CHINA-AFRICA COOPERATION TOWARDS GREEN ECONOMY DEVELOPMENT: THE CASE OF ETHIOPIA'S ADAMA WIND ENERGY PROJECT

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(Received 4th Jun 2024; accepted 3rd Dec 2024)

Abstract. This review paper aims to assess the cooperation between China and Africa from the perspective of green economy development and how this development contributes to clean energy infrastructure by taking the case of Ethiopia's Adama wind energy project one and two. It involved a systematic review of the scientific literature. The findings from this study revealed that China has been playing a vital role in the development of green economy in Ethiopia, particularly to the development of clean energy. So far, China has invested about $444 million in clean energy development in Ethiopia. The estimated annual clean energy output from the developed projects was 545,047.2 MW. This can help replace the total energy generated by planting woods established on more than 493 hectares of land per year, which have an estimated 4,930 tons of carbon sequestration capability. Furthermore, the project has contributed to the transfer of green technology to the local engineers and technicians who worked on it. Notwithstanding the role it has in clean energy provision and technology transfer, cooperation in green economy development is quite limited. Thus, enormous policy efforts that aim at enhancing collaboration in green economy development are still needed to realize clean energy advancement.
Keywords: *climate resilient, clean energy, technology transfer, China-Africa, Ethiopia*

Introduction

The greening of economies has the potential to be a new engine of growth, a net generator of decent jobs, and a vital strategy to eliminate persistent poverty (UNEP, 2011). As demonstrated by various researchers, government involvement in the transition to a green economy is strongly justified by leveling the field of green products, gradually eliminating detrimental subsidies (IEO, 2018), restructuring policies and incentives (Ouedraogo, 2017), enhancing market infrastructure and developing innovative market-based strategies (Benti et al., 2021), redirecting public investment, and going green in public procurement (UNEP, 2011), among others. At the continental level, the IEA (2014) verified that improving access to affordable energy services is largely viewed as a vital challenge to reveal Africa's development potential. According to the author, Africa is the only region with a projected decrease in per capita energy consumption, including electricity, from 2015 to 2040. This is due to the projected

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2301_11011113

population growth across the continent exceeding energy consumption growth (IEO, 2018). Addressing the continent's growing energy needs is seen as vital not just to its economic growth and development but also to the eradication of poverty (Shen and Power, 2017).

Renewable energy technologies in particular have arisen as crucial to meet Africa's energy needs (Shen and Power, 2017), partly due to growing international recognition of the relationship between energy availability, climate change, and environmental sustainability more broadly (IEA, 2014). The search for sustainable energy access, as stated by the (IEA, 2022), is now recognized as one of the SDGs, which in turn have constructed on preceding international initiatives such as the UN-led Sustainable Energy for All Global Initiative, which pursued universalizing energy access (IEO, 2018), enhancing the share of renewables in the energy mix, and improving energy efficiency by 2030 (Magnolia et al., 2023). A study revealed that energy demands in sub-Saharan Africa, where 13% of the world's population resides, increased by almost 45% between 2000 and 2012; however, this accounts for only 4% of the world total (AFREC, 2022). So, addressing the region's growing energy needs is seen as vital to meeting the growing population's needs (Shen and Power, 2017).

Ethiopia has one of the world's lowest access rates to modern energy supplies (DegefuHe and Zhao, 2015). BerhanuJabasingh and Kifile (2017) find that the majority of the population lives in rural areas, where more than 99% of households rely on traditional biomass for cooking and baking, whereas approximately 90% of urban populations rely on electricity for lighting. Despite its heavy reliance on traditional energy sources, the country is gradually transitioning to a renewable energy supply (Yalew, 2022). Because of the fast-growing economy and booming infrastructure, energy demand in the country is currently increasing at an alarming rate (Benti et al., 2021). In order to meet the nation's energy demand, the government of Ethiopia launched the Climate Resilient Green Economy strategy in 2011 that sets the goal that by 2025 Ethiopia will be a middle-income country, resilient to climate change impacts, with no net increase in greenhouse gas emissions from 2010 levels (FDRE, 2011; Mondal et al., 2018), as well as generating alternative renewable energy sources (Legesse, 2011). To attain this objective, in addition to constructing mega hydro projects, the government has started to look for different alternative clean energy sources like wind and solar energy. Particularly to develop wind energy, the government sourced out the project for securing external funds from collaborators and has been strongly working on it (MoFECC, 2017).

