



RENEWABLE ENERGY AND CLIMATE CHANGE MITIGATION - A REVIEW.

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ABSTRACT

Energy is a requirement in our everyday life as a way of improving human development leading to economic growth and productivity. Despite these opportunities, there are challenges that hinder the sustainability of renewable energy sources towards climate change mitigation. These challenges include Market failures, lack of information, access to raw materials for future renewable resource deployment, and our daily carbon footprint. The study suggested some measures and policy recommendations which when considered would help achieve the goal of renewable energy thus to reduce emissions, mitigate climate change and provide a clean environment as well as clean energy for all and future generations. The return-to renewables will help mitigate climate change is an excellent way but needs to be sustainable in order to ensure a sustainable future and bequeath future generations to meet their energy needs. Knowledge regarding the interrelations between sustainable development and renewable energy in particular is still limited. The aim of the paper is to ascertain if renewable energy sources are sustainable and examine how a shift from fossil fuel-based energy sources to renewable energy sources would help reduce climate change and its impact. A qualitative research was employed by reviewing peer-reviewed papers in the area of study. This study also brought to light the opportunities associated with renewable energy sources; energy security, energy access, social and economic development and climate change mitigation and reduction of environmental and health impacts.

Keywords: *Climate change, Renewable energy, Mitigation, Sustainability, Environmental impact, Sustainable development.*

INTRODUCTION

The world is fast becoming a global village due to the increasing daily requirement of energy by all population across the world while the earth in its form cannot change. The need for energy and its related services to satisfy human social and economic development, welfare and health is increasing. All societies call for the services of energy to meet basic human needs such as: health, lighting, cooking, space comfort, mobility and communication and serve as generative processes (Edenhofer et al., 2011). Securing energy supply and curbing energy contribution to climate change are the two over-riding challenges of energy sector on the road to a sustainable future (Abbasi, 2010). It is overwhelming to know in today's world that 1.4 billion people lack access to electricity, while 85% of them live in rural areas. As a result of this, the number of rural communities relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030 (Tiwari, 2011). Sustainable development has become the centre of recent national policies, strategies and development plans of many countries. The United Nations General Assembly proposed a set of global Sustainable Development Goals (SDGs) which included 17 goals and 169 targets at the UN in New York by the Open Working Group. In addition, a preliminary set of 330 indicators was introduced in March 2015 (Lu et al, 2015). The SDGs place greater value and demands on the scientific community than did the Millennium Development Goals. In addressing climate change, renewable energy, food, health and water provision requires a coordinated global monitoring and modelling of many factors which are socially, economically and environmentally oriented (Rogelj et al, 2016). Research into alternate sources of energy dated back in the late 90s when the world started receiving shock from oil produces in terms of price hiking (Abbasi et al., 2011). It is evidential in literature that replacing fossil fuel-based energy sources with renewable energy sources, which includes: bioenergy, direct solar energy, geothermal energy, hydropower, wind and ocean energy (tide and wave), would gradually help the world achieve the idea of sustainability. Governments, intergovernmental agencies, interested parties and individuals in the world today look forward to achieving a sustainable future due to the opportunities created in recent decades to replace petroleum-derived

materials from fossil fuel-based energy sources with alternatives in renewable energy sources. The recent launch of a set of global SDGs is helping to make sure that climate change for twenty-first century and its impacts are combated, and a sustainable future is ensured and made as a bequest for future generations (Edenhofer et al., 2011; Lu et al., 2015). Against this backdrop, the study seeks to examine the potentials and trends of sustainable development with renewable energy sources and climate change mitigation, the extent to which it can help and the potential challenges it poses and how a shift from fossil to renewable energy sources is a sure way of mitigating climate change. To achieve these objective, concepts, techniques and peer reviewed journals are analysed and reviewed judiciously.

