Academic Journal of Management and Social Sciences
ISSN: 2958-4396 | Vol. 8, No. 1, 2024

Carbon Emission Management under China-Africa Supply Chain Co-operation in Logistics

Canni Lin *

College of Nature Science, Trinity College Dublin, Dublin, Ireland
*** Corresponding author**: Canni Lin

Abstract: This study examines carbon emission management strategies in China-Africa supply chain cooperation, with a particular focus on logistics under the Belt and Road Initiative (BRI). Given the increasing carbon emissions from logistics in both regions, effective management is crucial for sustainable development. The study highlights the need to integrate low-carbon technologies, renewable energy deployment and green logistics practices. It also discusses the economic, political and technical challenges of implementing these measures. Recommendations include the improvement of policies and regulations, the enhancement of technology transfer and the promotion of stakeholder partnerships. Successful case studies, such as the Mombasa-Nairobi Standard Gauge Railway, demonstrate the potential of sustainable infrastructure projects. The study concludes that strategic alignment, policy strengthening and collaborative efforts are essential to achieve low-carbon logistics and support long-term China-Africa cooperation.

Keywords: Carbon Emission; Supply Chain; Logistics; Sustainability.

1. Introduction

China-Africa supply chain collaboration is developing sustainably, especially with introducing the Belt and Road Initiative (BRI). Initiated in 2013, the BRI is aimed at enhancing connectivity and fostering economic collaboration among China and the countries involved, which also include African countries [1]. On the other hand, BRI also brings up issues related to carbon emissions and environmental sustainability. Carbon emission regulation is one of the principal issues that must be addressed in international cooperation, with the rising number of people suffering from the fear over the consequences of climate change. As one of the most important sectors of economic activities and emission reduction, logistics is crucial for efficient carbon emissions management in the collaborations between China and African supply chains supporting sustainability.

2. Emissions Status in China-Africa Supply Chain Cooperation

Logistic and transport systems in Africa play the main role in trade facilitation and economic growth. Nonetheless, these systems are important carbon emitters. By the data obtained from the International Energy Agency [2], presented by Table 1, the emissions of CO2 from transport in Africa were 328 million tonnes in 2015 and 375 million tonnes in 2020, and they are expected to reach 533 million tonnes by 2030. This continuous trend emphasizes the growing environmental influence of transport and logistics sector in Africa. On the other hand, China, being a major player in the Sino-Africa supply chain collaboration, however, also portrays a worsening carbon footprint in its transport sector. During 2015 – 2020, emissions rose from 1023 million tonnes to 1187 million tonnes, while by 2030, it is expected to reach 1305 million tonnes. This growth path is steep and offers formidable environmental sustainability challenges especially in the context of the Belt and Road Initiative.

Table 1. CO2 emissions from transport in Africa and China (million tonnes)

Region	2015	2020	2030 (projected)
Africa	328	375	533
China	1023	1187	1305

The Belt and Road Initiative has positively impacted African logistics and transport infrastructure. Developing several infrastructure projects in China, such as roads, railways, and ports, has improved connectivity and trade. For instance, the Mombasa-Nairobi Standard Gauge Railway in Kenya has been financed and constructed by China and reduced the timeframe of travel and costs and has increased the cargo capacity [3]. Still, the effect of the BRI on the carbon footprint of the logistics branch in Africa is highly ambiguous. While the improved infrastructure has the potential to reduce transport and emissions per unit transported, it also induces higher trade volumes and hence, total carbon emissions. Knowledge on carbon emissions in the supply cooperation China-Africa, which is mainly in logistics section, is limited. Another research conducted by [4] specifically examined the carbon footprint of the South African logistics sector and found that road transport was the major contributor, followed by rail and air transport.