With this aim to develop environmentally friendly clean energy that can contribute to green economy development, the Ethiopian government signed an Engineering Procurement and Construction and financing contract with the Chinese companies to construct two wind farms with a total capacity of 204 MW (MoFECC, 2017). Following this successful cooperation in Ethio-China wind energy infrastructure development, Chinese companies have started to largely engage in the construction of clean energies in different parts of African (Baker and Shen, 2017; Lema et al., 2021; Takouleu, 2023). The success of this project is believed to have served as a way for Chinese companies to introduce their wind energy technology to African countries, and to this day, they have been largely engaged in its development in various countries on the continent (Chen, 2018).

Previous studies on China-Africa cooperation have examined cooperation in areas of trade relationship (Flores-Macías and Kreps, 2013; Huang, 2018), economic

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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collaboration (Krukowska, 2018; MOCPRC, 2022), infrastructure development (Daily, 2021; FOCAC, 2021), and technology and knowledge transfer (Chen, 2018). However, to the levels of the authors' knowledge, there is limited literature providing a comprehensive analysis of China-Africa cooperation in the area of green economic development. For instance, Hensengerth (2013) examines the role of environmental norms in Chinese overseas investment in hydropower dams, as exemplified by SinoHydro's involvement in the Bui Dam in Ghana. This is mainly from the perspective of whether China can be considered a norm-changer in international development or not. Others (Chen, 2018; Chiyemura, 2020) have considered Ethiopia's case of wind energy development mainly from the perspectives of comparison of South-South and North-South technology transfer and African agency in the context of Africa-China engagement, respectively. However, the contribution of cooperation to the development of the green economy is barely considered. Therefore, this review will give a comprehensive picture of the cooperation between China and Africa from the perspective of clean energy development and how it contributes to the region's green economy by taking the case of Ethiopia's Adama wind energy project, developed by Chinese companies, in which 85% of the project was financed by Chinese government (MoWIE, 2017).

This article presents a review of literature such as journal articles, books, book chapters, conference proceedings, and workshop reports on Africa-China engagements in the area of green economy development. It attempts to fill part of those prevailing gaps based on a systematic review of the latest scientific literature.

China-Ethiopia cooperation for wind energy development

The Ethiopian government has developed and implemented a series of policies, strategies, and programs to create a suitable policy framework for inclusive green development (FDRE, 2011). In this state, the government adopted the Climate-Resilient Green Economy strategy, which promotes sustainable economic growth that is resilient to climate and environmental tremors (EFDR, 2019). And also creating a competitive advantage out of sustainable resource use and higher productivity growth (BerhanuJabasingh and Kifile, 2017), as well as resolving the potential conflict between economic growth and battling climate change (Padam et al., 2018). The government has started environmentally friendly infrastructure development on renewable energy sources in order to put the strategy of green economy development into practice, particularly to address rising energy needs (FDRE, 2011). It is believed that addressing the country's growing energy demand is vital not just to its economic growth and development but also to the eradication of poverty (Mondal et al., 2018).

Similar to the rest of Sub-Saharan Africa, Ethiopia faces difficulties with infrastructure development and access to electric power (Azeb, 2015). The energy demand in the country has been gradually increasing as a result of economic growth. The total energy demand of Ethiopia grew by 30% from 2010 to 2018 (EEPCo, 2022) and is high at the present time, while electricity demand grew by 130% in the same period. Based on this increased demand, electricity generation is projected to increase by between 100% and 300% from 2018 to 2030 (ibid.). This projection will not be achieved only through hydropower development but rather by exploring other options to provide an adequate energy supply. Assuming the challenges of the absence and shortage of electricity infrastructure, the Ethiopian government planned to develop

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alternative energy sources as part of a broader solution to address electricity infrastructure gaps (Chen, 2018).

