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The Role of Renewable Energy Policies for Effective Climate Change Mitigation Actions in Tanzania - A Systematic Review

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Abstract

The use of renewable energy sources is one of the measures that have had a significant contribution in reducing greenhouse gas emissions while ensuring sustainable development. Hence, this necessitates the need to ensure a sustainable national socio-economic development pathway that supports low emissions through the development and use of renewable energy. This paper analyses data from a systematic review that was conducted to understand how research is approaching the state of public policies of renewable energy and climate change in Tanzania. The review screened more than 500 published papers and unpublished reports containing 120 unique studies related to renewable energy, climate change and sustainable development. Results indicate that renewable energy sources have the potential of contributing to the reduction of about two-thirds of the total global energy carbon dioxide emission. The results further indicate that renewable energy may save carbon dioxide for the range of global cumulative savings of about 220–560 $GtCO_2$ in the period 2010–2050. The results also show that Tanzania has targeted to reduce greenhouse gas emissions by between 30% and 35% by 2030. Thus, more appropriate renewable energy policies would enable the country to further efficiently contribute to the global goal of reducing greenhouse gas emissions, while achieving its sustainable development. This underscores the need for Tanzania to adopt appropriate policies for the utilisation of renewable energy sources such as solar, wind, hydro and geothermal energy for the reduction of greenhouse gas emissions, while achieving its sustainable development goals.

Keywords: *climate change mitigation, renewable energy, sustainable development, energy policies, Tanzania*

1. Introduction

Climate change is real (UN, 1992). Projections suggested that there will be an increased in the minimum and maximum temperature trends in Tanzania in three future periods: 2011–2040, 2041–2070, and 2071–2100 (Luhunga et al., 2018; URT, 2021b). Maximum temperatures are projected to be greater by more than 3.5°C in the western parts of Tanzania, southwestern highlands and the eastern parts of Lake Nyasa (Luhunga et al., 2020). The western sides of the Lake Victoria basin and parts of North-eastern highlands are likely to feature

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increased minimum temperatures in the range of 4.5°C to 4.8°C (Luhunga et al., 2020). During the June-July-August-September (JJAS) season, the country is likely to experience increased maximum temperature in the range of 1.7°C–2.4°C and 2°C–4°C in the mid- 2041–2070 and end 2070–2100, respectively (ibid.). Rainfall is projected to increase in the range of 0.5 to 1 mm/day over parts of north-eastern highlands and coastal regions of Tanzania (ibid.). Annual rainfall is projected to increase by around 3 to 4% by the 2040s in the north-east; while the Lake Victoria zone and the north-eastern zone will experience mean annual rainfall of up to 18–28% by 2100 (URT, 2021a).

URT (2014a) reported that greenhouse gas emission in Tanzania in the period 2000–2005 was 76,766.5Gg of carbon dioxide equivalent (CO_2 eq), while in 2014 it was 153,556 ktCO_2 eq (URT, 2021a). It is also projected that by 2030 greenhouse gas emission would increase to 219,469 ktCO_2 eq (URT, 2021a). The country has also a potential to grow economically, and hence increase its greenhouse gas emissions in the process. Hence, there is a critical need to pursue a sustainable national socio-economic development pathway that supports low greenhouse gas emissions through the development and use of renewable energy sources (URT, 2016). Such responses are linked to sustainable development in the context of balancing social well-being, economic prosperity and environmental protection (UNDP, 2008; IPCC, 2018).

Tanzania is currently pursuing efforts to achieve industrial growth that will transform socio-economic development to further consolidate its middle-income status as per the Tanzania Development Vision 2025, and as translated by five-year development plans. The country requires adequate, reliable, affordable and environmentally friendly electricity supply to achieve its industrial growth (NBS, 2019; URT, 2014b). Kichonge et al. (2015) recognized that renewable energy sources would be a great contribution to the economy and the environment in Tanzania. In the period 2021/2022–2025/2026, Tanzania plans to increase its energy-installed capacity from 1,694.55MW[1] to 5,000MW (MoE, 2021; URT, 2021a; MoE, 2022). The country also experiences serious energy deficits and high energy costs (Galvin et al., 2017), all of which require not only practical but also sound policies that can guide national transformation and development, while also taking into account global challenges, particularly climate change.

Despite the above concerns, there is still limited research on climate change mitigation and renewable energy policies in Tanzania. Available research shows a significant growth in interest with 62% (n = 23) of the peer-reviewed articles here being published in the last fourteen years (from 2008–2022).

[1] As of May 2022

This paper identifies existing information gaps on climate change mitigation policies and the renewable energy sub-sector in Tanzania. It is from this fact and context that a review was conducted on the role of renewable energy in enhancing effective climate change mitigation actions to support Tanzania's national socio-economic transformation. The review demonstrates how renewable energy sources in developing countries like Tanzania have the potential to contribute to climate change mitigation while achieving sustainable development. In this paper, we describe climate change and climate change mitigation; elaborate policies related to—and which can facilitate implementation of—mitigation actions in the Tanzanian context; and explore a set of renewable energy investments qualifying as mitigation actions. The paper illustrates the role that climate change mitigation actions can play in supporting the achievement of wider and inclusive industrial transformation in the country in the quest for socio-economic growth.

2. Conceptual Framework

A conceptual framework of the essential elements was developed to guide the review (see Figure 1). The framework was adopted from Arriagada et al. (2018) in their study of climate change governance. It was prioritized due to its relevance in the governance of climate change. However, the framework was modified to fit the Tanzanian context and its formulations; thus, it provides points of interest on current policy measures influencing the development of a renewable energy sub-sector. The framework also offers elements supporting the implementation of climate change mitigation policies.

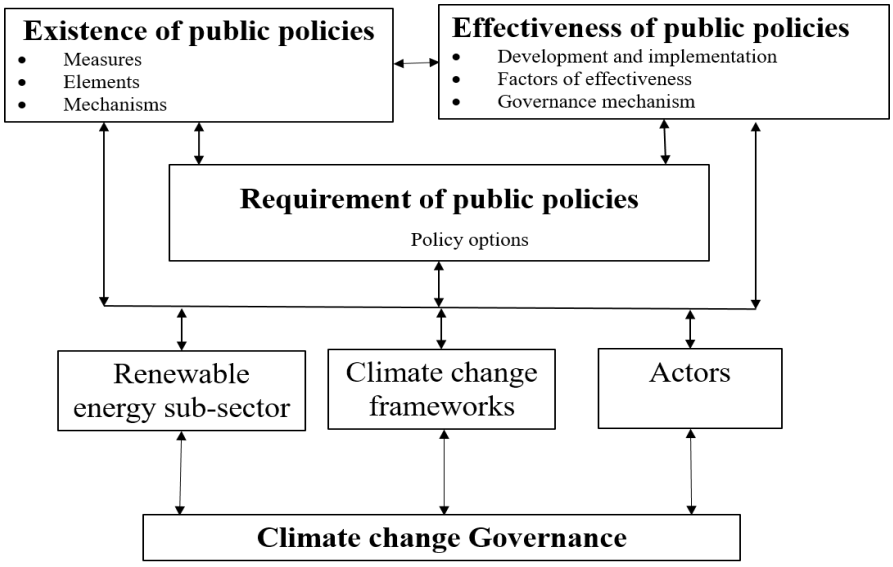

Figure 1: Conceptual Framework
Source*: Modified from Arriagada et al. (2018)*

3. Context and Methods

3.1 Context

This paper adopts a systematic literature review approach as recommended by Petticrew and Roberts (2011) to examine available research on climate change mitigation and renewable energy policies covering the 1992–2022 period. This period of 30 years was appropriate in producing a substantial literature to enable a holistic screening.

