document reviews. Questionnaires captured quantitative data while interviews provided qualitative insights. The main instrument was a structured questionnaire with Likert-scale items on climate development rationale. Interview guides supplemented this with in-depth qualitative data. Desk

research and literature review was undertaken via review of existing climate information by gathering and analyzing existing climate data, including historical records, climate models, and scientific literature related to the project's location and sector.

A pilot study involving 10% of the sample was conducted to test validity and reliability. Expert review confirmed content validity, and Cronbach's Alpha coefficient ($\alpha = 0.84$) indicated high reliability.

Quantitative data was analyzed using descriptive statistics (means, percentages) and inferential statistics (correlation and regression analysis) with the help of SPSS. Qualitative data was analyzed thematically to identify patterns on historical observations that helped us understand past and present-day climate risks. Findings were presented using tables, charts, graphs, and thematic summaries, ensuring clarity and alignment with the research objectives.

This methodology ensures a systematic and reliable approach to evaluating the climate development rationale approach.

The desk review enabled assessment of projected climate impacts by investigating climate models and projections to understand potential future climate scenarios and their impacts on the project's environment and target population. Further data gathered enhanced comprehension of climate vulnerabilities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks.

Scientific Literature mostly from reviewing studies on climate change impacts relevant to the project's context informed the conceptual framework as illustrated above.

Data Analysis (Results & Discussions)

This study analyzes how climate vulnerabilities affect communities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks. Out of the distributed questionnaires, 80% response rate was achieved, which is considered adequate for reliable data analysis.

Most AGNES participants were aged 25–45 years, with a majority having at least tertiary education and professional experience in climate science and environmental sustainability. A pilot study was conducted on 10% of the sample to refine the research tool. Results indicated clarity in the items and alignment with research objectives.

Content validity was confirmed through expert review, ensuring items aligned with how climate vulnerabilities affect communities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks.

Reliability tested using Cronbach's Alpha = 0.84, indicating strong internal consistency of the instrument. Descriptive Statistics/Analysis demonstrated awareness of how climate vulnerabilities affect communities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks at 88%, adoption of climate development rationale at a moderate (mean = 3.5 on a 5-point scale) and highlighted the main key barriers especially lack of infrastructure, high cost of compliance, and limited public awareness.

Inferential Statistics derived from correlation analysis demonstrated a positive and significant correlation ($r = 0.65$, $p < 0.01$) of how climate vulnerabilities affect communities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks outcomes.
Regression Analysis was deployed using the regression model that showed and explained how climate vulnerabilities affect communities by reviewing existing vulnerability assessments to understand which populations, sectors, or regions are most susceptible to climate risks outcomes at 72% of the variance in climate development rationale. This implied they are strong parameters of climate risks outcomes.

Qualitative Data Analysis was premised and anchored on the following basic thematic analysis revealed three core themes namely, Climate development rationale policy support by executing strong policies accelerate adoption; Community Engagement via public participation as well as technological innovation by investment in modern climate development rationale research tools, methods to address 21st century climate risk dynamics.

Optimal Conceptual Framework climate development rationale policy support by executing strong policies accelerate adoption; Community Engagement via public participation as well as technological innovation by investment in modern climate development rationale research tools, methods to address 21st century climate risk dynamics. integrates through: Inputs: Resources (technology, capital); Processes through innovation and stakeholder collaboration as well as outputs for climate risks enhanced sustainability.

This presentation provides both quantitative and qualitative insights, showing that Community Engagement via public participation as well as technological innovation by investment in modern climate development rationale research tools, methods to address 21st century climate risk dynamics. integrates through: Inputs: Resources (technology, capital); Processes through innovation and stakeholder collaboration as well as outputs for climate risks enhanced sustainability is key in climate development rationale.

Data collected, collated was analyzed to properly identify vulnerable populations by determining which groups are most susceptible to climate change impacts based on factors like age, gender, socioeconomic status, and location. The following parameters were observed that is, assess sector-specific vulnerabilities where there was an evaluation of the sensitivity of key sectors, such as agriculture, water resources, or infrastructure, to climate change impacts.

Spatial Mapping was done to map the spatial distribution of climate risks and vulnerabilities to identify hotspots. The spatial mapping enabled the researcher to execute an impact analysis mostly highlighting the potential impacts of climate change on the project, such as changes in temperature, rainfall, sea level rise, and extreme weather events. Assess economic impacts by evaluating the potential economic costs associated with climate change impacts on the project. A comprehensive environmental impact assessment was executed to analyze social and environmental impacts by considering the potential social and environmental consequences of climate change on the project, such as impacts on livelihoods, health, and ecosystems.

Conclusions

By following this comprehensive research methodology, environmental sustainability managers and scientists can create a strong climate rationale that effectively addresses climate change risks, promotes resilience, and contributes to sustainable development.

Recommendations

From the study on climate rationale development the case of evidence and climate data in analyzing historical and projected climate trends and impacts for project development the following have been recommended to strengthen scientific data on climate rational development.

Justification of Project Choices by explaining the rationale for chosen adaptation options especially by clearly articulate why specific adaptation measures were selected and how they address the identified climate risks and vulnerabilities. Prioritizing adaptation actions based on their potential to reduce vulnerability and enhance resilience. Highlight co-benefits emphasizing the triple bottom line, sustainability management, environmental management systems. This made it easy to explain any additional benefits of the project, such as improved livelihoods, reduced inequality, or enhanced ecosystem services.

In addition, the study proposed for formulation of climate risk management plans that clearly outline specific actions to manage the identified climate risks and ensure the project's long-term sustainability. A comprehensive EIA & SEA Environmental Management Plan would ensure that proper monitoring and evaluation establishes a monitoring and evaluation framework to track the project's progress in addressing climate risks and adapting to a changing climate.

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