THEORY

Renewable Energy

Scientifically, renewable sources of energy are considered as natural and clean sources of energy. However, excessive usage of the energy can lead to adverse effects on the environment and climate. These sources of energy produce acceptable amounts of secondary waste. Therefore, their consumption is sustainable as far as the on-going and future economic needs are met. Subsequently, industrial use of renewable sources of energy provide good opportunity for mitigating and controlling greenhouse gas emission and reduction in negative climate change attributed to global warming (Ćetković et al, 2016). The energy sector contributes to global development through trade. There should be enhanced efforts for enhancing power generation, promotion of regional trade and facilitation of renewable energy. Regional trade can be enhanced by expansion of transmission and distribution of energy networks and interconnection of regional networks. There have been constant efforts associated with strategic investment planning for renewable energy such as introduction of new technologies in electricity generation.

Climate Change

Climate change is a major global threat in relation to the growing world's population and industrialization. One of the main causes of climatic change

is the carbon emissions into the atmosphere. Moreover, it is caused by greenhouse gas emission, deforestation and land use. All these underlying causes lead to ozone layer depletion hence the rise in temperature and climate change. As a result of carbon emission, the atmosphere is constantly getting polluted. With depletion of the ozone layer to the projection reveals that there is a sudden rise temperature, glaciers are melting resulting to sudden floods (Schandl., et al. 2016).

Nevertheless, the atmospheric temperature is rising day by day resulting to global warming (Owusu, & Asumadu-Sarkodie, 2016a). By extension Agricultural sector is negatively impacted in attribution to global warming and this has a bigger influence on the international economy. The globe is also experiencing increase in land temperatures as well sea temperatures. Subsequently, there are high risks of coastal erosions and harm to the aquaculture (Rogelj., et al. 2016). Currently, the climate change is also altering the precipitation quantity and patterns leading to unexpected changes in rainfall seasons. Some parts of the globe are experiencing extreme drought and flood attributed to the current climate change. Coastal cities as warned by experts should be on the high alert to face high sea levels (Gulagi, Bogdanov, & Breyer, 2017). Several studies have also pointed out that carbon emissions and bubbling is more likely to lead to loss of global wealth amounting to three trillion dollars. This loss is comparable to the 2007 financial crisis.

LITERATURE REVIEW

Renewable energy sources and sustainability

Renewable energy sources replenish themselves naturally without being depleted in the earth; they include bioenergy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy. The main renewable energy forms and their uses are presented in Table 1 below.

Tester (2005) defines sustainable energy as, “a dynamic harmony between the equitable availability of energy-intensive goods and services to all people and preservation of the earth for future generations”. The world’s growing energy need, alongside increasing population led to the continual use of fossil fuel-based energy sources (Coal, Oil and Gas) which became

problematic by creating several challenges such as: depletion of fossil fuel reserves, greenhouse gas emissions and other environmental concerns, geopolitical and military conflicts, and the continual fuel price fluctuations. These problems will create unsustainable situations which will eventually result in potentially irreversible threat to human societies (UNFCC, 2015). Notwithstanding, renewable energy sources are the most outstanding alternative and the only solution to the growing challenges (Tiwari & Mishra, 2011). In 2012, renewable energy sources supplied 22% of the total world energy generation (U.S. Energy Information Administration, 2012) which was not possible a decade ago. Reliable energy supply is essential in all economies for heating, lighting, industrial equipment, transport, etc. (International Energy Agency, 2014). Renewable energy supplies reduce the emission of greenhouse gases significantly if replaced with fossil fuels. Since renewable energy supplies are obtained naturally from on-going flows of energy in our surroundings, it should be sustainable. For renewable energy to be sustainable, it must be limitless and provide non-harmful delivery of environmental goods and services. For instance, a sustainable biofuel should not increase the net CO₂ emissions, should not unfavourably affect food security, nor threaten biodiversity (Twidell & Weir, 2015). Is that really what is happening today? I guess not. In spite of the outstanding advantages of renewable energy sources, certain shortcoming exists such as: the discontinuity of generation due to seasonal variations as most renewable energy resources is climate-dependent, that is why its exploitation requires complex design, planning and control optimization methods. Fortunately, the continuous technological advances in computer hardware and software are permitting scientific researchers to handle these optimization difficulties using computational resources applicable to the renewable and sustainable energy field (Baños et al., 2011).

l., 2011)

Energy sources	Energy conversion and usage options
Hydropower	Power generation
Morden 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

Table 1: renewable energy sources and their uses.