3.2 Methods

3.2.1 Data Collection

The data on renewable energy policies, climate change mitigation, socio-economic development for Tanzania and other related literature were gathered from various sources including books, journals, policy documents, and from published and unpublished reports. The review was conducted by formulating key themes of focus, searching the extant literature, screening for inclusion, assessing the quality of primary studies, and extracting and analysing data (Templier & Paré, 2015).

The review used exhaustive coverage as a strategy where relevant studies—published and unpublished—were included (Petticrew & Roberts, 2011). A systematic review enabled the authors to discover the level of the study and existing gaps on the contribution of renewable energy resources to climate change mitigation actions as recommended by Davis et al. (2014). The resulting literature were shortlisted and selected based on their relevance to the subject matter. For instance, the results from the Internet search used keywords such as 'renewable energy and Tanzania', 'renewable energy', 'climate change', 'greenhouse', 'sustainable development', 'policies' and 'Tanzania' provided about 500 literature on the subject matter. Scanning and skim-reading techniques were used to select literature that were most relevant to the study. A research protocol was developed as shown in Table 1.

Table 1: Criteria for Literature Selection

Search Protocol	**Inclusion Criteria**	**Exclusion Criteria**
Initial database, and literature search	• English literature • Quantitative and qualitative • Peer review articles • Single studies • Reports and studies in Tanzania and developing countries	• Non-English literature
Review of title and abstract	• Renewable energy • Climate change	• They are explicitly focusing on climate change adaptation

Search Protocol	**Inclusion Criteria**	**Exclusion Criteria**
Full paper	• Climate change mitigation and adaptation • Renewable energy, environment, and • natural resources studies • Reduction of greenhouse gas emissions • Climate change mitigation policy frameworks • Renewable energy policy frameworks • Effectiveness of public policies	• Reports • Policy documents • Non-peer review
Full report and policy documents	• Climate change mitigation and adaptation • Renewable energy, environment, and • natural resources studies • Reduction of greenhouse gas emissions • Climate change mitigation policy frameworks • Renewable energy policy frameworks • Effectiveness of public policies	• No focus on renewable energy • No focus on climate change

Source: Authors (2022)

Figure 2 provides a summary of the literature reviewed. In the analysis and synthesis, the data were collated, summarized, aggregated, organised and compared to the evidence extracted from the reviewed studies.

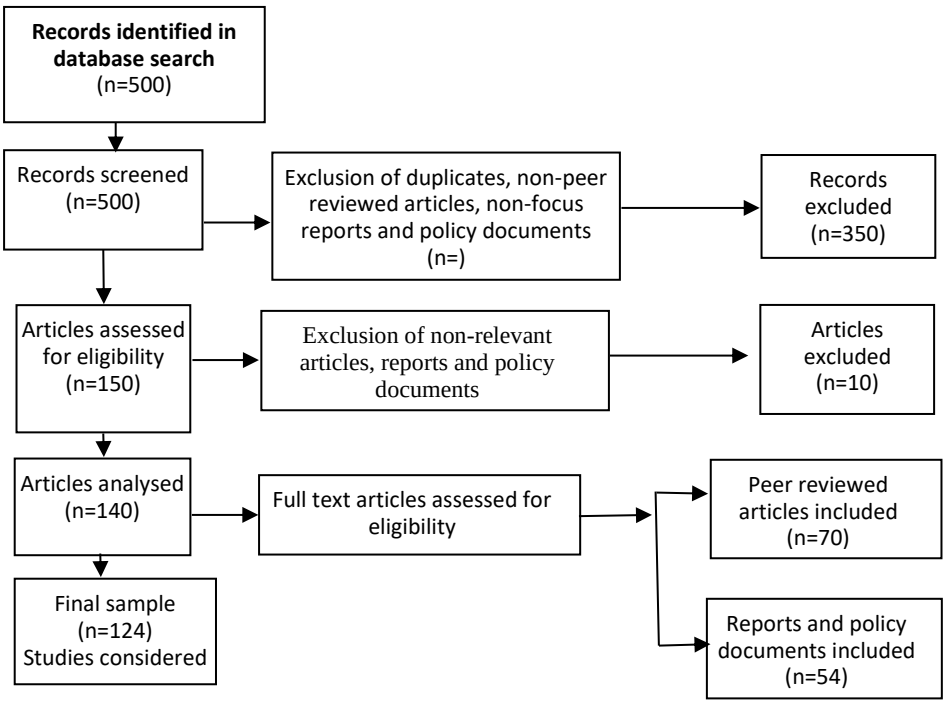

Figure 2: Summary of Literature Selection Process
Source: Compiled by Authors, 2022

4. Results

4.1 Climate Change Mitigation

The challenges associated with climate change require actions in the context of undertaking interventions to reduce sources, or enhance sinks, of greenhouse gas so as to limit global warming (UN, 1992; UN, 1997; URT, 2012; IPCC, 2014; IPCC, 2018; URT, 2015a). Climate change mitigation has been defined as human intervention to reduce the sources, or enhance the sinks, of greenhouse gases (UN, 1992; IPCC, 2007; UNEP, 2019). As provided in Article 4.1(c) of the United Nations Framework Convention on Climate Change (UNFCCC), the six relevant sectors to control, reduce or prevent greenhouse gas emissions are: energy, transport, waste management, agriculture, forestry and industry (UN, 1992). Tanzania's National Climate Change Response Strategy (NCCRS) identified six sectors, namely: energy, forest, industry, transport, waste management and livestock (URT, 2021a) as priority sectors for climate change mitigation. The two policy-related documents underscore the level of priority accorded to the energy sector, and the role it can play—particularly the renewable energy sub-sector—in enhancing mitigation actions.

