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An empirical analysis of the co-benefits of integrating climate change adaptation and mitigation in the Namibian energy sector

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Abstract
The Namibian energy sector and other energy sectors across the globe are currently in a rapid transformation era that must respond to climate change, which directly affects energy infrastructure's resilience to the effects of resource scarcities or extreme weather conditions. The energy sector must implement adaptation to guarantee the resilience of vital infrastructure to fulfil its regulatory commitments, which cover the elements of resilience and safety. Through investigating climate change adaptation and mitigation implementation in Namibia, this study validates the existence of these co-benefits where integration is fully observed. It employed a meta-analysis and content analysis to link the observed variables to the most recognised co-benefits. The findings suggest that integration is an efficient way to generate co-benefits that contribute positively to the climate change project. Effective leadership support is one way of realising such integration, either via public-private partnership or energy policy. Namibian energy policy, it is suggested, through voluntary tools and incentives, should create key public-private partnerships and promote management. These recommendations have application beyond the Namibian energy sector, and the lessons learned here could be implemented in scenarios outside of it.

Keywords: *public-private partnership; energy policy; adaptation and mitigation synergies*

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1. Introduction and background

1.1 Overview of the energy sector in Namibia

Namibia's fast economic growth in recent years has led to an increased demand for electricity, much faster than anticipated by energy planners. NamPower, the state-owned power utility, runs three power generation facilities built in the 1970s, namely: Ruacana Hydro plant (330 MW), Van Eck thermal plant (120 MW), and Paratus thermal plant (24 MW). These usually never generate electricity at complete capability (GRN, 2017a; NamPower, 2017). A 21.5 MW power plant in Walvis Bay commenced operation in late 2011. Peak demand for Namibia is over 500 MW (GRN, 2016).

Namibia's energy industry includes formalised electricity, upstream oil and gas, and downstream liquid fuels subsectors, in addition to the less formalised downstream gas and thermal energy subsectors (NamPower, 2017; GRN, 2017a). In the past, many viewed renewable energy as a distinct subsector. However, this policy integrated these industries according to their particular positions into the electricity and thermal subsectors. The country's electricity industry has experienced several significant developments and shifts over the past two decades. The industry has a well-developed legislative structure that is operationalised by the regulator (i.e. the Electricity Control Board, ECB) (NamPower, 2017). NamPower owns and operates some 11 561 kms of transmission network, which links multiple regional markets in Namibia and promotes the dynamic electricity trade. Furthermore, NamPower supplemented some 120 MW of domestic electricity generating capability, bringing the complete installed capacity to 493 MW (NamPower, 2017). Various independent power producers (IPPs) such as KuduPower, Xaris Energy Namibia, Innosun Energy Holdings, among others, have lately started activities, with more expected in the near future. The 2016 draft of the National Integrated Resource Plan (NIRP) envisaged adding extra base-load ability in the order of 300 MW over the following five years (GRN, 2016). The NIRP was updated in 2020, and draft reports were disseminated to relevant stakeholders who were given the opportunity to comment on significant findings. These included NamPower, regional electricity distributors, the ECB, government officials, and energy sector stakeholders (Chojnowska, 2021).

About 59% of the electricity provided in Namibia had to be imported from neighbouring countries over the past century. According to the Namibia Statistics Agency (NSA) (2021), the country's energy output in July 2021 was 48 192 MWh, with IPPs accounting for 54.4%. In July 2021, Namibia imported 297 297 MWh (11% monthly rise) of electricity, with South Africa supplying 50.9% of this, Zambia 27.3%, and Zimbabwe 12.4% (Ndjavera, 2021; NSA, 2021). This is not in line with the goal of the Namibian White Paper on Energy Policy, which specified that at least 75% of electrical energy and 100% of peak electricity demand should be provided from local resources (GRN, 2017a). Overall, in July 2021 Namibia imported about 60% of its total energy requirement and 92% of commercial types of energy (all but biomass-derived power), thus exposing the nation to the danger of relying on imported energy. Renewable energy in the form of solar, wind and biomass are accessible in abundance as local energy resources (Ndjavera, 2021; NSA, 2021; GRN, 2017b; NamPower, 2017). On capacity utilisation, hydro and marine energy accounted for about 42%, and wind energy for another 40%, as shown in Figure 1.

Generation in 2019	GWh	%
Non-renewable	**164**	**9**
Renewable	**1 654**	**91**
Hydro and marine	1 288	71
Solar	348	19
Wind	18	1
Bioenergy	0	0
Geothermal	0	0
Total	**1 818**	**100**

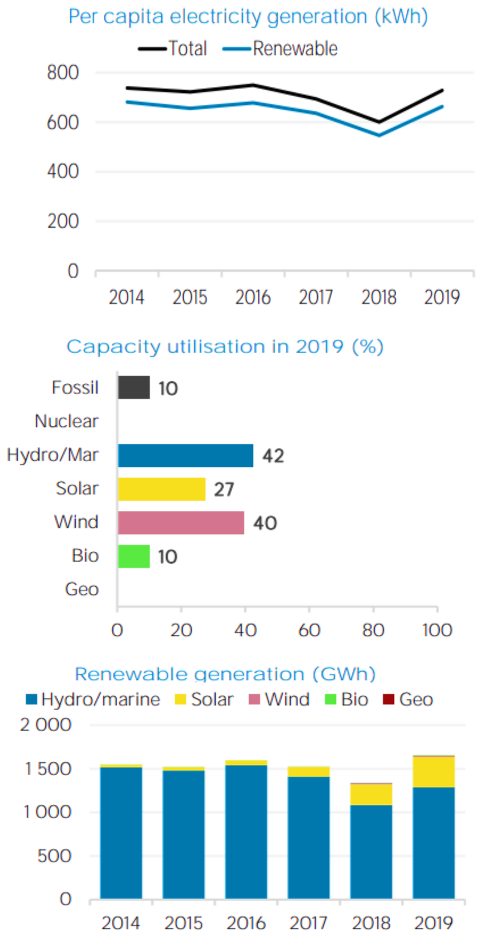


Figure 1: Namibia's electricity generation and capacity utilisation in 2019 (IRENA, 2021).

1.2 The renewable energy sector in Namibia

Namibia has plenty of renewable energy resources, such as solar, wind and biomass. However, renewable energy (besides large hydro) accounts for only an insignificant quantity of the country's installed capacity thus far. Figure 2 offers an overview of the country's installed capacity for the generation of electricity, including from renewable energy sources. In addition, imports account for more than half of the Namibia's energy consumption, as shown in Table 1. The weighted charges for these importations rely on agreement conditions, yet are likely to be costly in relation to the price of current and new power generation alternatives.