Given the irregular nature of hydropower-based generation, Ethiopia had shown interest in developing non-hydro renewables after attending the Solar and Wind Energy Resource Assessment (SWERA) meeting sponsored by the United Nations Environment Programme and Global Environment Facility in 2001 (Padam et al., 2018). The researcher (Chiyemura, 2020) stated that the Ethiopian government requested the German Society for International Cooperation (GIZ) to conduct suitability studies for the establishment of wind farms after SWERA was complete, and 11 sites were found to be feasible. From these 11, feasibility studies were conducted for three sites: Harena, Ashegoda, and Nazareth. The three sites had sufficient wind energy potential, with annual averages of 6.86 m/s, 8.50 m/s, and 9.36 m/s, respectively (HCC, 2012). The author (Chen, 2018) considered that while this was going on, the Ethiopian government appointed HydroChina to do a Wind and Solar Energy Master Plan for Ethiopia, in which they revealed that Ethiopia had a 3.03 TW wind resource reserve, of which 1.35 TW could be installed. Additionally, the corporation took into account that Ethiopia has 51 potential sites for wind farms with a total installed capacity of 6.72 GW (MoWIE, 2019).

According to MoWIE (2019), the Ethiopian government had access to precise, verifiable, and trustworthy data following the conclusion of the SWERA and HydroChina Master Plan reports, which supported its ambitious development for wind and solar energy. In 2010, the Ethiopian government proposed to develop eight wind farms during GTP1 (MOFED, 2010). In the meantime, it was suggested that the Ethiopia-China Development Cooperation Directorate of the Ministry of Finance and Economic Cooperation (MoFECC) contact the Chinese Export and Import Bank (C-EXIM Bank) to obtain funding for the project (ibid.). Since the Chinese do not precondition their assistance with governmental reform, the Chinese government preferred to fund the project’s development. As stated by (Chen, 2018), all of the funding for the two wind farms was provided through Engineering Procurement and Construction plus financing agreements, with Adama 1 receiving a favorable export buyers’ credit and Adama 2 receiving a concessional loan. With these, the projects were implemented in such a way that Adam 1 was started in 2011 and completed in 2012, generating 51 MW of power; following this, after three years, Adam 2 with a capacity of 153 MW was started in 2013 and completed in 2015 (MoWIE, 2019). Out of the total budget allotted to the project, $522 million, 85% was covered by the Chinese government, and the rest (15%) was by the Ethiopian government. The farms cover about 15% of the total electric energy supplied on-grid and are recorded as the first clean energy project in Africa built by Chinese companies (Power-China, 2016).

Environmental contribution of the wind energy project cooperation

Environmental development is the process by which we are empowered to preserve and maintain natural resources and protect them from pollution (TofuWolka and Woldeamanuel, 2022). The shift to a green economy could lead to a noticeable reduction in greenhouse gas emissions. The IEA’s research (IEA, 2022) considered that at a global level, in the investment scenario where 2% of GDP is invested in key green economy sectors and more than half of that investment is dedicated to boosting energy efficiency and expanding the production and use of renewable energy resources, the

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result is a 36% reduction in the global energy intensity, which is expressed in millions of tons of oil per unit of GDP by 2030. Likewise, according to the investment scenario (Khanfar, 2014), carbon dioxide emissions related to energy would go from 30.6 GT in 2010 to 20.0 GT in 2050. The issues that the low-carbon economy brings can consequently be greatly improved by investing in it (Zazykina and Bukova, 2021).

Furthermore, among the other environmental benefits to be earned from a green economy, as pointed out by MEA (2005), are those that can be derived from the sustainable use of ecosystem services. Research for the UNEP report on the green economy (UNEP, 2011) demonstrates how substantial progress may be achieved towards this objective by implementing efforts targeted at regulating demand for ecosystem services used, supplemented by investments to boost the supply of such services. This is due to the fact that it is a better and more sustainable technique that helps to enhance soil fertility (Ferede, 2020), water accessibility (TofuWolka and Woldeamanuel, 2022), and carbon emission storage services (Zazykina and Bukova, 2021) that contribute to green development. The implications of green economy development portfolios and pathways for sustainable development are particularly important in Africa (Ouedraogo, 2017), where access to electricity and other modern energy sources remains limited. As considered (Blimpo and Cosgrove-Davies, 2019), on the continent, more than 51% of the population mainly depends on biomass for energy sources, which has many environmental consequences, for which Ethiopia is not exceptional.