Renewable energy and climate change

Presently, the term “climate change” is of great interest to the world at large, scientific as well as political discussions. Climate has been changing since the beginning of creation, but what is alarming is the speed of change in recent years and it may be one of the threats facing the earth. The growth rate of carbon dioxide has increased over the past 36 years (1979–2014) (Asumadu-Sarkodie & Owusu, 2016b), “averaging about 1.4 ppm per year before 1995 and 2.0 ppm per year thereafter” (Earth System Research Laboratory, 2015). The United Nations Framework Convention on Climate Change defines climate change as being attributed directly or indirectly to human activities that alters the composition of the global atmosphere and which in turn exhibits variability in natural climate observed over comparable time periods.

For more than a decade, the objective of keeping global warming below 2 °C has been a key focus of international climate debate (Asumadu-Sarkodie, Rufangura, Jayaweera, & Owusu, 2015; Rogelj, McCollum, Reisinger, Meinshausen, & Riahi, 2013). Since 1850, the global use of fossil fuels has increased to dominate energy supply, leading to a rapid growth in carbon dioxide emissions. Data by the end of 2010 confirmed that consumption of fossil fuels accounted for the majority of global anthropogenic greenhouse gas (GHG) emissions, where concentrations had increased to over 390 ppm (39%) above preindustrial levels (Edenhofer et al., 2011).

Renewable technologies are considered as clean sources of energy and optimal uses of these resources decreases environmental impacts produces minimum secondary waste and are sustainable based on the current and future economic and social needs. Renewable energy technologies provide an exceptional opportunity for mitigation of

greenhouse gas emission and reducing global warming through substituting conventional energy sources (fossil fuel based).

Renewable energy and sustainable development

Renewable energy has a direct relationship with sustainable development through its impact on human development and economic productivity (Asumadu-Sarkodie & Owusu, 2016c). Renewable energy sources provide opportunities in energy security, social and economic development, energy access, climate change mitigation and reduction of environmental and health impacts.