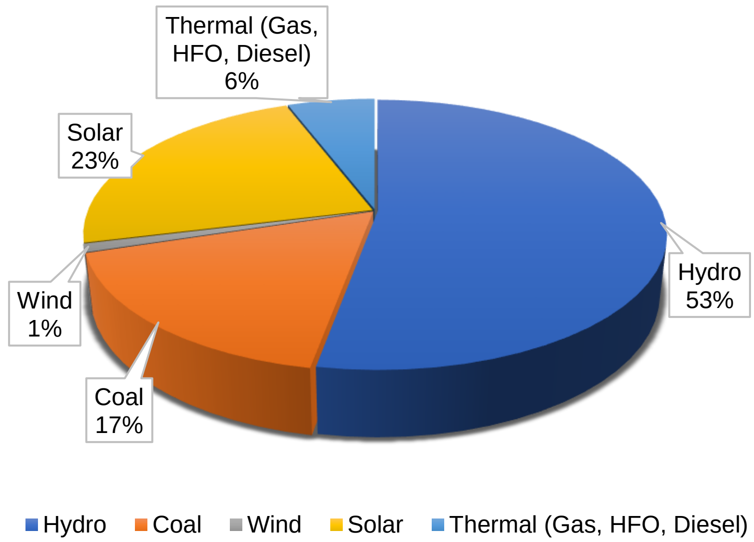


Figure 2: Namibia's installed capacity for the generation of electricity including renewable energy sources as of July 2021 (~680 MW) (USAID, 2021).

Table 1: Summary of Namibia's power imports (GRN, 2017b).

Import source	*Max. supply capacity (MW)*	*Capacity factor (%)*	*Net supply (MW)*
South Africa (Eskom supplemental)	200	20	40
South Africa (Eskom off-peak)	300	50	150
Zimbabwe (ZPC)	80	50	40
Zambia (ZESCO)	50	100	50
Total	**630**		**280**

There are a number of new renewable energy projects in Namibia that are at different stages of growth. These include the Mega Solar project, which is a cooperative effort between Power Africa and the governments of the Botswana and Namibia, the International Finance Corporation, the International Bank for Reconstruction and Development (World Bank), and the African Development Bank to promote the development of Southern Africa's largest solar-generation project, expected to generate 2–5 GW of solar power (USAID, 2021). Another notable new renewable energy project in Namibia is the green hydrogen project. This is seen as holding the potential for Namibia to become a green hydrogen hub in Southern Africa. The significant prospect for green hydrogen is to boost African's goal of decarbonisation and it is anticipated to have a substantial impact on energy transformation in African socio-economic development (Atlantic Council, 2021). Namibia's NIRP design will offer directions to upcoming procurement of power from renewable energy sources (Chojnowska, 2021; GRN, 2016). This will allow renewable energy policy to offer further directions for the renewable energy industry and promote a supporting environment to exploit Namibia's plentiful renewable energy resources (Chojnowska, 2021; GRN, 2017b).

Green hydrogen is viewed by the Namibian government as a growing market prospect, possibly boosting national and regional economic development. The government is concentrating its efforts on fostering public-private partnerships to assist local green hydrogen development, with Namibia aiming to become a net energy exporter (Nexentury, 2021). Germany has invested USD 46 million in Namibia's green hydrogen development, and the country is relying on environmental, social, and governance-oriented capital flows and sustainable finance to boost renewable energy initiatives (Atlantic Council, 2021).

Namibia can decarbonise its economy, boost its industrial sector, and create national and regional jobs through the diverse applications of green hydrogen. Clean electricity and green hydrogen can be used to broaden the economy by developing new businesses like domestic steel manufacture and zinc processing as additional renewable energy generation comes online. With regard to the additional applications for Namibia's renewable energy resources, Namibia is one of the driest countries in the world, and the country's abundant solar and wind energy might be used to power desalination plants. It has also been suggested that Namibia's uranium riches could be used to spark interest in domestic nuclear energy development for pink hydrogen generation (Atlantic Council, 2021; USAID, 2021).

1.3 Strategy for the renewable energy sector and key components in Namibia

A study by the International Energy Agency (IEA) on the transition to cost competitive renewables policy frameworks shows how renewable energy technologies approaches should be developed depending on each technology's maturity and cost-competitiveness of (IEA, 2016; REN21, 2015). For instance, certain technologies that are not yet competitive might need further support in the form of R&D, for preliminary demonstrations. Others that are cost-competitive, on the other hand, involve a supporting organisational and policy framework to guarantee that they can compete with options on an equal playing ground at a minimum. The RE policy as indicated in Figure 3 gives priority to three policy framework components to assist in driving the renewable energy development once fossil fuel costs have been attained:

- Establishing a long-term vision for a viable energy scheme (e.g. RE targets, climate change targets).
- Improving the flexibility of the power system; for instance, RE grid integration and stabilisation study, fair access for distributed generation.
- Maintaining the bankability of renewable energy projects; for instance, permitting IPP PPA laws, streamlined licensing procedures and other risk mitigation procedures (IEA, 2016; GRN, 2017b).

1.4 Institutional and regulatory framework for the Namibian energy sector

The RE policy issues must be understood in the light of energy sector's organisational and supervisory background. Once these are completed, further guidelines and improvements will be necessary to guarantee compatibility with the RE policy along with other draft policies and bills. Figure 4 offers a graphical illustration of the organisational framework for the energy industry in Namibia and shows various draft guidelines and proposal laws that are yet to be concluded and brought into line with this RE policy.