In Ethiopia, Electricity barely accounts for 3% of its total energy supply (MoWIE, 2019). Merely 44% of the households have access to basic electricity supply, and the annual per capita electricity consumption is 100 kWh per person as of 2017 (IEA, 2022), indicating one of the lowest in the world and Africa (MoWIE, 2019; Padam et al., 2018). As reported (AFREC, 2022), Ethiopia ranks among the top ten African nations in terms of the percentage of their total energy consumption that is made up of biomass fuels. Compared to the average energy consumption of 51% in Africa, biomass fuels in Ethiopia made up roughly 86% of the total energy consumption in 2019 (IEA, 2022). Currently, at least one-third of fuelwood is derived from unsustainable forest and woodland extraction (MoFECC, 2017), which causes a fuelwood shortage in several regions of the nation (EUEI, 2013). Besides, the profound reliance on biomass fuel and unsustainable use of it lead to deforestation and land degradation (Yalew, 2022), which have environmental consequences. Moreover, FDRE (2011) specified that forest degradation due to fuelwood consumption accounts for about 46% of the total GHG emissions from the forestry sector in Ethiopia. And also, it pointed out that fuelwood consumption could annually cause the deforestation of 730 thousand ha of forest, woodlands, and shrublands in the country.

According to Ferede (2020), Ethiopia consumes 105,172,465 tons of biomass fuel annually from total charcoal equivalent wood and wood products (round wood, branches, leaves, and twigs). If we consider this in terms of total energy production, in GJ or MWh, as stated by Kofman (2010), all wood has roughly the same gross calorific value per ton dry matter, in which conifers have 19.2 GJ/ton and broadleaves have 19.0 GJ/ton. Likewise, in his study (Kofman, 2013) considered that the net energy content of wood fuel depends greatly on its moisture content. In connection with this, the author specified that for wood to burn satisfactorily, it needs to be at or below the fiber saturation point, which varies for different species but is typically around 25% moisture content. For broadleaves, the net calorific value per ton can be calculated using the following formula (Kofman, 2010):

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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$$NCV = 19(0.2164 * MC) = x\ GJ/to$$

where: NCV = net caloric value; MC = Moisture content, which is expressed as a percentage, not as a proportion; and GJ = gage joule.

As stated by MorketoFekadu and Dajene (2022), in Ethiopia, *Eucalyptus globulus* trees are the most common and productive fuel wood sources that burn suitably at 25% moisture content of their total weight. At this moisture content, based on the equation developed by Kofman (2010), its net calorific value per ton is equivalent to 13.59 GJ/ton (3.78 MW) by taking the coefficient developed for broadleaves. This value is almost similar with the result obtained by Kofman (2010), who indicated that the amount of fuel wood needed to replace a standard amount of fossil fuel is dependent on its moisture content. Furthermore, the author found that at 25% moisture content, wood chips can generate a total energy of 3.79 MW/ton. For computing the NCV of Eucalyptus species, we used the coefficient developed for broadleaf rather than the one developed for conifer species. This is mainly because most broad-leaved species have hard wood, where Eucalyptus species have also been categorized as hard wood species (Kofman, 2013) while, coniferous species are soft wood tree species. Based on the above explanation, given the average annual fuel wood consumption of Ethiopia of 105,172,465 tons per year, the total amount of energy it can generate can be estimated at 397,551,918 MW. In other words, if one ton of dry weight of *Eucalyptus globulus* tree fuel wood generates 3.78 MW of energy, 105,172,465 tons of wood can generate 397,551,918 MW of energy.