The reduction of greenhouse gas emissions is essential if human and other living organisms are to survive (IPCC, 2013; Ndaki, 2014; Owusu & Asumadu-Sarkodie, 2016). Through the Nationally Determined Contributions (NDCs) Tanzania voluntarily committed herself to reduce greenhouse gas emissions economy-wide between 30–35% by the year 2030 relative to the Business as Usual (BAU) scenario of 138–153m tonnes of carbon dioxide equivalent (CO_2 eq) to contribute to global reduction of greenhouse gas emissions so as to stop global warming at 2°C above the pre-industrial levels (URT, 2021a). Clean energy technologies that are attributed by solar photovoltaic and wind electricity generators, the storage of electricity in Li-ion batteries and solar hydrogen (Pagliaro, 2019) are important as climate change mitigation actions. In Tanzania, climate change mitigation actions, as identified in the energy sector, are enhancing the use of renewable energy share in the national grid and off-grid, enhancing off-grid power supply to rural areas and clean technologies for power generation. Other mitigation actions include promoting the use of renewable energy sources such as geothermal, wind, solar and renewable biomass. Exploitation of geothermal, clean coal and safe nuclear energy are also key climate change mitigation actions in the energy sector (URT, 2012; URT, 2015a). The country also focuses on energy efficient technologies and practices for supply, transmission/ transportation and demand side; as well as behavioural change in energy use, and green energy related technologies (URT, 2012; URT, 2015a).

4.2 Renewable Energy Resources

Renewable energy sources include bioenergy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy. In Tanzania, there

are ten potential power sources, namely: hydro, wind, solar, natural gas, liquid fuels, biomass, coal, uranium, geothermal and tidal waves (URT, 2018; Mhache, 2021). The reported potential contributions of various renewable energy sources in the country are geothermal (5GW); solar (with sunshine ranges from 8 to 10 hours per day); hydropower (4.7GW); and wind, with an average speed of 5–9.9 meters per second, annually (URT, 2015a; Bishoge et al., 2019). These renewable energy resources have the potential to tackle climate change (URT, 2012; URT, 2015a); and have the biggest potential to contribute to Tanzania's voluntary commitment of reducing greenhouse gas emissions economy-wide by 2030 (URT, 2021b). Climate change mitigation actions in Tanzania require technologies such as energy-efficient and conservation demand-side management; wind energy development; mini-small hydropower development; solar photovoltaics; solar thermal; and biomass energy (URT, 2012). Table 2 elaborates how the various renewable energy sources can be used.

Table 2: Renewable Energy Sources and Their Use

Energy Sources	Energy Conversion and Usage Options
Hydropower	Power generation
Biomass	Heat and power generation, pyrolysis, gasification, digestion
Geothermal	Urban heating, power generation, hydrothermal, hot dry rock
Solar	Solar home systems, solar dryers, solar cookers
Direct solar	Photovoltaic, thermal power generation, water heaters
Wind	Power generation, wind generators, windmills, water pump
Wave and tide	Numerous design, barrage, tidal stream

Source: Panwar et al. (2011)

The development of renewable energy resources in Tanzania is induced by (1) a political priority to expand electrification in the country; (2) development partners who are pro-renewables; and (3) large-scale power projects, which are mostly financed by international financial institutions that also encourage investments in the renewable energy sector (Aly et al., 2019).

Globally, renewable-based power investment in 2018 declined to around US$390bn. However, the IEA (2019) states that in any case of scenario the world decides to follow, acceleration of investments in renewable technologies are required. The Stated Policies Scenario (SPS) shows that global investment in renewables will cumulatively reach a total of around US$10.6tr between 2019 and 2040, while the Sustainable Development Scenario (SDS) shows that global investment in sustainable energy grows at a much faster rate, and will reach around US$15.6tr between 2019 and 2040 (IEA, 2019). Table 3 presents the global annual average investment in renewables by scenario between 2018 and 2040.

Table 3: Global Annual Average Investment in Renewables By Scenario (Billion USD)

Global annual average investment	States Policies			Sustainable Development		Change 2018 vs 2031-2040	
	2018	*2019–30*	*2031–40*	*2019–30*	*2031–40*	*STEPS*	*SDS*
Renewable-based power generation	304	329	378	528	636	24%	109%
• Wind	89	111	122	180	223	37%	151%
• Solar PV	135	116	125	179	191	-7%	41%
End-use sectors	25	117	139	124	145	456%	480%
Total	**329**	**456**	**517**	**652**	**781**	**57%**	**137%**
Cumulative		5477	5166	7829	7802		

Note: Renewables for end-use include solar thermal, bioenergy and geothermal applications for heating
Source: IEA (2019)

Marie-Louise et al. (2011) states that governments need to provide support in the development and use of renewable energy resources. In this context, laws on the reduction/elimination of duties and taxes, promotion of subsidies, and setting up of energy regulation agencies need to be adopted. The government should also adopt strategies, fund mechanisms, and partner with donor organisations to build technical capacity, promote market, monitor and evaluate actions that develop renewable energy resources (ibid.). Policy work should also focus on raising awareness about renewable energy (Yadoo & Cruickshank, 2012).

To secure affordable and accessible energy in the country, renewable energy is termed as the alternative energy source because it is also environmental-friendly (Obadia et al., 2018). Kichonge et al. (2016) advance that the use of renewable energy sources increases Tanzania's energy security from disruptions of supply. If properly utilised, renewable energy sources have benefits of also reducing negative impacts on the environment, and enhancing sustainable development (Figure 3).

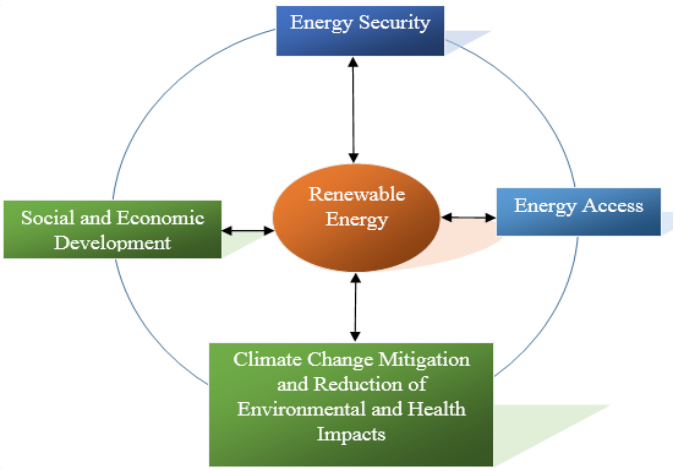

Figure 3: Benefits of Renewable Energy Sources
Source: Owusu and Asumadu-Sarkodie (2016)

These benefits specifically lead to less global warming through reduction of greenhouse gas emissions, public health improvement, everlasting energy, job creation and other economic benefits, stable energy prices, and energy reliability and resilience. Other benefits include improved livelihoods, particularly in rural areas (AfDB, 2015; Owusu & Asumadu-Sarkodie, 2016).