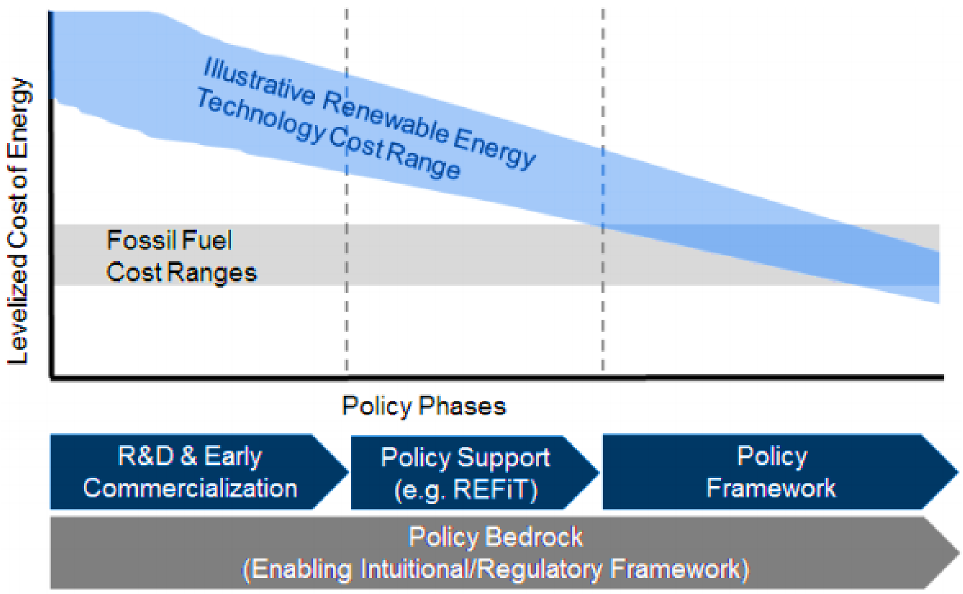


Figure 3: RE policy evolution with levelised costs (IEA, 2016).

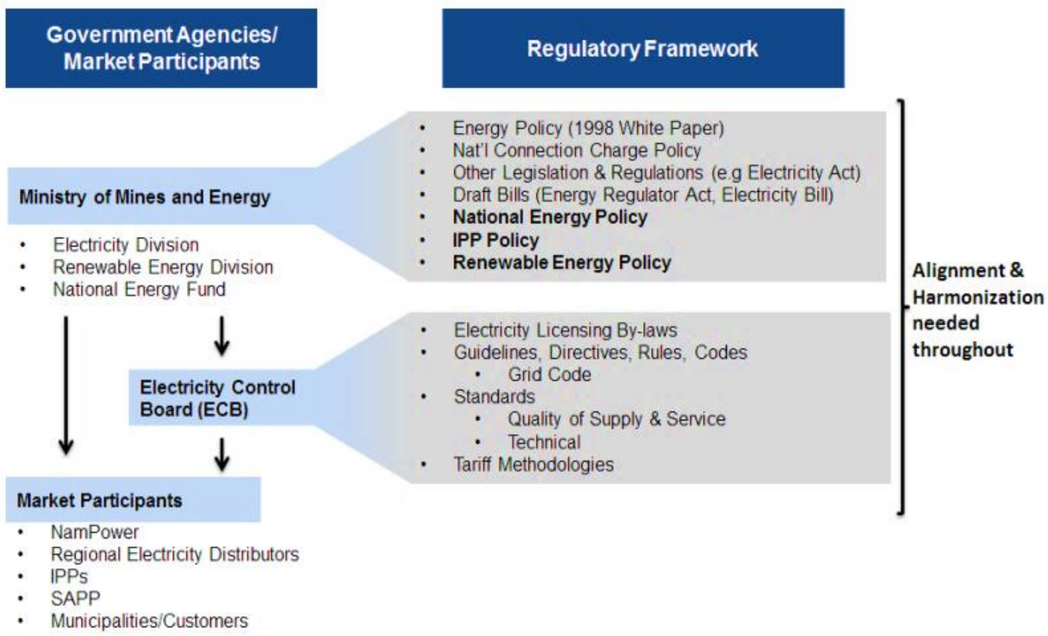


Figure 4: The institutional and regulatory framework of Namibia's energy sector (GRN, 2017b).

2. Establishing the co-benefits of incorporation for the Namibian energy transformation

As stated by the Intergovernmental Panel on Climate Change (IPCC), mitigation relates to activities that handle greenhouse gas (GHG) emissions emanating from anthropogenic activities, whereas adaptation relates to actions that boost the adaptive capability or resilience of an industry, area, business or government to climate change-related vulnerabilities (IPCC, 2012; Hennessey et al., 2017). Adaptation and mitigation are frequently segregated in science and policy. The motive is that, while both measures are aimed at reducing the adverse impacts of climate change, they vary in their particular goals: mitigation seeks to address the causes whereas adaptation seek to resolve the consequences (Duguma, 2014; Swart and Raes, 2007; Hennessey et al., 2017).

Mitigation of climate change is essential to restrict the degree of climate change as a whole, while adaptation is needed to respond to present and future energy threats. Although no strategy can bring about a successful decrease in climate change danger, when harmonising adaptation and mitigation, 'responses can complement each other and together can greatly reduce the risks of climate change' (Hennessey et al., 2017). There is increasing interest in the relationship between adaptation and mitigation and exploring future synergies or co-benefits between the two methods (Hoppe and Van Bueren, 2015; Gregorio et al., 2017). As stated by Klein et al. (2007), an integrated strategy that includes both mitigation and adaptation objectives can create interactions concerning the two reactions, meaning that their joint impact is bigger than the sum of their impacts if applied individually (Klein et al., 2007; Swart and Raes, 2007). There are four main kinds of interrelationships between adaptation and mitigation that generate interactions: a) adaptation benefits of mitigation activities; b) mitigation benefits of adaptation actions; c) mitigation and adaptation actions; and d) policies and strategies promoting integrated mitigation and adaptation interventions.

It is equally imperative to identify the possible trade-offs that require a mitigation and adaptation balance when both activities cannot be carried out in full at the same time. For instance, economic or other limitations can lead in discrepancy cost savings, where the mitigation measures are linked with instant cost savings, whereas adaptation is linked with cost circumvention (Klein et al., 2007; Achieng Ogola et al., 2012; Hennessey et al., 2017).

Actions that incorporate both adaptation and mitigation have the ability to minimise climate change uncertainty and the complexity of climate impact reactions. This dynamic is feasible because adaptation and mitigation reactions to climate change are nested within higher financial and technical issues (Audinet et al., 2014; Hennessey et al., 2017). These huge challenges are precisely those that the energy sector is trying to solve and offer the needed framework for inclusion (Bulkeley et al., 2014; Chenoweth et al., 2018). The nested nature of these problems argues for a consistent climate policy and programs that encourage the creation of cost-effective responses and, more so, for increasing energy security. This would similarly promote climate intervention and the inclusion of adaptation and mitigation (Catron et al., 2013).