3. Management of Carbon Emission

Several aspects are to be considered in the management of carbon emissions in the Chinese-African supply chain cooperation. Economic factors contribute to success or failure of carbon emission management. The price of low-carbon technologies and the availability of funds are significant in the implementation of sustainable practices in the logistic operations. However, increased demand for environmentally friendly products and services may stimulate companies to reduce their carbon footprint and gain a competitive advantage. On the other hand, the high upfront costs of some low-carbon technologies for example, electric vehicles or renewable energy systems, may discourage companies from investing in such technologies. Carbon emission management

in China-Africa supply chain cooperation is also influenced by political drivers, including policies, legislation, and international treaties. Carbon taxes and emissions trading schemes are some of the carbon pricing mechanisms that governments introduce so that companies reduce their emissions [5]. Besides, international treaties such as the Paris Agreement that force countries to create and execute low-carbon development policies. Nevertheless, factors such as weak enforcement of environmental regulations and limited political factors will act as a hindrance to success in the management of carbon emissions. Technical aspects, which cover the supply of green technologies and their utilization, are significant in successfully reducing carbon emissions in logistics activities. The progress in electric cars, renewable energy systems, and sustainable technologies will help the transport sector decarbonize [6]. Still, adopting these technologies in Africa is slow due to limitations in finance and technical know-how; thus, they are underutilized in reducing carbon emissions. Renewable energy is critical in handling carbon emission in logistical operations. According to [7], as presented in Table 2, China has higher shares of the use of solar, wind, and biofuels than Africa. This highlights an opportunity of penetration of renewable energy in African logistics in the context of carbon emission management. Interactivity and educational methods with all parties, including consumers, are the best practices to initiate the demand for low-carbon logistics services. Logistics networks and energy systems are among the infrastructure dimensions that impact the carbon footprint of supply chain operations. Effective logistics will include both the port and the connecting logistics system, which will reduce carbon emissions [8]. However, Africa's infrastructure deficit in transport and energy, in particular, could limit the option for low-carbon logistics. The problem would be solved by investing in the development and upgrade of infrastructure paying particular attention to sustainability.

Table 2. Adoption of renewable energy in logistics in Africa and China

Region	Solar (%)	Wind (%)	Biofuels (%)
Africa	2.1	0.8	1.2
China	5.6	3.2	2.7

4. Carbon Emission Management Techniques

To address the carbon industrialization problems in the China-Africa supply chain cooperation, especially in the logistics part, a number of strategies are utilized. Strategies also involve green logistics management (GLM) practices, sustainable transport and fuel efficiency, renewable energy adoption, supply chain optimization and collaboration, carbon offsetting, and emissions trading schemes. The GLM practices include the optimization of transit routes, consolidation of shipments, and the use of green packaging materials [8]. Table 3 provides data from McKinnont to show possible CO2 emission savings that can be made through various green logistics practices [9]. Consequently, this implies that many environmentally friendly approaches such as collaborative logistics and eco-driving have a more pronounced anti-pollution effect than any other tactics with route optimization and low carbon packaging coming second.

Table 3. Potential CO2 emission reductions from green logistics practices

Practice	Potential reduction (%)
Route optimization	5-10
Eco-driving	5-15
Collaborative logistics	10-30
Low-carbon packaging	2-5

In addition, incorporating principles of circular economy like reverse logistics and waste minimization can also contribute to lowering the carbon footprint caused by transport activities. Carbon emission control measures in logistics sector are largely characterized by long-term transportation and fuel efficiency. Some examples include adopting greener vehicles such as electric or hybrid trucks as well as improving on fuel efficiency in the current fleet through regular maintenance and driver training programs [6]. Further, carbon emissions will also be greatly reduced with the adoption of renewable energy by logistics operations. It includes warehouse roofs fitted with solar panels, logistics hubs equipped with wind turbines, and material handling equipment powered by electricity or hydrogen. Supply chain optimization and collaboration are some of the major factors contributing to reducing carbon emissions relevant to China-Africa supply chain cooperation. This includes simplifying logistical procedures, minimizing wastage and encouraging unity between supply chain partners in pursuit of shared sustainability objectives [10]. Such an implementation, collaboration planning, forecasting and replenishment (CPFR) system align the supply and demand, cut inventory levels and the need to run into emergency shipments and, therefore, cut carbon emissions. Moreover, developing long-term relationships with suppliers and logistics service providers that support sustainability help promote low-carbon practices across the supply chain.