4.3 Reduction of Greenhouse Gas Emissions

The use of renewable energy is the best approach to climate change mitigation (Owusu & Asumadu-Sarkodie, 2016). In 2008, renewable energy accounted for 12.9% of primary energy supply, signifying that the world was significantly investing in renewable energy. According to Moomaw et al. (2011), the largest renewable energy contributor was biomass (10.2%), mainly for cooking and heating applications; hydropower (2.3%); and other renewable energy sources (0.4%). The global share of renewables in the power mix is projected to rise from one-quarter to two-thirds by 2040, signifying that the world will continue to invest in renewable energy (IEA Webstore, 2018). The IPCC (2018) recommended renewables supply of 70–85% of electricity by 2050 so as to limit global warming by up to 1.5°C. The IENRA (2017b) projected that by 2050, about 90% of the reduction of emission will come from energy efficiency and renewable sources; and that the use of renewable energy will contribute about two-thirds (20Gt CO_2 per year) of the total primary energy CO_2 emission reduction (Figure 4). Likewise, renewable energy is likely to have CO_2 savings of global cumulative CO_2 from about 220 to 560Gt CO_2 in the period of 2010 to 2050 (Moomaw et al., 2011).

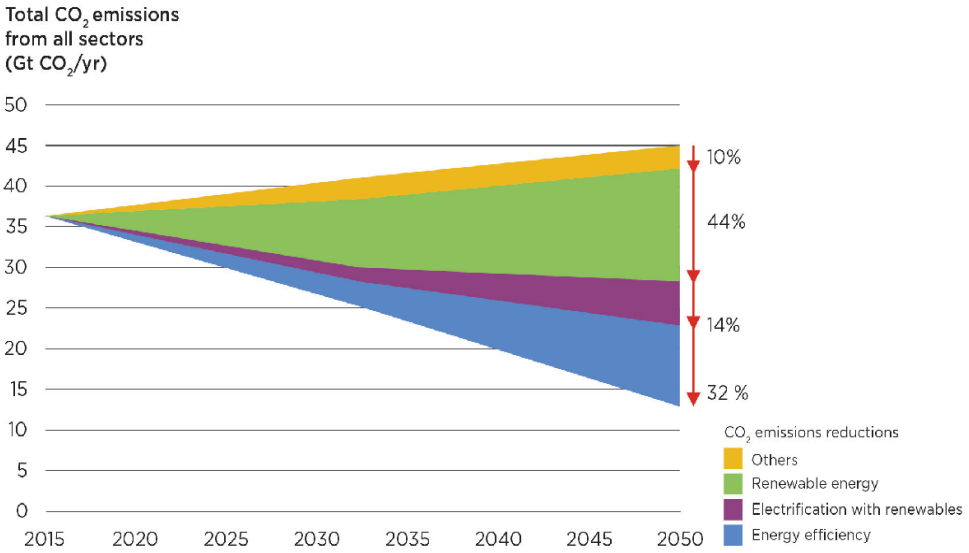

Figure 4: Primary CO2 Emission Reduction Potential by Technology
Source: IRENA (2017a)

Overall, renewable energy has the biggest potential to contribute to Tanzania's voluntary commitment of reducing greenhouse gas emissions economy-wide by 2030 (URT, 2021b).

4.4 Public Health Improvement

Coal and natural gas plants emit air and water pollutants that are reported to cause health problems such as breathing difficulties, heart attacks, cancer, premature deaths and neurological damages (Moomaw et al., 2011). Nevertheless, on the side of renewable energy, for example, there are no air and water pollutants produced from the use of wind, hydro and solar systems. Epstein et al. (2011) further states that geothermal and biomass systems have air erosions that are much lower than coal- and natural gas-fired power plants. Thermal power plants—including coal, gas, oil, biomass and geothermal—consume water for cooling, and can have significant impact on water resources (Epstein et al., 2011). Therefore, the use of renewable energy sources will enhance quality public health in the country.

4.5 Job Creation and Other Economic Benefits

The renewable energy industry is comparatively more labour-intensive. For example, technicians are needed for installations and maintenance of wind farms and solar panels (Wiser & Bolinger, 2017; AWEA, 2017). In this regard, for instance, the UCS (2009) reported that the 25% renewable energy target by 2025 policy in the United States was found to create more jobs. In Tanzania, for example, the construction of the Julius Nyerere Hydro Power Project is expected to employ about 6,000 Tanzanians. However, it is still unclear whether the potentiality of achieving simultaneous environmental and socio-economic goals through renewable energy sources can fully be realized.

4.6 Everlasting Energy, Reliability and Resilience

In Tanzania, the potential role of renewable energy sources would be a great contribution to the economy and environmental conservation (Kichonge et al., 2015). This implies that the development of renewable energy sources will enhance energy security in the country. Renewable energy sources supply energy that constantly comes from strong winds, solar, geothermal and hydropower. The nature of wind and solar being evenly distributed and modular make them to be less prone to large-scale failures (Unger, 2012). While non-renewable energy power plants such as coal, nuclear and natural gas plants can be at risk due to severe droughts and heat waves as they need sufficient water for cooling, wind turbine generators are assumed to be 100% reliable (Niu et al., 2021). This means future impacts of climate change such as increased droughts, heat waves, intense storms and severe wildfire will not pose high risks to renewable energy sources and energy production (Unger, 2012).

4.7 Climate Change Mitigation and Renewable Energy Policy Frameworks

The international and regional communities have taken measures to address the challenges of climate change by adopting various policy frameworks (e.g., UN, 1992, 1997, 2015, 2016a; SADC, 1996; EAC, 1999, 2011; AU, 2015). For instance, in 1992 the international community adopted the United Nations Framework Convention on Climate Change (UNFCCC) (UN, 1992). Regarding the energy sector, the UNFCCC requires controlling, and reducing and/or preventing anthropogenic emissions of greenhouse gases from fossil fuels in the energy sector (Article 4.1(c)). Another intervention by the international community is the Kyoto Protocol (KP) to the UNFCCC that was adopted in 1997, and entered into force in 2005 (UN, 1997). The Protocol is in the second commitment period that was adopted on 8th December 2012 to run from 2013 to 2020, known as the Doha Amendment to the Kyoto Protocol, with 37 binding targets to developed countries (UNFCCC, 2020; 2023). The Amendment strengthened quantified emission limitation/reduction commitments for 37 developed countries, and set a goal of reducing GHG emissions by 18% compared to the 1990s levels (UNFCCC, 2023). Since the adoption of the second commitment period (as of 15th June 2022), 148 parties have deposited their instruments of acceptance of the second commitment period. This implies that a total of 144 instruments of acceptance (excluding the EU) that are required for the entry into force of the amendment, was met. The Doha Amendment entered into force on 31 December 2020 (ibid.).