Integration can be viable due to the prevalent determining factor that command an organisation's ability to act, whether to mitigate or acclimatise to climate change (Hennessey et al., 2017). These factors include access to technology and resources, comprehensive policy improvement, and permission to use reliable data and reliable decision makers (Bulkeley et al., 2014). Therefore, a high level of adaptive capability has proved useful in creating, and thereby executing, a successful mitigation strategy (Berry et al., 2014). Executing a mitigation intervention can also boost resilience if it operationalises risk-spreading interventions or applies risk-reducing human or economic resources (Castán Broto, 2017). These synergies eventually produce mutual 'co-benefits', which are characterised as extra advantages beyond the original rise in resilience and decrease of GHG emissions (Ciscar and Dowling, 2014). Co-benefits hold the potential to decrease residual damage to the energy sector as a result of climate change. Those damages that occur after adaptation or mitigation activities have been done while improving the price of applying programs to boost resilience (Croci et al., 2017). Four comprehensive kinds of co-benefits were apparent from an examination of climate change adaptation and mitigation literature:

1. Minimised competitiveness for resources

Competition in the energy sector is likely to arise from limitations on natural, human and monetary resources and diverse urgencies on how to capitalise on them (Hennessey et al., 2017). For instance, in the event of biomass production, disputes may arise between the agriculture and energy industries over water resources (Davis and Clemmer, 2014; Chenoweth et al., 2018). Connecting adaptation with mitigation can minimise such competition, leading to better access to resources (National Energy Board, 2016).

2. Minimised impact of scientific ambiguity on climate change policy development and execution

By emphasising the more quantifiable attributes of mitigation, the scientific uncertainty resulting from the longstanding timelines and difficulty characteristic in adaptation decisions can be minimised (Hennessey et al., 2017). Mitigation projects are categorised by particular results, for instance, power generation or GHG decreases (Hennessey et al., 2017). For instance, Hurtado et al. (2015) have empirically established that integrat-ing mitigation requirements into financial adapt-ation cost models can decrease the impact of scientific doubt on the cost of activities for adaptation.

3. Coordination of climate change execution objectives

Some of the adaptation resolutions in the energy sector might result in greater GHG emissions if they result in energy sprawl or enhanced and improper use of land required for decentralised energy developments, deforestation for biomass, or some further maladaptive use of land for energy generation or transmission purposes. Equally, some mitigation alternatives may enhance the vulnerability of the energy sector to extreme weather occurrences (Hennessey et al., 2017).

4. Enhanced community license of energy projects

The more indigenous and easier to observe advantages offered by adaptive behaviour can offset public resistance to energy projects, for instance, regionalised energy projects faced by local demonstrations. For instance, renewable energy projects can contribute favourably to local ecosystem services that can promote recreational assets (Hennessey et al., 2017) or decrease the adverse impact of renewable energy projects in close proximity to valued fields (Hoppe and Van Bueren, 2015). Another instance is the electrification of isolated villages using decentralised renewable energy in the province of Jujuy, Argentina (IPCC, 2012; Kazmierczak, 2014).

The co-benefits of this nature can enhance the Namibian energy sector's capacity to execute climate change responses, for example, industry operations to decrease GHG emissions, offset infrastructure susceptibility, or enhance outage reaction intervals, while mitigatingthe cost liability experienced during previous energy-generating infrastructure renewal periods (Klein et al., 2005; Hennessey et al., 2017; Miika Rama et al., 2013). Such enhanced responses link climate change activities to wider approaches to 'promote the energy transformation benefits of public-private partnerships, government institutions, and private-sector benefits' (Hennessey et al., 2017). Consequently, the impacts arising from these co-benefits are multiplier impacts that equally demonstrate the prospective benefits of inclusion for the energy sector.

This study seeks to define and assess possibilities for integrating climate adaptation and mitigation within the Namibian energy sector. This study presents selected effects of climate change on the Namibian energy sector and summarises the lessons learned from the co-benefits identified in preceding studies to establish concepts and ideas to integrate the two fields of concern in practice. The findings are usually oriented towards energy sector planners, engineers, and policymakers in the energy sector and provide overall suggestions on how to enhance the integration of adaptation and mitigation in the Namibian energy sector.

3. Research methodology

The study adopted a meta-analysis and content analysis of freely accessible information and data on the co-benefits of integration of adaptation and mitigation in the Namibian energy sector. These datasets include various scholarly publications, national reports, policy documents, and, especially, industrial detailed information originating from both national (i.e., Namibian) and international levels. The significant existence of the co-benefits was carefully considered as a confirmation that integration was indeed happening (Hennessey et al., 2017). These datasets were obtained from the Namibian Ministry of Mines and Energy (MME), and include reports, government official reports and statistics, industry-specific publications, newspaper articles, and company reports, consistent with the approach set by Barnett and Thomas (2009). This study also gathered secondary data through comprehensive analysis around several issues such as national reports on co-benefits of integration of adaptation and mitigation in the Namibian energy sector. This was carried out with the sole purpose of acquiring appropriate secondary data from the MME, which is the key custodian of energy supply in Namibia and its associated institutions (GRN, 2016). The measurement tool for this investigation was subsequently determined through a comprehensive assessment of relevant studies.

4. Results and discussion

Adequate literature has been reviewed and analysed to identify causal pathways leading to the co-benefits of integrating climate change mitigation and adaptation in the Namibian energy sector. These fundamental paths are described from the collaboration of change drivers (policy, public-private partnership, management, and purpose) as they produce the recognised co-benefits (decreased resource competitiveness, decreased impact of uncertainty, coordination of results, and enhanced social licensing).

4.1 Namibia's thermal energy supply

Thermal energy usually relates to heat energy. Various renewable energy sources in Namibia can provide thermal energy, such as solar radiation, geothermal power, sea heat gradients, and biomass or biofuels combustion. Thermal energy can similarly be used in a broad range of applications, including but not restricted to industrial process heat, national hot water heating, and business building cooling or heating supply.

4.2 Solar thermal application in Namibia

The abundance of solar resources in Namibia and the growing affordability of solar technologies make solar thermal systems and applications a top priority for the nation. In collaboration with the Namibia University of Science and Technology and SOLTRAIN, the Namibian Energy Institute created a solar thermal technology roadmap for Namibia that specifies the potential for solar thermal in multiple end-uses, as shown in Figure 5.

Other solar thermal applications – e.g. for desalination, solar cooking, and solar dryers – are also recognised as appropriate to Namibia. The solar thermal technology roadmap offers proposed sector-specific solar thermal objectives up to 2030 to fulfil a target of 0.5 m^2 of flat plate solar heat collector installed ability per inhabitant, as indicated in Table 2.