Considering the aforementioned result of the total amount of energy that can be generated by the annual fuel wood consumption from an environmental perspective, it could be possible to view it as how many trees or forests per hectare can produce the stated total amount of annual fuel wood consumption. The comparative growth performance study conducted by DejeneaKidaneb and Bahirua (2018) on a fast-growing tree species for fuel wood production in a high-land area of Ethiopia planted at 1.5 × 1.5 m, *Eucalyptus globulus*, showed a 100% survival rate till seven years of harvesting. Taking into account the survival rate obtained by the researchers, 4,444 Eucalyptus trees could be managed per hectare and reached for final fuel wood production. Besides, the research carried out on the same site (MorketoFekadu and Dajene, 2022) revealed that the above-ground biomass (AGB), including components of stem wood, branch, foliage, and bark, of a single tree of *Eucalyptus globulus* at harvesting age recorded an average of 87.47 kg/tree. Taking 25% of its total weight as a MC for the wood to be used as a fuel, as considered by Kofman (2013) and MorketoFekadu and Dajene (2022), the remaining 65.8kg/tree could be the dry weight of a tree or wood that could be utilized as a fuel wood to generate the required amount of energy at seven years of harvesting age. Based on this computation, per hectare, about 292.42 tons of fuel wood could be produced from the specified tree species at the stated harvesting age, which could generate about 1,105.35 MW of energy. Consider the total amount of annual fuel wood consumption in Ethiopia, 105,172,465 tons per year, with the total weight of fuel wood trees produced per ha of area; it is expected to be produced from 359,662.35 ha of land. This revealed that every year, the mentioned hectares of forest are cleared for fuel wood supply in Ethiopia.

Taking into account the total amount of fuel wood produced per hectare, 292.42 tons, by *Eucalyptus globulus* trees that have shown better performance (DejeneaKidaneb and Bahirua, 2018) for fuel wood production, it can generate about 1,105.35 MW of power

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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in seven years. In connection to this, if we are considering the Adama wind energy project, which has 204 MW of power with a turbine output capacity factor of 30.5% (HCC, 2012), it can generate 62.22 MW of energy per hour, which is estimated to save more than 16.46 tons of fuel wood to be consumed per hour. This is anticipated to be 144,189.6 tons of fuel wood per year that is expected to be grown on more than 493 ha of land. Myers and Goreau (1991) demonstrated that tropical pine and eucalyptus tree plantations can store an average of 10 tons of carbon per hectare per year. In this case, per 493 ha of forest land, about 4,930 tons of carbon is expected to be sequestered per year. In such a way, the Adama wind energy project contributes to environmental conservation through climate change mitigation as part of green economy development.

Technology transfer perspective of the cooperation

Developing countries are experiencing unprecedented levels of economic growth. They will therefore be largely in charge of the future growth in energy demand and greenhouse gas emissions (Pueyo and Linares, 2012). The researcher contends that the development, transfer, and use of technology for renewable energy are encouraging steps toward low-carbon growth in these countries. Chen (2018) noted that, since these technologies are mainly originated in developed nations and countries with emerging economies, developing countries are looking for the transfer of these technologies and adapting them to their local conditions to support their economic growth, for which Ethiopia is not exceptional.

According to Pueyo and Linares (2012), the term "technology transfer" has been defined and measured by a wide range of disciplines in a variety of ways. However, this review paper considers (Kirchherr and Urban, 2018) that the broad and inclusive term encompasses the diffusion of technologies and technology cooperation across and within countries. This includes the process of becoming familiar with and using the technology, as well as having the ability to select, modify, and incorporate it with local technologies (ibid.). Chiyemura (2020) indicated that transferring skills and technologies is a political issue, no doubt about it; it is not primarily a technical problem that needs technical solutions. For instance, Urban et al. (2015) considered that China is a major technology transfer country with significant linkages to Africa as well as Southeast Asia, which can be explained by their close political, economic, and geographic ties. Low-carbon energy technology is just one small component of China's vast and diverse trade, assistance, and investment portfolio that it operates in Africa (Baker and Shen, 2017).

Considering the contribution of Chinese companies in technology transfer the Adama wind energy development could be taken as the major practical site for Ethiopia cases. Although adequate literature is not available, Chiyemura (2020) considered that the local engineers and technicians who worked on the project received technical skills and know-how from the Chinese contractors from Adama wind energy project. For instance, for Adama 1, twenty-five, and Adama 2, thirty Ethiopian Electric Power staff underwent onsite training throughout the construction phase as well as one month of theoretical training on the wind turbine generation system in China. Besides, the project consultancy work was contracted to local Universities, in which Addis Ababa University Institute of Technology (AAUIT) consulted on the Adama 1 project and Mekelle University (MU)-Adama Science and Technology University (ASTU)-Joint Venture (JV) consulted on the Adama 2 project (Chen, 2018; Chiyemura, 2020). As

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project consultants, the local Universities' responsibilities included managing the contract between EEP and HydroChina-CGCOC-JV and carrying out commissioning tests of the wind farms (HCC, 2012). Sources indicate that the Ethiopian government saw the use of local Universities as a means of imparting skills and technical knowledge to Ethiopians.