In 2015, the international community adopted the Paris Agreement (UN, 2016a), which in its article 4.4 requires undertaking economy-wide absolute emission reduction targets by parties in developed countries. Also, in 2015 the UN adopted the 17 sustainable development goals and 169 targets to stimulate actions areas deemed as critical for humanity and the planet for a period of 15 years (UN, 2015). Out of the 17 goals, are: Goal 7 – sustainable energy; Goal 8 – sustainable economic growth; Goal 13 – combating climate change and its impacts; and Goal 17 – partnership. Tanzania is a party to the UN and the other international frameworks (see Table 4).

Moreover, regional climate change and energy instruments have been adopted. The instruments include the Southern African Development Community Protocol on Energy adopted in 1996 (SADC, 1996), the East African Community Climate Change Policy adopted in 2011 (EAC, 2011), and the AU adopted Agenda 2063 – The Africa We Want in 2015 (AU, 2015). As a member of these organisations, Tanzania is obliged to implement relevant policy instruments on renewable energy and climate change to achieve its sustainable development. Figure 5 provides a summary of the timeline of the relevant policies on climate change mitigation, including sectoral policies, laws, strategies and plans in the renewable energy sub-sector.

Table 4: Climate Change and Renewable Energy Policy Framework in Tanzania Context

Instrument	When enacted/ adopted	Relevant Focus Area(s)	Level of Implementation	Type	Source of info.
Environmental Management (Control and Management of Carbon Trading) Regulations	2022	Provide legal framework for the control and management of carbon trading projects (article 5.1) while ensuring sustainable environmental development in the context of Tanzania's contribution towards global efforts on greenhouse gases emissions reduction (article 5.2).	Under implementation	Regulation	URT, 2022b
National Environmental Master Plan for Strategic Interventions (2022 – 2032)	2022	Calls to enhance climate resilience of people, ecosystems and productive sectors as strategic interventions by reducing adverse impacts of climate change and build capacity for harnessing of climate change mitigation opportunities.	Under implementation	Plan	URT, 2022a
National Environmental Policy (NEP), 2021	2021	Strengthening institutional and human resources capacity on climate change issues; public awareness on climate change impacts; collaboration with private sector on climate change initiatives; promoting regional and international cooperation to address climate change; and promoting development and transfer of green affordable technologies (section 3.7). Development of alternative sources of energy which are readily accessible and affordable to public (*section 3.5*).	Under implementation	Policy	URT, 2021c
The National Five Year Development Plan (2021/22 - 2025/26)	2021	Emphasises the protection of environment (section 4.3 (xii)(f)) and addressing climate change adaptation *(sections 4.5.4 (ix) and 5.3.5 (v))*. Requires the development of renewable energy sources (section 5.2.5 (vi)) and promoting renewable green energy technologies (section 5.3.5 (i)).	Under implementation	Plan	URT, 2021d
Nationally Determined Contribution	2021	Tanzania voluntarily committed herself to reduce greenhouse gas emissions economy-wide between 30% and 35% by year 2030 relative to the Business as Usual (BAU) scenario of 138-153 million tonnes of carbon dioxide equivalent. One of the proposed actions is promoting diverse renewable energy sources such as wind, solar, geothermal and hydropower. The country plans to develop micro and mini-grid renewable generation for rural electrification.	Under implementation	Strategy	URT, 2021b

Instrument	When enacted/ adopted	Relevant Focus Area(s)	Level of Implementation	Type	Source of info.
National Climate Change Response Strategy (2021-2026)	2021	Energy, forest and mangroves, industry, transport, waste management and livestock identified as key sectors. Underscores the level of priority the energy sector is accorded to and the role the sector can play, particularly renewable energy sub-sector, in enhancing mitigation actions in Tanzania.	Under implementation	Strategy	URT, 2021a
The National Energy Policy, 2015	2015	Provides guidance for sustainable development and utilization of energy resources to ensure optimal benefits to Tanzanians and contribute towards transformation of the national economy. Section 3.1.4 calls for integration of renewable energy technologies in buildings and industrial designs, national and isolated grids. The Policy also calls to establish feed-in-tariffs for renewable energy technologies (Section 3.1.4).	Under implementation	Policy	URT, 2015b
Intended Nationally Determined Contributions (NDCs)	2015	Tanzania is voluntarily committed to take climate change mitigation actions through the sectors of transport, waste management, forestry and energy. The country focuses building adaptive capacity and enhancing long-term resilience to the adverse impacts of climate change and greenhouse gas emissions reduction global efforts to meet the ultimate objective of the Convention while achieving sustainable development consistent with national development agenda and priorities.	Implemented	Strategy	URT, 2015a
Electricity Supply Industry Reform Strategy and Roadmap (2014–2025)	2014	Provides strategic actions in the energy sector including diversifying generation resources including wind, geothermal, hydro and solar.	Under implementation	Strategy	URT, 2014b
National Climate Change Strategy (2012)	2012	Tanzania voluntary committed to reduce greenhouse gas emissions economy wide between 10-20% by 2030 relative to the BAU scenario of 138 - 153 MtCO2e- gross emissions, depending on the baseline efficiency improvements, consistent with its sustainable development agenda. Intended to enable the country to effectively adapt to and participate in global efforts to mitigate to climate change with a view to achieving sustainable economic growth in the context of the	Implemented	Strategy	URT, 2012

Instrument	When enacted/ adopted	Relevant Focus Area(s)	Level of Implementation	Type	Source of info.
		national development goals (section 3). The Strategy proposed strategic actions to enhance supply and use of renewable energy.			
The Electricity Act, 2008	2008	Provides for the facilitation and regulation of generation, transmission, transformation, distribution, supply and use of electric energy. The Electricity Act provides for cross-border trade in electricity planning, and regulation of rural electrification.	Under implem.	Law	URT, 2008
National Adaptation Programme of Action (2007)	2007	Promoting the use of renewable energy sources in the industry sector. NAPA also requires the development of community based mini-hydropower in energy sector and increase use of geothermal power generation.	Under implem.	Programme	URT, 2007
Rural Energy Act – REA, 2005	2005	Promotes improved access to modern energy services in rural areas Tanzania. *Article 22.2(d)* of the REA requires the grants by Rural Energy Fund be applied to also investments in innovative pilot and demonstration projects and applications for renewable energy.	Under implem.	Law	URT, 2005
The Environmental Management Act Cap 191 (EMA, 2004)	2004	Provides for legal and institutional framework for sustainable management of environment. Section 75 of EMA provides measures for addressing climate change in Tanzania. EMA also requires promoting research in appropriate renewable energy sources (article 64 (a). The law also requires for creating incentives for promotion of renewable energy sources (article 64 (b)) and the minister responsible for climate change is required to issue guidelines on addressing climate change in the country (article 75(b)). This act also requires government ministries, departments and agencies (MDAs) to put in place strategies and action plans to deal with climate change (article 75(c)). This article further requires schools and higher learning institutions to include climate change matters in their curriculum. The law also requires the minister responsible for climate change to develop a national climate change position at global level on how to deal with climate change (article 75(e)). This implies the country ensures national climate change policy take into account global implications.	Under implem.	Law	URT, 2004