4.3 The impact of climate change on the Namibian energy sector

Climate change is anticipated to result in continuous rises in temperature, region-specific variation in precipitation, and increases in extreme weather intensity and frequency (Iyer et al., 2018; Jakob and

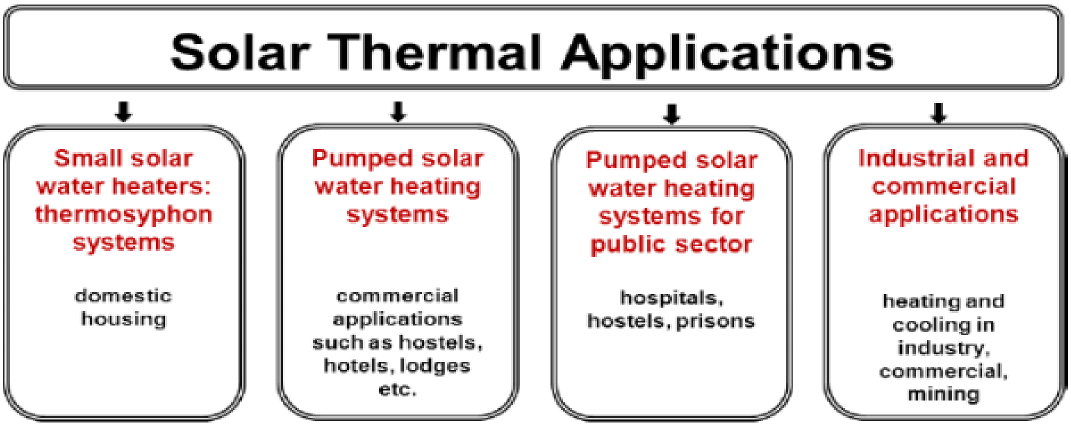


Figure 5: Summary of common solar thermal applications relevant for Namibia (NEI, 2015).

Table 2: Solar thermal technology roadmap 2030 targets by sector (NEI, 2015).

Sector	*Thermal energy measure (units)*	*Collector area (m^2)*
Mass housing project	SWHs for additional 185 000 domestic houses	400 000
Private one-family housing	SWHs to replace domestic electric water heaters	600 000
Private multi-family housing	~20 000 SWH units	100 000
Private commercial locations	~1 000 SWH units	20 000
Hotels, hospitals, student homes	180 hotels, 343 hospitals and clinics units	60 000
Solar air-conditioning and cooling	Office building units	20 000
Industry & mining applications	Low temperature applications, <200 ^{o}C	200 000
Domestic and commercial	Solar cooking, 1 m^2 /family	100 000

Steckel, 2014). The growing effects of these stresses could result in reduced water availability and infrastructure stress, leading to consequences which include service interruptions across the entire energy system (Elum and Momodu, 2017). For instance, hydropower depends on the availability of water and thus the future of hydropower in dry countries like Namibia is extremely dependent on future changes in precipitation patterns and extreme weather occurrences (Namibia Nature Foundation, 2016; MET, 2015; EIF, 2016). There are important financial costs for all industries that go hand in hand with the energy disruptions resulting from extreme weather, including loss of output and salaries, spoiled inventory, delayed production, and inconvenience (Landauer et al., 2015; Locatelli et al., 2015). Long energy outages can interrupt the flow of clean water and solid waste from municipal water treatment amenities, resulting in hospitals losing energy supply and access to clean water, and causing companies to shut down their business operations, which could have a negative impact on revenues and profitability (Hurtado et al., 2015; Morand et al., 2015). Energy system disruptions can have serious impacts on other critical facilities and services such as communications and transportation (Schaeffer et al, 2012).

Aging infrastructure is more vulnerable to climate change effects and severe weather occurrences (O'Neill et al., 2017; Oteman et al., 2014). Studies indicate that tiny rises in extreme weather and climate can lead to big increases in harm to current facilities (Shrestha and Dhakal, 2019; Somorin et al., 2016). As a consequence, it is appropriate for the Namibian energy sector to consider how to decrease its general contribution to climate change (via mitigation initiatives) and boost its resilience to future climate effects (through adaptation policies).

4.4 Exploring the intersection of adaptation and mitigation

Up to now, the energy sector has concentrated its focus on measures that either mitigate GHG emissions or assist the industry to adapt; however, there is advantage in adopting policies that achieve both (Steckel et al., 2013; Stringer et al., 2014). A number of actions conducted to decrease GHG emissions can have direct or indirect advantages that boost the energy sector's resilience to assist guarantee safe, secure and uninterrupted power supply (Xie et al., 2018; West et al., 2013).

Adaptation or mitigation space is described by those approaches that exploit the synergies between climate change adaptation and mitigation. These synergies result from technology and resources, sound policy development, and access to reliable data and/or reliable decision-makers (UN, 2016; von Stechow et al., 2015). The energy sector's resilience can also be enhanced by incorporating adaptation and mitigation. Such operations can minimise the probability of a danger or the severity of its effects by working to enhance the reaction of energy industry infrastructure to environmental stress while also enhancing its effectiveness (World Energy Council, 2014). The resulting co-benefits, obtained from optimising synergistic adaptation or mitigation reactions, can enhance the energy sector's capacity to execute climate change response programs. Therefore, the synergies between adaptation and mitigation identify the adaptation/ mitigation room, while its value is determined by expected co-benefits that can be extracted from it (World Energy Council, 2014).

Challenges of institutional complexities, different views and inadequate possibilities could restrict any advantages that may arise from the inclusion of adaptation and mitigation (Rao et al, 2016). Such problems will be intensified by enhanced competition between adaptation and mitigation objectives as climate change further decreases the availability of some resources, particularly water, and places growing pressure on infrastructure (Rutherford and Coutard, 2014). How climate change adaptation and mitigation elements are incorporated will be crucial, given that how systems develop affects their efficiency, ensuring that the Namibian energy sector can optimise any future advantages from the climate change programme or policy development (GRN, 2017b).

4.5 Defining adaptation/mitigation actions in the Namibian energy sector

Adaptation has been described as actions that boost the resilience of an industry, area, business or government to those susceptibilities connected with climate change. One significant element of this classification is that adaptation advantages are characteristically felt locally (Oteman et al., 2014; O'Neill et al., 2017). Mitigation has been described as actions that handle anthropogenic GHG emissions. The advantages of a mitigation intervention have been identified as worldwide in scale (REN21, 2015).