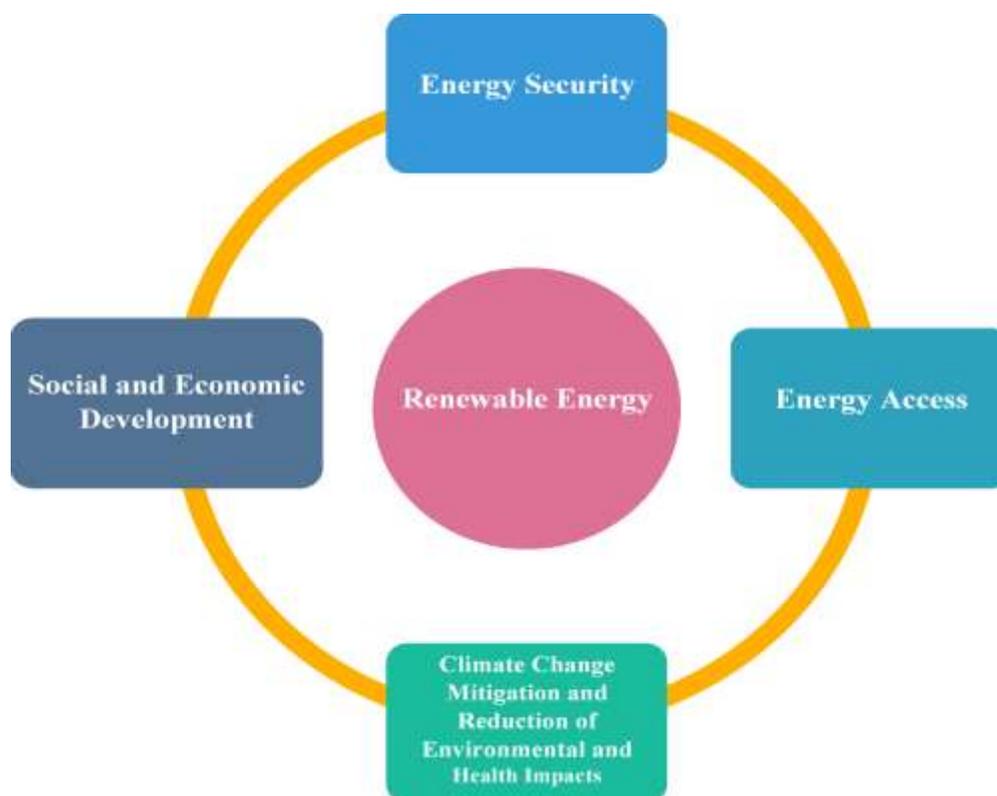


Figure 1: shows the opportunities of renewable energy sources towards sustainable development.

(a) Energy security

The notion of energy security is generally used; however there is no consensus on its precise interpretation. Yet, the concern in energy security is based on the idea that there is a continuous supply of energy which is

critical for the running of the economy. Given the interdependence of economic growth and energy consumption, access to a stable energy supply is of importance to the political world and a technical and monetary challenge for both developed and developing countries, because prolonged interferences would generate serious economic and basic functionality difficulties for most societies (Edenhofer et al., 2011; Larsen et al., 2009). Renewable energy sources are evenly distributed around the globe as compared to fossils and in general less traded on the market. Renewable energy reduces energy imports and contributes diversification of the portfolio of supply options and reduces an economy's vulnerability to price volatility and represent opportunities to enhance energy security across the globe. The introduction of renewable energy can also make contribution to increasing the reliability of energy services, to be specific in areas that often suffer from insufficient grid access. A diverse portfolio of energy sources together with good management and system design can help to enhance security (Edenhofer et al., 2011).

(b) Social and economic development

Generally, the energy sector has been perceived as a key to economic development with a strong correlation between economic growth and expansion of energy consumption. Globally, per capita incomes are positively correlated with per capita energy use and economic growth can be identified as the most essential factor behind increasing energy consumption in the last decades. It in turn creates employment; renewable energy study in 2008, proved that employment from renewable energy technologies was about 2.3 million jobs worldwide, which also has improved health, education, gender equality and environmental safety (Edenhofer et al., 2011).

(c) Energy access

The sustainable development goal seven (affordable and clean energy) seeks to ensure that energy is clean, affordable, available and accessible to all and this can be achieved with renewable energy source since they are generally distributed across the globe. Access concerns need to be understood in a local context and in most countries there is an obvious difference between electrification in the urban and rural areas, this is especially true in sub-Saharan Africa and South Asian region (Ajanovic, 2011).

Distributed grids based on the renewable energy are generally more competitive in rural areas with significant distances to the national grid

and the low levels of rural electrification offer substantial openings for renewable energy-based mini-grid systems to provide them with electricity access (Edenhofer et al., 2011).

(d) Climate change mitigation and reduction of environmental and health impacts Renewable energy sources used in energy generation helps to reduce greenhouse gases which mitigate climate change reduce environmental and health complications associated with pollutants from fossil fuel sources of energy. Nevertheless, there was variation in individual member countries, while there was a decrease in GHG emissions in other (22 EEA) countries, there was an increase in other (11 EEA) countries.

Challenges affecting renewable energy sources

Renewable energy sources could become the major energy supply option in low-carbon energy economies. Disruptive alterations in all energy systems are necessary for tapping widely available renewable Energy sources. Organizing the energy transition from non-sustainable to renewable energy is often described as the major challenge of the first half of the twenty-first century (Twidell al., 2015). It is evident that a major barrier towards the use of renewable energy source depends on a country's policy and policy instrument which in turn affect the cost and technological innovations. In addition, technological innovations affect the cost of renewable energy technologies which in turn leads to market failures and low patronization of the renewable energy technology. In the light of this, an effective renewable energy policy should take the interconnection of factors affecting renewable energy supplies and sustainability into consideration.