Instrument	When enacted/ adopted	Relevant Focus Area(s)	Level of Implementation	Type	Source of info.
Energy and Water Utilities Regulatory Act No. 11 Cap 414	2001	Establishes a Regulatory Authority in relation to energy and water utilities. Article 6(f) of EWURA requires protecting and preserving the environment. EWURA in Article 7(c)(iii) sets a requirement to monitor the performance of the regulated sectors in relation to cost of services. Article 17(2)(a) of the law gives a Regulatory Authority powers to regulate rates and charges taking into account costs of making, producing and supplying goods and services. EWURA requires all rates, tariffs and charges to be published in the Government Gazette {article 17(3)}.	Under implem.	Law	URT, 2001
Tanzania Development Vision 2025	2000	Actively mobilizes the people and other resources to achieve shared national goals (section 1.1). Section 1.2.3 of the Vision requires ensuring a culture of accountability and rewarding good performance. In Section 1.2.5, the Vision also requires a strong, diversified, resilient and competitive economy.	Under implem.	Vision	URT, 2000
The National Environmental Policy (NEP), 1997	1997	Provides the framework for making fundamental changes that are needed to bring environmental considerations into the mainstream of decision-making in Tanzania (paragraph 17). The policy calls for studies in order to come up with climate change mitigation options in the country and promotes sustainable renewable energy sources (URT, 1997).	Implem.	Policy	URT, 1997
National Investment Promotion Policy (NIPP), 1996	1996	Promotes investments that make national socio-economic aspirations a reality (section 3.1) (NIPP also requires adoption of systems of production, transportation, distribution, procurement and end-use that are not harmful to the environment (section 3.4-g(iii)).	Under implem.	Policy	URT, 1996a
Sustainable Industries Development Policy (1996-2020), 1996	1996	Sets broad guidelines on principal factors that influence industrialization (This Policy promotes development of energy supply (section 3.4.8(c)).	Implem.	Policy	URT, 1996b

Source*:* Compiled by the Authors (2023)

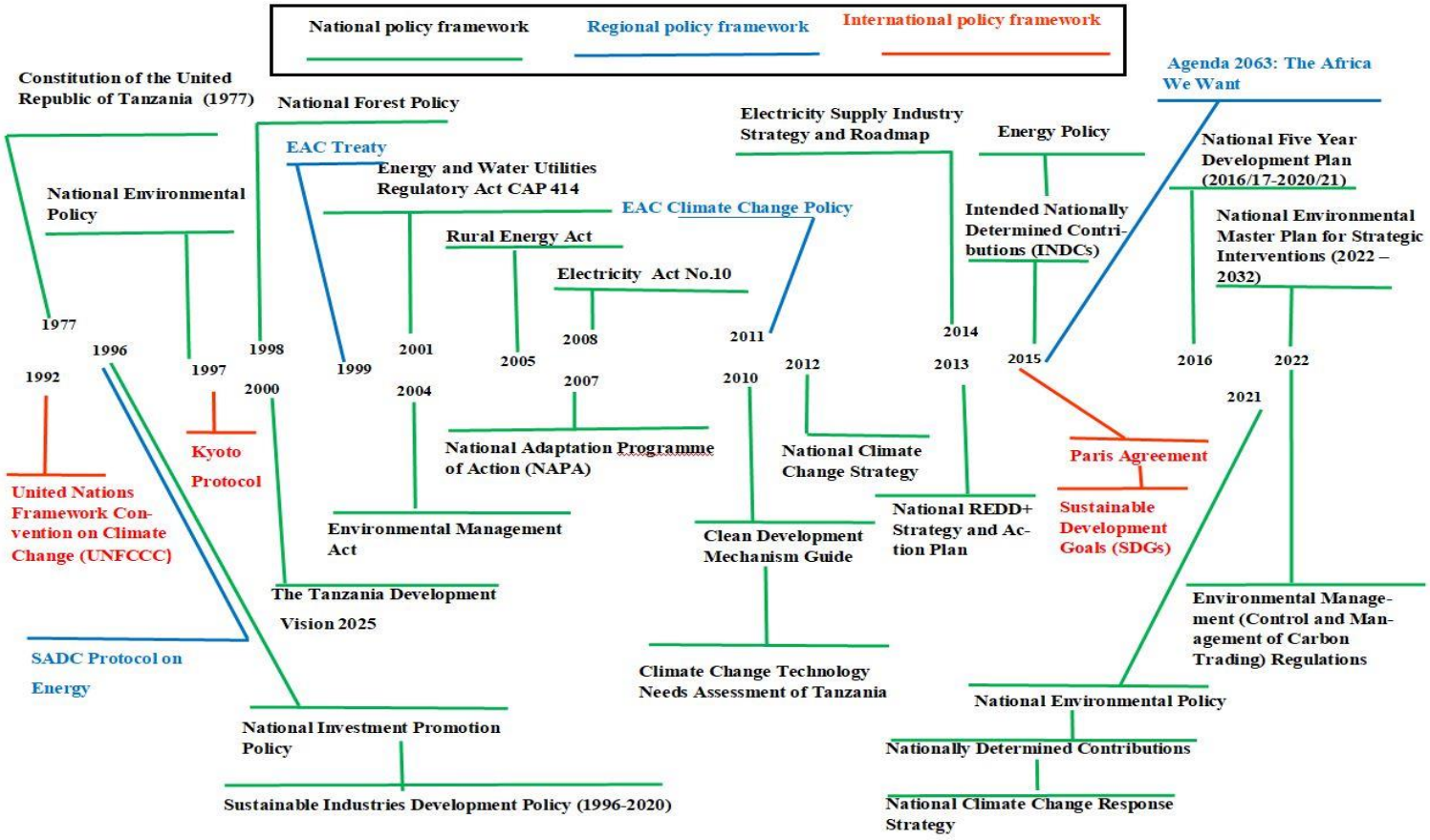

Figure 4: Timeline of Policy and Legal Aspects of Climate Change Governance in Tanzania Perspectives Since 1977

Source: Compiled by the Authors (2023)

Despite initiatives taken by governments in Sub-Saharan countries—including Tanzania—towards taking measures to mitigate the hazards of climate change through enforcement of the use renewable energy, there are still some key challenges needed to be addressed. There are issues like poor energy financing and incentive mechanisms, inadequate energy planning, and weaknesses of the national energy policies that have not been adequately analysed, understood and deployed towards that end (Chaurey et al., 2012; Bishoge & Mushi, 2018).

The study by Kyaruzi et al. (2021) revealed that Tanzania has no adequate policies on climate change mitigation and renewable energy frameworks. It was found that although there is a policy framework to support the implementation of actions of climate change mitigation in the renewable energy sub-sector, there is a need of more specific policies on climate change and renewable energy, especially to support the development and use of renewable energy resources (Marie-Louise et al., 2011).