In terms of mitigation contributions, Namibia is committed to the Paris Agreement, as well as to implementing concrete and ambitious steps to mitigate emissions and guarantee a climate-resilient economy. This significant commitment takes the form of a reduction in GHG emissions over the 2015-2030 period when compared to the business-as-usual baseline. This reduction demonstrates Namibia's commitment to fulfilling the Paris Agreement objective and pursuing a path to net zero emissions by 2050. Namibia's national sustainable energy policy aims to introduce innovative emissions-reducing technologies and promote healthier, more energy-efficient practices in the energy sector (Republic of Namibia, 2021). Reduced deforestation is the primary driver of the 2030 target in the agriculture, forestry, and other land use (AFOLU) sector. Over 13.5 $MtCO_2e$ will be lost in the next 10 years. Through optimal forest management techniques, Namibia has recognised the importance of reforestation, agroforestry, and urban forests for both carbon and timber productivity (Republic of Namibia, 2021).

Energy conservation methods, such as the conversion of municipal solid waste into compost and electricity, are the most imperative potential in the waste sector. Overall GHGs emissions are predicted to increase by up to 24.167 $MtCO_2e$ in 2030 under the BAU scenario. Through 2030, emissions are expected to be reduced by 21.996 $MtCO_2e$ (a decrease of 91%, with AFOLU accounting for 78.7%), as indicated in Table 5.

Namibia is one of the countries most liable to the effects of climate change, with floods and droughts

Table 5: Industry-specific contribution and percentage of BAU GHG emissions in 2030 (Republic of Namibia 2021).

Sector	*Mitigation potential ($MtCO_2e$)*	*% reduction compared to BAU scenario in 2030*
Energy	2.800	11.6%
IPPU & RAC*	0.134	0.6%
AFOLU	19.030	78.7%
Waste	0.031	0.1%
Total	**21.996**	**91%**

* IPPU & RAC: Industrial processes and product use; RAC: Refrigeration and air conditioning.

the main dangers, so adaptation is important. As of 2020, there were 49 priority activities identified by various ministries with adaptation significance. From this perspective, adaptation has been considered specifically important in several sectors of the economy, such as agriculture, tourism, and fisheries. To this effect, various ministries and other government agencies have established goals for youth and women's contribution (Republic of Namibia, 2021). It is estimated that the net cost of implementing the nationally determined contribution (NDC) mitigation measures in Namibia is likely to be over USD 3.61 billion by 2030, with more than USD 1.72 billion for adaptation targets, for a total funding requirement of around USD 5.33 billion (Republic of Namibia, 2021). Table 6 shows the estimated funding requirements and terms for the revised NDC. Unconditional measures account for around 10% of total planned financing, whereas conditional measures account for 90%. There would be a mix of national and international financing in the pool.

Table 6: Projected mitigation and adaptation funding requirements in USD billions (Republic of Namibia, 2021).

	Mitigation measures	*Adaptation measures*	*Total)*
Unconditional	0.36	0.17	0.53
Conditional	3.25	1.55	4.80
Total	**3.61**	**1.72**	**5.33**

A conceptual understanding of adaptation/ mitigation space, as shown in Figure 6, was extracted from the two prevalent components of these definitions. Both refer to actions with results on a worldwide or local proximity or geographic scale. They are designed to handle human systems to control vulnerability or pollution.

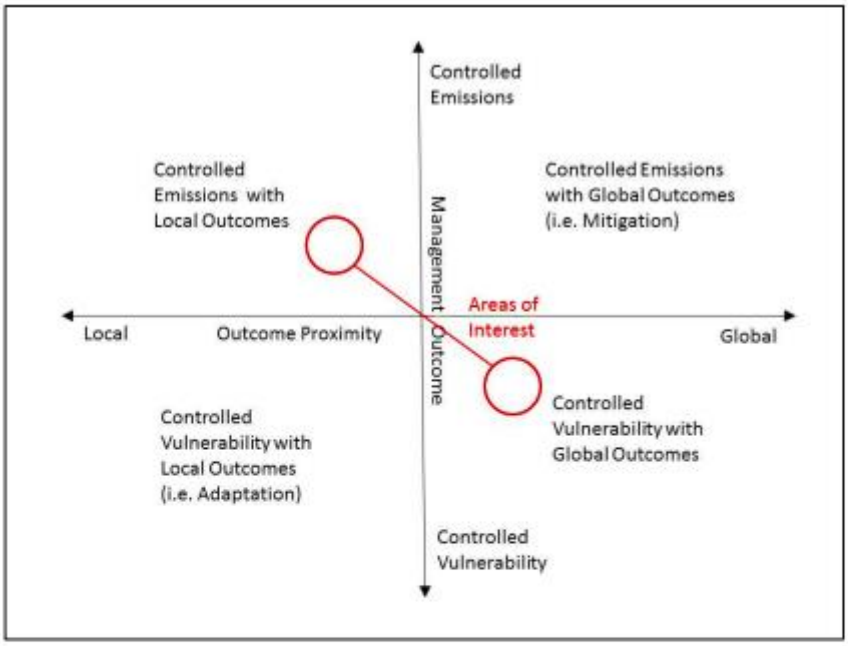


Figure 6: Conceptual understanding of the adaptation/mitigation space (Morand et al., 2015).

Table 7: Adaptation/mitigation contribution matrix (Morand et al., 2015).

		Contribution to Mitigation			
		Technological	Behavioural	Managerial	Policy
Contribution to Adaptation	Technological				
	Behavioural				
	Managerial				
	Policy				

The basic utility of this strategy was the articulation of two theoretical fields where the features of the advantages of adaptation and mitigation vary. The literature proposed that these areas contribute to the energy sector's capacity to respond to climate change, or the energy sector's ability to respond to effects, or its resilience (Duguma et al., 2014; Dorner et al., 2013). Similarities between adaptation and mitigation were also created on the basis of their characteristics. The definition of adaptation has been extended to include 'an array of prospective responses ranging from purely technological, behavioural, managerial, and policy' (Morand et al., 2015).