Along with the EEP engineers, the three nearby institutions that served as consultants profited from the transfer of skills and knowledge. ASTU and AAUIT students regularly visit wind farms to undertake practical lessons, which are now used as "open" laboratories (Chiyemura, 2020). The same researcher found that notwithstanding the professors' lack of prior expertise, they are now qualified to conduct design reviews and oversee the construction of wind farms, despite having served as consultants. And also HCC (2012) demonstrated that the Ethiopian Shipping and Logistics Services Enterprise (ESLSE), which brought the wind technology equipment from China to Djibouti, is now equipped to handle big and delicate cargo. EEP and MOWIE are now capable of carrying out wind farm planning, civil works, assembly of the turbines, connecting to the national grid, monitoring performance, as well as operations and maintenance, as they have acquired all the technical skills, knowledge, and technology transfer required (Chen, 2018; Chiyemura, 2020; Power-China, 2016).

According to Kirchherr and Urban (2018), successful technology transfer and cooperation not only provide recipient countries with hardware but also equip them with the skills necessary to operate, maintain, replicate, and innovate this technology. Other researchers (Urban et al., 2015) revealed that if the recipient of the technology is able to use and maintain it but is unable to replicate and develop with it, the technology transfer and cooperation outcome is considered "mixed." In addition to these, Ockwell and Mallett (2012) stated that technology transfer and collaboration would fail if only hardware was made available.

On the basis of the above description, the Adama wind energy project's technology transfer could be considered "mixed" technology transfer. This is mainly because the technology for the Adama wind energy project was imported from China as finished capital goods, leaving little to no possibility for the development of the wind energy sector in Ethiopia due to the EPC nature of the contracts. In addition (Chen, 2018), because Ethiopia lacked a native wind energy industry with the capacity to design and engineer wind energy technology, the Ethiopian government permitted the export of finished capital goods from China. Thus, there were rare chances for local value chain development in the wind energy industry due to the limited local supply chain links formed by the technology transfer. Furthermore, Power-China (2016) reflected that, from the perspective of the Chinese contractor, language continued to be a barrier to the more effective and methodical transfer of technology and knowledge to the local engineers.

Applicable policies and strategies for the sustainability of the cooperation

Ethiopia has been a proponent of the green economy since the early 1990s (UNEP, 2011). As stated by FDRE (2011), even though the approach so far has consisted of the formulation of supporting policies, mainly at sectoral levels, a consolidated green economy policy framework is the Climate-Resilient Green Economy Strategy. According to MoFED (2014) the established strategy has two cornerstones namely: green economy and climate-resilient strategies. The aim of a developed green economy,

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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as voiced in the strategy, is not only reliable with the structural transformation plan but also strengthens the country's long-term economic vision (MOFED, 2010). Furthermore, the government cascaded the strategy down to the sectoral level, and the Growth and Transformation Plan now includes many of the sectoral strategies to enhance green development (EFDR, 2019).

According to the National Growth and Transformation Plan (GTP), the government of Ethiopia aims for universal electrification and is developing large-scale hydroelectric projects to support this objective (MoFED, 2014). According to MoFED, hydropower is regarded as the primary renewable energy source that can help the nation make the shift to more environmentally friendly energy sources. In light of this, the Ethiopian government has acknowledged hydropower as an economically feasible and environmentally friendly option (DegefuHe and Zhao, 2015). However, as considered by Legesse (2011), since hydropower plants are less reliable as droughts intensify, the Ethiopian Electric Power Corporation (EEPCo) plans to mix alternative power plants. The plan includes solar, geothermal, and gas-based plants, to meet the anticipated rise in domestic electricity demand while simultaneously (Azeb, 2015) exporting electricity to surrounding countries. In the context of the Ethiopian power system, wind power will play a significant complementary role to the hydroelectric power grid (MoWIE, 2017). Due to a natural cycle, wind energy availability is highest during the dry season when hydroelectric reservoirs are depleted of water, and it is lowest during the wet season when the reservoirs are rapidly filling with water (MoWIE, 2019). This makes wind power a crucial component of the grid energy mix by enhancing the consistency of the system even in dry seasons (TuchoWeesie and Nonhebel, 2014).