5. Results

The findings indicate that there are existing information gaps on climate change mitigation policies in the renewable energy sub-sector in Tanzania. From the reviewed literature, most of the studies in the country (by August 2022) were on climate change adaptation (Kangalawe et al., 2011; Ndaki, 2014; Bahati & Kalugendo, 2017; Luhunga, 2018; Said et al., 2019; Shagega et al., 2019; Mourice, 2020; Chang'a et al., 2020; Doughertya et al., 2020; Birthe et al., 2020; Alemaw & Simatele, 2020; Mngumi, 2020; Nyembo et al., 2022; Mswima & Kaswamila, 2022). Where a study focused on climate change mitigation and energy, it was not on mitigation policies in the renewable energy sub-sector (Mwakaje, 2008; Rickerson et al., 2010; Marie-Louise et al., 2011; Ahlborg & Hammar, 2012; Ngaira & Omwayi; 2012; Sarakikya, 2015; Wood et al., 2016; Kashwan, 2017; Harnesk & Brogaard, 2017; Obadia et al., 2018; Ngowi et al., 2019; Obadia et al., 2020; Alemaw & Simatele, 2020; Rocco et al., 2020; Mhache, 2021; Olabisi & Richardson, 2022; Bazila et al., 2022; Rugaimukamu, 2022; Kristin, 2022; Mnzava et al.; 2022, Adornetto, 2022; Gill-Wiehl et al., 2022).

Examples of studies on the subject in the country include those by Mourice (2020) on the effect of climate change on agricultural droughts in terms of water deficit index (WDI) throughout the near-term (2010-2039) at the newly-established Mkulazi II Sugar Estate at Dakawa, Mvomero District, Morogoro; Shagega et al. (2019) on the potential impacts of climate change on water resources in Ngerengere River catchment in Tanzania; and Doughertya et al. (2020) on identifying the effect of learning, expectations and ambiguity on insurance demand in the face of increasing drought probabilities. Other studies present research evidence of climate change and anthropogenic impacts on the slopes of Mt. Kilimanjaro and its implications on water, food and energy

production (Said et al., 2019); drivers and barriers to rural electrification in Tanzania in grid-extension, off-grid, and renewable energy technologies (Ahlborg & Hammar, 2014). The barriers identified by these studies as impeding the development of renewable energy include the lack of access to human capital, difficulties in planning, donor dependency, low rural markets, and little interest from the private sector. The main drivers that were identified to affect the development of renewable energy are political ambitions and local initiatives by churches and industries. On the other hand, the study by Birthe et al. (2020) explored sustainable livestock intensification options that reduce agro-environmental trade-offs across different smallholder farming systems in Northern Tanzania; Kashwan (2017) focused on forest-based (not solar, wind, hydropower and geothermal sources) climate change mitigation in India, Tanzania and Mexico; whereas Bahati and Kalugendo (2017) investigated the feasibility of engaging rural communities in the process of institutionalising climate change adaptation and mitigation to the issues of renewable energy in Kilosa, Tanzania. We can see that all these studies either focused on renewable energy or climate change, but not both.

Other studies in the country and the region have also focused on promoting inclusive and sustainable economic and social development while simultaneously adapting to climate change impacts and reducing greenhouse gas emissions in Botswana, Malawi, Tanzania, Zambia, DRC, Ethiopia, Ghana and Nigeria (Alemaw & Simatele, 2020). The study by Rocco et al. (2020) focused on the implications of the expanding electricity sector on Tanzania's sustainable development, but not on policies in the renewable energy sub-sector. While Kangalawe et al. (2011) analysed ways in which climate change adaptation can be mainstreamed in the management of freshwater resources, taking the Great Ruaha River catchment area, in Tanzania, as a case study; Mngumi (2020) undertook a study in Dar es Salaam that focused on climate change effects in peri-urban areas of the city. Also, the study by Harnesk and Brogaard (2017) identified prevailing norms, mechanisms of decision-making, and the network of actors involved in subsidies, mandatory targets, and prescriptive criteria for liquid biofuels in Tanzania. Again, although these studies somehow address policy issues, one can note that none has addressed the direct contexts between the reduction of greenhouse gases and the development of renewable energy.

Although there are studies that have addressed issues related to the renewable energy sector, yet most of these hardly address issues related to policies on climate mitigation. For instance, Obadia et al. (2018) reviewed and examined challenges of the current potential renewable energy for the achievement of sustainable development in Tanzania, but not climate change mitigation policies in the context of promoting renewable energy resources. On the other hand,

Wood et al. (2016) focused on financing energy access by clean development mechanism using evidence from Tanzania; while Nyembo et al. (2022) assessed the impact of climate change on groundwater recharge in the lake Manyara catchment, in Tanzania. Mswima and Kaswamila (2022) assessed the role of eco-village practices in strengthening climate change adaptive capacity and mitigating desertification in Chololo, Dodoma, Tanzania. Olabisi and Richardson (2022) studied the reasons for the poor paying higher energy prices; while Bazila et al. (2022) assessed the electrical power behavioural usage in public institutions and its intervention in higher learning institutions in Tanzania. Other studies on energy are by Rugaimukamu (2022) that focused on an analysis of the determinants and barriers of household sustainable energy transitions in Tanzania. A study on the shifting landscapes of light, labour, and value produced by the politics of electrification in Tanzania was done by Kristin (2022); whereas Mnzava et al. (2022) identified opportunities toward investments in renewable energy such as hydropower and geothermal energy, and recommended that investment in gas as a non-renewable energy source is a good option for Tanzanians. Also, Adornetto (2022) studied energy trajectories and solar energy imaginaries of the Maasai; while Gill-Wiehl et al. (2022) evaluated the energy justice of off-grid solar mediated through gender and class.

In the context of the foregoing, we can conclude that most of the existing research in Tanzania is based on climate change vulnerability and adaptation, even though there are few on climate change mitigation. This research gap indicates that an understanding of climate change mitigation policy options in renewable energy sub-sector is desirable in the country. It is from this context that working on integrating the thinking of traditional science on climate change into policymaking process, particularly the issue of governance, is critical (Kate & Andrew, 2008). Having such matters reflected in national political and social development agendas bring them to reality, and facilitate their implementation: rather than remaining in research papers, publications, scientific symposia discussions, assessment reports, and the like.