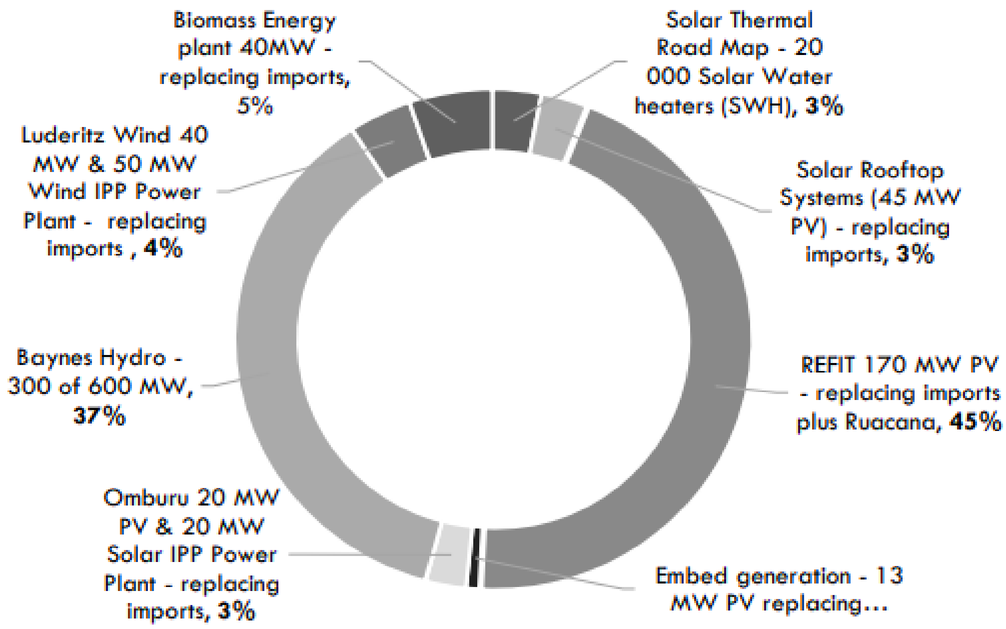
UNEP (2014) has created similar characteristics for mitigation, stating that managing carbon emissions utilises 'fresh technologies and renewable energies, making older equipment more energy effective, or altering management procedures or consumer behaviour.' The overlap of characteristics between adaptation and mitigation was subsequently advanced in the work of Yohe (2001) and Winkler et al. (2007), providing a comprehensive matrix for classifying alternatives in the adaptation/mitigation room as indicated in Table 7.

Adaptation and mitigation measures in the energy sector have been widely described as operations that change the techniques used to offer products and infrastructure or alter consumer or corporate behaviour *or* inform managerial procedures *or* create policies that change the energy industry operations adequately to obtain a mix of decreased local vulnerability and a decreased contribution to worldwide GHG emissions (Klein et al., 2005; Kazmierczak, 2014).

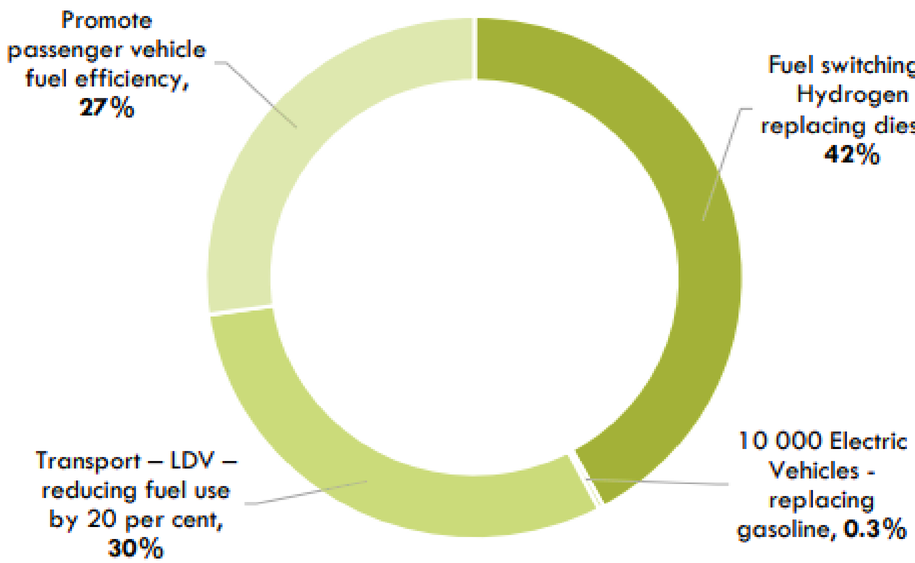
Figure 7 shows the anticipated emissions reduction prospective in 2030 for all mitigation strategies evaluated from the NDC 'long list' of mitigation actions. The charts show comparative contributions result from measures in the significant sectors of energy, i.e., electricity production and transportation, industrial processes and product use (IPPU), cement industry and refrigeration and air conditioning (RAC), AFOLU (forestry), and waste (solid waste conversion and reprocessing), compared to the BAU baseline.

