

Sustainable Transportation Corridors: Integrating Ports, Railways, and Green Logistics in the Horn of Africa

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ABSTRACT: The Horn of Africa is a region of significant geopolitical and economic importance, yet it faces challenges in transport effectiveness, environmental sustainability, and regional connectivity. This study explores sustainable transportation corridors to enhance port operations, railway networks, and green logistics. It focuses on the current development of these corridors in Djibouti, drawing insights from Poland's experiences. By reviewing existing literature and data, the research identifies best practices and offers recommendations for improving sustainability and connectivity. Key challenges include fragmented infrastructure, regulatory inconsistencies, and underutilized renewable energy sources. The findings suggest that enhancing intermodal transport connections and adopting green logistics can lower transportation costs and improve environmental performance. The study stresses the importance of coordinated policymaking, infrastructure investment, and green technology adoption to support sustainable development and align with Sustainable Development Goals (SDGs).

1 INTRODUCTION

The Horn of Africa continues to face major transportation challenges fragmented infrastructure, limited cross-border coordination, and underdeveloped logistics systems. As trade grows and climate pressures intensify, countries in the region are being pushed to rethink how freight moves. Ports like Djibouti, Berbera, and Massawa act as trade gateways, yet moving goods inland remains slow, expensive, and carbon-heavy. At the same time, the African Continental Free Trade Area is reshaping regional commerce. With rising populations and fast urbanization, there's an urgent need for better internal connectivity. Inland transport is still dominated by roads about 75% of freight moves this way, which drives up costs and delays. Weak rail links, different track gauges, and a lack of modern inland terminals only compound the problem. Landlocked economies

pay the price in competitiveness and access [1]. In contrast, Poland offers illustrative examples of successful integration between ports and inland transport systems, emphasizing sustainable practices [2]. The Port of Gdańsk, for instance, has significantly enhanced its rail connectivity, enabling efficient cargo movement and reducing reliance on road transport. Investments in electrified rail lines and the implementation of the European Rail Traffic Management System (ERTMS) have streamlined operations and minimized environmental impact. Poland's strategic development of intermodal transport corridors showcases the benefits of integrating rail and maritime logistics [3]. The modernization of Gdynia port's rail infrastructure has boosted capacity and efficiency for cargo transfers between sea and land. The new intermodal terminals, like the one in Wrocław, highlight Poland's commitment to improving inland connectivity and

sustainable freight movement. These advancements, backed by strong policies and investments, position Poland as a leader in green logistics in Europe.

In this context, well-designed transportation corridors linking major seaports, rail lines, highways, and inland terminals can cut travel times and costs, boost intraregional trade, and support engineering goals for growth. As an example, the African Development Bank emphasizes that modern corridor infrastructure is crucial for reducing transportation time and costs, boosting intra-African trade, and driving economic growth [4]. At the same time, climate change and energy concerns demand that these corridors adopt low-carbon and green practices. Current challenges include incomplete rail links, varying track gauges, and limited inland terminals. In many cases, transport chains still rely mainly on roads, 75% of freight moves by road in the Horn of Africa corridors, which raises costs and delays. Without such integration, landlocked producers face especially high logistics costs and reduced competitiveness. For example, a recent study noted that many African economies lag because they have not connected efficiently to the arteries of international trade roads, rails, sea and airports [5].

Transport is a major source of greenhouse gases, and the Horn of Africa's increasing freight demand could exacerbate emissions if not addressed properly. Implementing cleaner technologies, such as electric locomotives, biofuels, and shore power for ships, can significantly reduce fuel consumption. Ports in the region are beginning to adopt these measures; for instance, the Port of Mombasa has introduced a green port policy with shore-power connections for vessels and energy-efficient equipment. With 90% of its electricity from renewable sources, Kenya has the potential to produce green hydrogen and support sustainable shipping corridors throughout the Horn of Africa [6]. International experts suggest that the Horn of Africa could utilize its renewable resources to establish green shipping corridors connecting ports and industrial hubs with zero-emission fuels. However, challenges such as inadequate infrastructure and high upfront costs hinder green logistics. In regions with better infrastructure, efficient corridors, like high-speed electric rail, can significantly lower per-ton emissions by shifting freight from road to rail. This research will explore how policy, financing, and technology can be integrated into corridor planning to reduce environmental impacts and increase throughput [7]. Sustainable corridors in the Horn of Africa play a vital role in addressing societal goals such as poverty reduction, industrialization, and regional stability. By improving transport infrastructure, they enhance connectivity, lower goods prices, improve market access for rural communities, and create jobs in logistics and manufacturing. The East African Community aims to leverage modern corridors for efficient natural resource exports. Additionally, climate-smart projects enhance resilience to weather shocks and reduce pollution. Building these corridors presents engineering challenges, including structural design, materials science, and maintenance planning, while also requiring collaboration among governments, the private sector, and international donors like the World Bank and Afdb [4].