Furthermore, Asresu (2017) considered that the policies of the Ethiopian government encourage the development and transformation of modern energies, targeting the development of domestic energy sources. According to the Ethiopian National Energy Policy, the government's top priority for the development of the energy sector is to maximize the use of domestic energy resources while achieving efficiency and energy self-sufficiency (FDRE, 2011). The policy proposes diversification and enhancement of modern technologies for the purpose of increasing the national energy supply mix (ibid.) and also as a technique of lessening the strain associated with unsustainable use of the natural biomass energy resource base (Benti et al., 2021). Among those modern energy sources, the government of Ethiopia gave priority to the development of wind energy next to hydropower. According to the Ethiopia Electric Power Report (MoWIE, 2019), the total exploitable wind energy potential of the country is around 1,350 GW. However, despite the tremendous potential of this energy system, the development of wind farms is in its early stages in the country (Azeb, 2015). According to Hailu and Kumsa (2021), for both technical and financial considerations, wind locations with a wind density of 300 W/m2 and a wind speed of 6.5 m/s or above are ideal for grid-based power generation in Ethiopia.

The proceeding reviews give an overview of how the availability of pre-existing policies on green economy development in the country has facilitated the acceptance of cooperation between Ethiopia and China to realize the development of green economy projects smoothly. Besides, the over ambitiousness of the Ethiopian government to intensively utilize the existing renewable energies makes the Adama wind energy project lucky and has got attention to be easily established in a speedy way. Furthermore, the presence of pre-identified potential areas for wind energy sources and the chosen Chinese financing loan for the project implementation, which did not

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2301_11011113

precondition their assistance with governance reforms, are overlaying and serving as opportunities for the proposed wind energy project to be smoothly implemented and maintained sustainably.

Conclusion and recommendation

This review paper considered the China-Africa cooperation associated with green economy development through a case study of wind energy project development by Chinese companies in Ethiopia. The study result implies that collaboration on green economic development is critically needed in the region, not only for its vital role in realizing the region's clean energy development goals but also for its considerable role in environmental conservation. Typically, given the annual fuel wood consumption in Ethiopia of 105,172,465 tons, it is expected to be produced from 359,662.35 ha of *Eucalyptus globulus* plantation forest established at 1.5x1.5m spacing and harvested within seven years of its establishment. The estimated total amount of fuel wood produced per ha of this plantation forest is 292.42 tons, with an estimated energy production of 1,105.35 MW. Considering the contribution of the Adama wind energy project, which can generate 62.22 MW of energy per hour, it is anticipated to save about 16.46 tons of fuel wood per hour, which is estimated to be 144,189.6 tons per year, and that is expected to be grown on 493 ha of land. Tropical pine and eucalyptus tree plantations can store an average of 10 tons of carbon per year (Myers and Goreau, 1991). In this case, per 493 ha of forest, about 4,930 tons of carbon is sequestered annually. It showed that the cooperation has significant importance in contributing to the region's green economy development by providing clean energy as well as carbon sequestration, and also plays its own role in contributing to environmental conservation by saving forests from being degraded through fuel wood consumption. In addition, it contributes to technology transfer to Ethiopians who have participated in the project work. Despite the role it has both in the environment and technology transfer, cooperation in green economy development is quite limited. As a result, significant legislative initiatives aimed at fostering cooperation in the development of the green economy are still required to realize clean energy advancements that use a variety of alternative energy sources as well as for technology transfer advocates. Even if Ethiopia established defined implementation roadmaps and clear and realistic policy targets for the growth of the green economy, China's policymakers should invest in the sector's capacity building. This aids Ethiopia in creating projects for a sustainable green economy that are in accordance with government policies.

Finally, the study attempted to consider the linkage of investment cooperation with green economy development and its contribution to clean energy infrastructure as well as technology transfer. It provides results that can easily be integrated with future studies and also serve as policy input that aimed at getting cooperation with counterparts in areas of green economy development that have an indispensable environmental as well as technological impact.

Acknowledgements. This paper has been financially supported by Science and Technology Program of Hunan Provincial (Fund No. 2022WZ1043).

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