Carbon offsetting and emissions trading schemes are market-oriented mechanisms which encourage companies to lower their carbon emissions. Carbon offsetting is an act of the investment in projects that remove or avoid greenhouse gas emissions like, reforestation or renewable energy development, to absorb the emissions produced by the operations of a company [11]. One of the ways of putting the limit on the total quantity of emissions is represented by emissions trading schemes, for instance systems of cap-and-trade, that allow trading emissions allowances amongst companies. Successful mechanisms of carbon emission management in China-Africa cooperation demonstrate examples and best practices of efficient strategies. Mombasa-Nairobi Standard Gauge Railway in Kenya as an example, built by a Chinese company, included sustainability aspects such as energy-saving locomotives, and solar powered stations to minimize its carbon emission [3]. The Sino-African Cooperation on Low-Carbon Development also falls on the list of such programs, which the Chinese government started to foster the exchange and technology transfer of renewable energy and energy efficiency, amongst others [12].

5. Optimization of the Cooperation Between China and Africa in Low-Carbon Supply Chain Development

The trend of mass data in power system provides a basis for load characteristic analysis and prediction model establishment, but the classical load forecasting method can

not afford such a huge time and computing resource consumption. The problem of over fitting in large sample set will affect the prediction accuracy. In this paper, a power load forecasting model is built by using the BP neural network model, making full use of the powerful data processing function of Clementine and preventing the over fitting function. The experimental results show that the BP neural network model has good predictability and robustness, and has a certain practical application value.

Firstly, supply chain strategies alignment with global climate change mitigation goals is a critical driver of low-carbon development in China-Africa cooperation. This involves setting and maintaining achievable but challenging reduction targets, integrating sustainability into supply chain decision-making, and taking a long-term perspective on the environmental effect of logistics that include aligning supply chain strategies with global climate change mitigation goals which are a key in driving low carbon logistics [13]. The first step is to request business companies to set science-based targets. It implies that they would synchronize their emissions reduction goals with the objectives of the Paris Agreement in order to limit the global warming to well below 2°C above pre-industrial levels .Table 4 reveals how China has been investing in renewable energy projects across Africa. These ventures have increased steadily for example in the solar, wind and hydro power projects starting from 2015 to 2021 thus showing that China is really committed to supporting low-carbon development initiatives through clean energy infrastructure in Africa [14]. Lastly, improvement of the policies and regulations is needed to create an enabling environment for sustainability within the logistics industry. Furthermore, governments shall also set the standards with respect to the emission for transportation operations and the reporting requirements in order to ensure that the area has a complete picture and is responsible for its operations. Low carbon logistics transition should be directed by government and hence contribute to China-Africa cooperation under the supportive policy and regulation. To support the African countries in low-carbon development, it is crucial to enhance the green logistics technology transfer and capacity building basically to the Chinese practice of low carbon. China has achieved success in electric vehicles, renewable energy, and smart logistics systems, among others, which is sent to the African nations via technology transfer and capacity building programs [15]. This may also encompass establishment of training centers, organization of workshops and seminars and facilitation of the exchange of best practices among Chinese and African logistics experts. By means of enhancing the ability of African states to implement green logistics, China will greatly contribute to the development of the continent and will even more reinforce the foundation for long-term cooperation.