Energy

Electricity generation

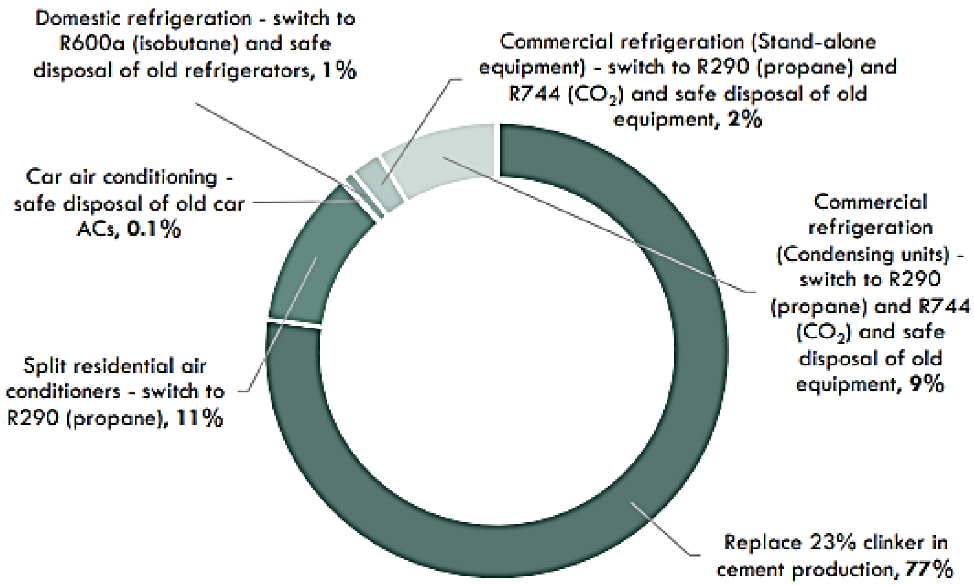


Transport

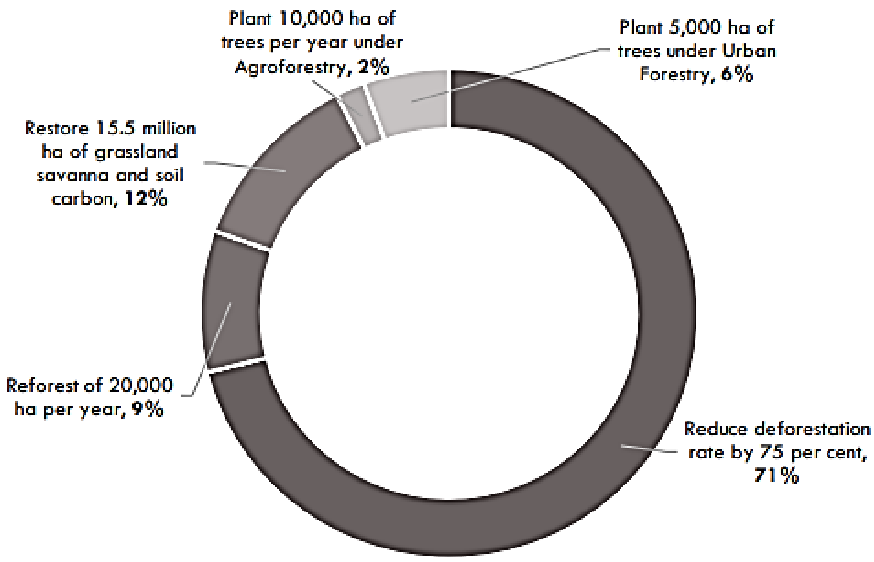


(Figure 7, first part)

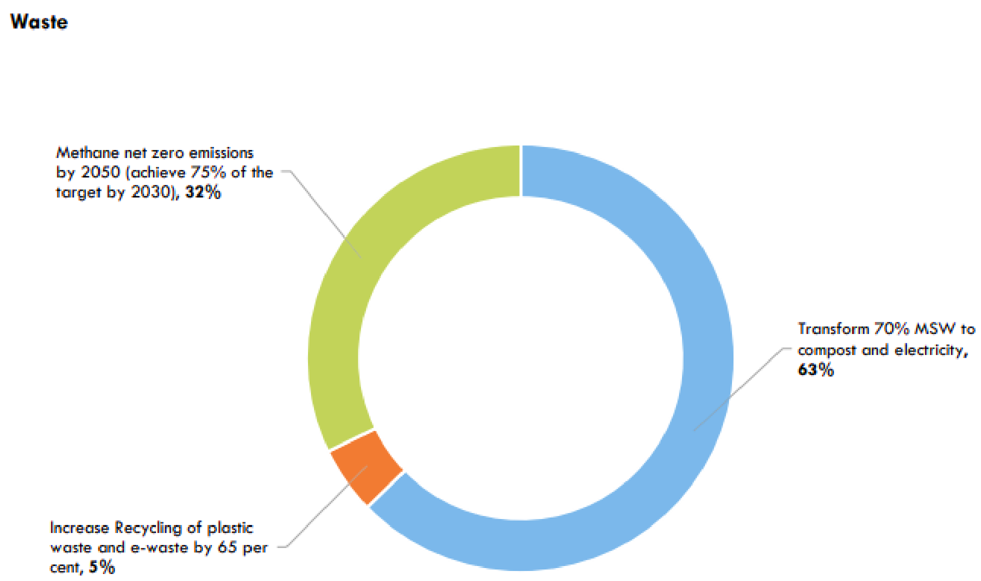
IPPU including RAC



AFOLU



(Figure 7, second part)



(Figure 7, third part)

Figure 7: Mitigation prospective from all mitigation actions (Republic of Namibia, 2021).

5. Policy implications

Intent is presently driving inclusion in the energy sector under circumstances of appropriate governance and support from public-private partnerships. Given the absence of observed assets and climate policy accessible to promote integration, the impact of intent is established on project or program goals independently of inclusion, and the increasing of co-benefits consequently represents those that would have accumulated (Landauer et al., 2015). This means purpose and management heavily depend on the project or programme structure created autonomously of inclusion and, as anticipated, is probably context-specific. Subsequently, this perspective offers the conditions in which public-private partnerships impact integration and indicates how energy policy can promote inclusion (GRN, 2017b; GRN, 2017a). Explicitly, energy policy can promote intent by decreasing the danger of management and creating a favourable position for public-private partnerships in energy projects (GRN, 2017a; Hennessey et al., 2017).

Effective leadership and purpose can be adopted through energy policy that promotes the application of voluntary tools that decrease the danger of various actions. Typically, policy-based voluntary tools are oriented to unilateral obligations, negotiated agreements between sector and government officials, and voluntary programmes established by government officials (Stringer et al., 2014). Policy measures in the way of incentives are alternative popular and efficient techniques for decreasing perceived hazards on the energy market and changing investor behaviors (Hennessey et al., 2014). All of these tools can be applied to promote change and how climate change projects are executed.

6. Conclusion

This paper reviewed the literature on the co-benefits of integrating climate change adaptation and mitigation in the energy sector, with a special focus on Namibia. This is a rapidly evolving research area with few truly large-scale integrated analyses, mostly owing to informational and methodological challenges. The findings of the literature reviewed are not irrefutable in terms of the anticipated net effect of climate change on the energy sector. There are many uncertainties linked to the possible determinants of energy demand that need to be considered in a systematic manner when making statements about predicted effects of climate change over time. The literature reveals that the most significant aspect that has yet to be resolved is the adaptation choices available in the Namibian energy sector (on both demand and supply sides), their cost, efficiency and potential. This is because policymakers are interested in what adaptation opportunities are available now and in the shorter-term future. Adapting to climate change offers diverse co-benefits, in particular through enhanced sinks to adopt effectiveness to decrease expenses accredited to extra adaptation, yet this will demand worldwide acceptable metrics to be established. Thus, climate change adaptation and mitigation portfolios are becoming inclusive and proactive, in such a way that they give possibilities for resource maintenance and sustainability for informed benefits to reducing GHGs. This paper also concludes that integrating climate change adaptation and mitigation can contribute to various co-benefits, such as ecosystem services and bioenergy resource management. There remains an immense quantity of work needed in order to comprehend the susceptibility of the energy sector, which is economically wide-ranging but potentially has comparatively low-cost adaptation alternatives in comparison to other sectors and taking into consideration the time scales of effects and lifetime of energy infrastructure.

Author roles

Kassian T. T. Amesho: Conceptualised the study and formulated the primary research suppositions; data collection; interpretation of results; prepared the final article for submission.
Emmanuel Innocents Edoun: Conceptualised the study; research formulation; proofreading; supervision; and reviewed the manuscript.
Sioni Iikela: Data collection; prepared the final article for submission and proofreading.
Timoteus Kadhila: Data collection; prepared the final article for submission and proofreading. Lovisa R. Nangombe: Data collection; prepared the final article for submission and proofreading.

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