The following are policy recommendations emanating from the study that can help mitigate climate change and its impacts:

- All sectors and regions have the potential to contribute by investing in Renewable energy technologies and policies to help reduce it. Reducing our carbon footprint through the changes in lifestyle and behaviour patterns can contribute a great deal to the mitigation of climate change.
- Research into innovations and technologies that can reduce land use and also reduce accidents from renewable energy sources and the risk of resource competition, for example in Bioenergy where food for consumption competing with energy production.
- Enhancing international cooperation and support for developing countries towards the expansion of infrastructure and

upgrading technology for modern supply and sustainable energy services as a way of mitigating climate change and its impacts.

CONCLUSION

Energy is a requirement in our everyday life as a way of improving human development leading to economic growth and productivity. The return-to-renewables will help mitigate climate change is an excellent way but needs to be sustainable in order to ensure a sustainable future for generations to meet their energy needs. Knowledge regarding the interrelations between sustainable development and renewable energy in particular is still limited. The aim of the paper was to ascertain if renewable energy sources were sustainable and how a shift from fossil fuel-based energy sources to renewable energy sources would help reduce climate change and its impact. A qualitative research was employed by reviewing papers in the scope of the study. Even though, the complete lifecycle of renewable energy sources have no net emissions which will help limit future global greenhouse gas emissions. Nevertheless, the cost, price, political environment and market conditions have become barriers preventing developing, least developed and developed countries to fully utilize its potentials.

In this way, a creation of global opportunity through international cooperation that supports

least developed and developing countries towards the accessibility of renewable energy, energy efficiency, clean energy technology and research and energy infrastructure investment will reduce the cost of renewable energy, eliminate barriers to energy efficiency (high discount rate) and promote new potentials towards climate change mitigation.

The study brought to light the opportunities associated with renewable energy sources; energy security, energy access, social and economic development and climate change mitigation and reduction of environmental and health impacts. There are challenges that tend to hinder the sustainability of renewable energy sources and its ability to mitigate climate change. These challenges are: market failures, lack of information, access to raw materials for future renewable resource deployment, and most importantly our (humans) way of utilizing energy in an inefficient way.

From the findings, the following suggestions are made that can help improve the concerns of renewable energy being sustainable and also reduce the rate of the depletion of the ozone layer due to the emissions of GHG especially carbon dioxide (CO₂):

- Formulation of policies and discussions from all sectors towards the improvement of technologies in the renewable sector to sustain them.
- Changes in our use of energy in a more efficient way as individuals, countries and the world as a whole. Efforts that aim at increasing the share of renewable energy and clean fossil fuel technologies into global energy portfolio will help reduce climate change and its impacts. Energy efficiency programmes should be introduced globally, which give tax exemptions to firms who prove to provide energy efficiency initiatives (energy-efficient homes), product design (energy efficient equipment) and services (industrial combined heat and power). Introducing the concept of usability, adaptability and accessibility into energy-dependent product design is a way of promoting energy efficient behaviours.

Increase research in these areas, so that the fear of some renewables posing risks in the future is limited.

Improve education, awareness-raising and human institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. Developed countries should incorporate decarbonisation policies and strategies into the industry, energy, agricultural, forest, health, transport, water resource, building and other sectors that have potential of increasing greenhouse gas emissions. Efforts in developing countries aimed at improving institutional training, strengthening institutions and improving capacity of research on climate change will increase awareness, promote adaptation and sustainable development. Least developed countries should develop and test tools and methods with a global support that direct policy and decision-making for climate change mitigation, adaptation and early warnings. Supporting a global dialogue through international cooperation and partnership with developed, developing and least developed countries will promote the development, dissemination and transfer of environmentally friendly technologies, innovation and technology, access to science, and among others which will increase the mutual agreement towards combating climate change and its impacts.

If these suggestions are implemented, the sustainability of renewable energy resources would be addressed as well as the seventh and thirteenth goal of sustainable development which seeks to ensure access to affordable, reliable, sustainable, modern energy for all and combat climate change and its impact.

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