Table 4. China's investments in renewable energy projects in Africa (USD millions)

Year	Solar	Wind	Hydro
2015	1230	680	2150
2018	1950	1120	3420
2021	2780	1670	4530

Sustainable consumption and production patterns bring a positive contribution to reducing the environmental impact of China-Africa supply chain cooperation. This covers the promotion of circular economic ideas, like resource productivity, waste reduction, and life cycle of products, in logistics processes [16]. Organizations should adopt sustainable procurement practices that favor green products and services and enable them to work with suppliers to decrease their products' carbon footprints. Awareness raising, eco-labeling schemes, and development of sustainable business models also facilitate governments in promotion of sustainable consumption and production. Another element is stakeholder partnership and knowledge sharing in fast tracking the transition to low-carbon logistics in China-Africa cooperation. It means collaboration of the governments, businesses, non-governmental organizations, and academic institutions to carry out sustainability initiatives and share knowledge [17]. The creation of China-Africa Low-Carbon Logistics Alliance would support development and cooperation of joint projects and also development of supportive policies. Moreover, development of online information exchange sites as well as arranging international fora will provide for information transfer and will foster a sense of community among stakeholders. Through stakeholder partnerships and knowledge sharing, China and Africa would put their skills and resources together to advocate for low-carbon development in the logistics sector.

6. Opportunities and Challenges for Future Carbon Management

Opportunities and challenges on carbon management in the China-Africa supply chain are the way forward. The trends and innovations in low-carbon logistics are a promise for the decrease of carbon emissions in the China-Africa supply chain cooperation. According to the World Economic Forum, innovations in logistics could afford a great chance to reduce carbon emissions [18]. For instance, electric vehicles, drones, 3D printing, and blockchain are shown in Table 5 as technologies that can significantly reduce CO2 emissions and Electric vehicles have the highest potential impact. Furthermore, the incorporation of modern digital technologies like internet of things and big data analytics into logistics helps to improve its efficiency and transparency. Furthermore, the extended usage of the inverted economics, black circle of logistic and closed cycle of deliveries lead to the decrease of waste and environmental impact of logistic activities [13].

Table 5. Potential carbon emission reductions from emerging technologies in logistics

Technology	Potential reduction (%)
Electric vehicles	30-60
Drones	10-30
3D printing	5-20
Blockchain	2-10

The good performance of current carbon emission management practices under China-African cooperation suggests scalability of these programs for better impact. One of such infrastructure being the Mombasa-Nairobi Standard Gauge Railway located in Kenya that embodied a number of sustainability elements that could be emulated by other infrastructure projects across Africa [3]. However, the Sino-African Cooperation on Low-Carbon Development platform is proposed to be enlarged to involve more countries and sectors, enhancing the sharing of information and best practices as well [12]. This transition, which is a key

component of global climate change mitigation efforts, requires the identification and expansion of successful practices in China and Africa, but there are also challenges to implementing carbon emission management strategies in China-Africa supply chain cooperation. The infrastructure and technical capacity deficit in most African countries is a big challenge which slow down the adoption of low-carbon technologies and practices [15]. Moreover, high initial investments in establishing sustainable logistics systems, for example, electric vehicles or renewable energy systems, are a major obstacle for the companies, especially small and medium-sized enterprises (SMEs). Further, lack of standardized policies and as well as regulations across the different countries may make people suffer complexities and uncertainties where they are operating in the China-Africa logistics sector [8].

The challenges and the possible future management of carbon are overcomed using a number of recommendations. First, the investment of money in low carbon infrastructure and capacity building projects could eliminate the difference in technical know ledge and resources to Africa. The second aspect is about motivation, and the supportive practices including green finance and carbon pricing as well as other incentives have the ability to favor the usage of sustainable logistics practices, specifically by SMEs. Third, policy dialogue and coordination between the African and Chinese governments may also create more stable and positive regulatory environment for low-carbon logistics [17]. Future research directions and knowledge gaps should be addressed in this realm for the purpose of policy making support and business strategies support. For instance, more detailed investigation aimed at quantifying the carbon footprint of different logistics activities and evaluating the effectiveness of various emission reduction measures in the case of China-Africa needs to be carried out. Further, research on social and economic co-benefits of low carbon logistics such as employment opportunities and improved health of the public would strengthen the case for sustainable development in this sector. Lastly, exploration of new business models and financing schemes of low-carbon logistics provide a model for entrepreneurs and investors who would like to invest in this field.