6. Discussion

Tanzania supports independent power producers, including their access to the national grid. For example, in the year 2019/2020, the government registered twelve (12) small solar projects of 317.78 kW capacity, to be implemented by the Power Corner (T) Ltd and PowerGen Renewable Energy Ltd companies (MoE, 2020). The Mwenga Hydro Ltd Company has also been granted a short licence to produce hydropower of 2.5MW and sell it to its neighbouring rural areas through the national grid (MoE, 2020). Generally, developing countries need to encourage investments by independent power producers to develop renewable energy plants to supply energy, particularly to rural areas where the majority of the people live (Ngaira & Omwayi, 2012). Studies have also

recommended the adoption of legal and regulatory frameworks—such as the Paris Agreement—which have instruments on the mechanisms, instruments and institutions for effective implementation of climate change adoption (Worker & Northrop, 2018). Similarly, some studies have required governments to introduce feed-in-tariffs as a policy option to promote renewable energy integration into energy systems (see, e.g., Moomaw et al., 2011). Other studies have recommended an increase in the share of renewable energy—such as wind, solar, geothermal, hydro and bio energy—in total energy production to 50% by 2063 (AU, 2015).

As underscored by other studies, it is important to note the need to provide a sound business and investment environment to local and foreign investors who can provide capital in the development of renewable energy technologies in the country (Obadia et al., 2018). More training and raising awareness of the public on how to invest and use renewable energy resources are also needed. This should go in tandem with the introduction of direct payments such as grants and rebates, loans and guarantees that promote renewable energy integration into energy systems (Moomaw et al., 2011). For instance, the there is a need to enhance the use of solar energy in both rural and urban areas, instead of it being mostly in rural areas (64.8%) compared to urban areas (3.4%). The existence of awareness as a key policy option is supported by studies which state that state policy work in this regard should focus on raising awareness about renewable energy (Obadia et al., 2018; Yadoo & Cruickshank, 2012). These studies propose that the government needs to provide support in renewable energy resources through public awareness, monitoring and evaluation (Marie-Louise et al., 2011; PytlikZillig et al., 2018).

According to URT (2021c), Tanzania has inadequate institutional arrangements to deal with climate change. The huddle remains on how to overcome political and institutional challenges in responding to current and future climate change risks (Adger et al., 2009). In Tanzania, there are climate change public policies in various strategies and plans that have set clear roles and responsibilities of state and non-state actors. In particular, the Environmental Management Act (URT, 2004) is a national climate change policy that provides measures on climate change that are supported by the law, and which provide clear mandate to stakeholders. This is in line with Harris and Russell (2010) who advanced that, to have a continuous spiral of change and ensure its sustainability in a country, it is necessary to have in place a national climate change policy to guide any action taken to address climate change. Such an observation also agrees with other studies—for instance, Obadia et al. (2018)—that support the requirement that the government, along with other renewable energy stakeholders, should complement existing policies and strategies to address issues related to the development of renewable energy to ensure timely and sustainable utilisation of available resources.

Regarding increasing awareness on climate change, scholars recognise the increasing role that renewable energy can play in world energy systems, especially in the supply of energy in rural areas, which has increased the interest of most countries in creating appropriate training programmes related to renewable energy sources (Kimuli et al., 2017), and ensuring long-lasting communication channels at different levels (Arriagada et al. (2018).

Meadowcroft (2009) recommends that governance mechanisms in climate change should address societal reach in the context that majorities of the society should favour active mitigation policy regimes. The international community expects developing countries to act accordingly by enacting laws, policies, strategies and plans that consider global implications. However, previous works have established that individuals, institutions or countries need to act together with the same interests for effective achievements in the mitigation of climate change (Harris & Russells, 2010; Meadowcroft, 2009). Bulkeley and Newell (2015) further support the need of compatibility of governance in climate change that requires avoiding any fragmented and unclear roles of state and non-state actors on the reduction of greenhouse gas emissions. This observation is consistent with that of Folke et al. (2005) and Gupta (2016) on the effectiveness of climate change governance, where a reassessment of institutional arrangements is considered as one of the requirements of climate change policy. Yadoo and Cruickshank (2012) argued further that policy work on renewable energy should focus on improving institutional, technical and regulatory frameworks.

Building human and institutional capacity requires expanding specialised training, supporting local educational and sector institutions that deal with renewable energy, supporting partnerships with international firms through south-south and north-south exchanges, and developing implementation models that can deliver services more efficiently (AfDB, 2015). The Paris Agreement, for instance, encourages developing countries to take domestic actions with support from developed countries that can provide funds and technology transfer to facilitate matters of climate change mitigation (UN, 2016). National policies, for instance, need to consider Article 2(1) of the Paris Agreement that requires strengthening global response to the threat of climate change in the context of sustainable development and efforts to eradicate poverty (UN, 2016). These viewpoints agree with those of other studies: that the integration of climate change into national-level policies, plans and strategies is important to encourage action on the mitigation of climate change (Pardoe et al., 2018).

Renewable energy targets concerns are also supported by the IEA's argument (2019) that sustainable development scenario requires setting climate targets. For example, a country may start with renewable energy targets in city buildings that are key actors in reducing the causes of climate change. Also,

tax exemptions to renewable energy sources may be implemented as one of the appropriate policy options to promote climate change mitigation in the renewable energy sub-sector. This is consistent with Barry et al. (2011) who argued that governments need to provide support in renewable energy resources through reduction/elimination of duties and taxes. According to Moomaw et al. (2011), governments are also required to introduce policies of monetary incentives such as grants, discounts, loans and guarantees that promote renewable energy integration into energy systems.

7. Conclusion

The paper illustrates that climate change is the greatest challenge in the 21st century that is associated with increased greenhouse gas emissions mainly due to human quest for development. The paper has also shown that a reduction of greenhouse gas emissions is required to limit temperature increases; and that science or technology alone cannot solve climate change risks because of their complexity that call for collective efforts by all stakeholders. The review also provides evidence that climate change problem will persist for many years, which necessitates the need to take a different approach to deal with climate change by reducing greenhouse gas emissions. The impacts of temperature increase are vivid, confirming that although developing countries may engage in mitigation actions, adaptation is still the first priority. Addressing climate change threats requires an effective and progressive response by particularly reducing global warming. This would require individuals, institutions and countries with the same interests concurrently acting in the same direction to address climate change mitigations more effectively.

It is evident from the discussion above that developing countries have also the potential to contribute to the reduction of global greenhouse gas emissions, although in negligible terms. Although Tanzania has negligible greenhouse gas emissions, it also has the potential to grow economically through the development of energy, industries, agriculture, transport and livestock sectors: all of which will in turn potentially increase its share of global greenhouse gas emissions. However, the projected increase of renewable energy in the national grid will counter this, in addition to creating more jobs that imply an increase in household income, and hence increased potential use of alternative energy sources, including renewable energy.

The study concludes further that while there are policies related to climate change mitigation in Tanzania with government support, there is no robust national climate change policy and/or national renewable energy policy. The absence of specific policies makes it difficult for the country to effectively deploy renewable energy power generation as a climate change mitigation action. Thus, this calls for the government and other stakeholders to further support renewable energy initiatives through legislation.

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