In conclusion, sustainable supply chain development, including effective carbon emissions management, is vital for promoting sustainable development and eliminating climate change. China and Africa should work together on the development of a low-carbon and resilient logistics industry in case of strategic alignment, policy reinvention, technology transfer stimulation, incentives for sustainable practices, and partnerships. It is necessary to act immediately and combine efforts of all stakeholders to leverage opportunities and eliminate the challenges of sustainable supply chain development.

References

[1] Wang, Y. (2016). Offensive for defensive: the belt and road initiative and China's new grand strategy. The Pacific Review, 29(3), 455-463.

[2] International Energy Agency. (2021). CO2 emissions from transport in Africa and China, 2015-2030. Retrieved on (4THApril 2024) from https://www.iea.org/data-and-statistics/ charts/transport-sector-co2-emissions-by-mode-in-the-sustainable-development-scenario-2000-2030.

[3] Wissenbach, U., & Wang, Y. (2017). African politics meets Chinese engineers: The Chinese-built standard gauge railway project in Kenya and East Africa (No. 2017/13). Working Paper.

[4] Havenga, J. H., & Simpson, Z. P. (2018). Freight logistics' contribution to sustainability: Systemic measurement facilitates behavioural change. Transportation Research Part D: Transport and Environment, 58, 320-331.

[5] Price, R. A. (2020). Lessons learned from carbon pricing in developing countries. Institute of Development Studies, K4D Helpdesk Report, 799.

[6] Fischedick, M., Roy, J., Acquaye, A., Allwood, J., Ceron, J. P., Geng, Y., ... & Tanaka, K. (2014). Industry In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Technical Report.

[7] RENA. (2020). Renewable energy adoption in logistics in Africa and China. Retrieved on (4THApril 2024) from https://africanclimatefoundation.org/wp-content/ uploads/ 2021/ 11/800539-ACF-NRDC-Report.pdf.

[8] Zhang, Q., Geerlings, H., El Makhloufi, A., & Chen, S. (2018). Who governs and what is governed in port governance: A review study. Transport Policy, 64, 51-60.

[9] McKinnon, A. (2018). Decarbonizing logistics: Distributing goods in a low carbon world. Kogan Page Publishers.

[10] Ramanathan, U., & Gunasekaran, A. (2014). Supply chain collaboration: Impact of success in long-term partnerships. International Journal of Production Economics, 147, 252-259.

[11] Hall, C. M., Gössling, S., & Scott, D. (Eds.). (2015). The Routledge handbook of tourism and sustainability (Vol. 922). Abingdon: Routledge.

[12] China Daily. (2022). Sino-African Cooperation on Low-Carbon Development. Retrieved on (4THApril 2024) from http://global.chinadaily.com.cn/a/202211/14/WS63717be8a310491754329671.html.

[13] Govindan, K., Soleimani, H., & Kannan, D. (2015). Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. European journal of operational research, 240(3), 603-626.

[14] American Enterprise Institute. (2022). China global investment tracker. Retrieved on (4THApril 2024) from https://www. aei.org/china-global-investment-tracker/.

[15] Shen, W., & Power, M. (2017). Africa and the export of China's clean energy revolution. Third World Quarterly, 38(3), 678-697.

[16] Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm?. Journal of cleaner production, 143, 757-768.

[17] Prataviera, L. B., Creazza, A., & Perotti, S. (2023). A call to action: a stakeholder analysis of green logistics practices. The international journal of logistics management.

[18] World Economic Forum. (2021). The impact of emerging technologies on carbon emissions in logistics. Retrieved on (4THApril 2024) from https://www. weforum.org/agenda/ 2021/12/digital-tracing-industrial-carbon-emissions-decarbonization/.