Figure 1. Green logistics dimensions [8]

Green logistics incorporates environmental and social objectives into transport planning. It involves powering corridors with clean energy, minimizing waste and emissions, and enhancing resilience. A green corridor may utilize renewable energy to operate electric trains and port cranes, promote efficient supply chain practices, and optimize transportation routes [9]. These concepts are gaining momentum in the Horn of Africa, where concerns about carbon emissions, air quality, and land use are becoming increasingly significant. While international organizations and national governments have initiated pilot programs, there is still a need for comprehensive strategies. In summary, this study situates Horn of Africa's emerging transportation corridors at the intersection of infrastructure engineering, logistics innovation, and environmental sustainability. By reviewing recent projects such as Kenya's SGR, Djibouti and Berbera Corridor expansion, port modernization programs and identifying engineering solutions, the research will demonstrate how integrated corridor design incorporating ports, rail links, and green logistics technologies can accelerate economic development and reduce carbon intensity in the region. Well-integrated, low-carbon corridors have the potential to transform regional trade and advance the continent's sustainable development aspirations.

Drawing parallels between Poland's experiences and the Horn of Africa's context reveals actionable insights. The emphasis on electrified rail systems and intermodal terminals in Poland underscores the importance of multimodal transport solutions in reducing carbon emissions and improving efficiency. Adopting similar strategies tailored to regional specificities for the Horn of Africa could address current logistical bottlenecks and environmental concerns. Investments in renewable energy sources, such as geothermal and solar power, could support the electrification of transport corridors. Moreover, the development of policy frameworks that encourage public-private partnerships and international cooperation would be instrumental in replicating Poland's successes.

1.1 Research Objectives

This research aims to examine the development of sustainable transportation corridors in the Horn of Africa through a comprehensive review of existing literature and secondary data. It focuses on how ports and railways can be effectively integrated with green logistics strategies to improve performance. A central case study is the Djibouti corridor, including the Port

of Djibouti and the Addis Ababa–Djibouti railway, as a pivotal regional link.

Key objectives include:

1. assessing the current state of transportation corridors and trade flows in the Horn of Africa, especially Ethio-Djibouti's port-rail connectivity and comparing it with that of Poland;
2. analysing environmental impacts of the logistics systems and identifying green initiatives or gaps;
3. reviewing national and regional strategies that seek to promote sustainability and multimodal integration; and
4. identifying challenges and opportunities for enhancing regional cooperation and sustainable development through these corridors.

2 LITERATURE REVIEWS

Recent research on sustainable transport corridors in Horn of Africa highlights the critical role of integrated port–rail networks, intermodal hubs, and green logistics practices in enhancing trade efficiency, reducing carbon emissions, and promoting regional economic development. Simulation-based and optimization models have quantified the benefits of seamless port–rail connectivity [10], while stakeholder-driven analyses emphasize institutional coordination across the Northern, Central, and LAPSET corridors. Research shows that well-integrated corridors can significantly reduce transport costs and times for landlocked countries. Strategic planning and investment in all modes of seaport terminals, rail lines, highways and hinterland logistics are needed to realize these gains. For instance, researchers at the Infrastructure Transitions Research Consortium mapped Tanzania's road, rail, port and air networks to model freight flows, finding that coordinated upgrades could greatly reduce vulnerability to disruption. Multi-stakeholder workshops in Ethiopia have mapped intermodal challenges and proposed targeted strategies to facilitate export-led growth [11]. Meta reviews underscore the broader socioeconomic impacts and potential trade-offs of corridor investments in Sub-Saharan Africa [12], while recent studies explore digitalization and value chain frameworks under the AfCFTA [13], [14]. Emerging GIS-based site selection tools and DEA efficiency analyses further support corridor planning for landlocked economies. Together, these studies form a comprehensive evidence base guiding policy and investment toward greener, more integrated transport corridors in the Horn of Africa.

East Africa's transport corridors, especially the Northern Corridor (linking Mombasa to Uganda, Rwanda, Burundi, and eastern DRC) and the Central Corridor (via Dar es Salaam), are crucial for connecting landlocked economies to global markets. These corridors integrate roads, railways, ports, and inland waterways into multimodal networks but often face bottlenecks, such as congestion at Northern Corridor ports and delays on road links [13]. Effective corridors rely on the seamless interconnection of ports, railways, and roads, incorporating elements like inland container depots and efficient customs facilities. The Northern Corridor integrates rail, highways, and navigable routes to link Rwanda, Burundi, and

Uganda with the Kenyan coast, while the Central Corridor uses road and rail to connect to Dar es Salaam port. However, research highlights gaps, with the UNCTAD framework urging East African planners to incorporate sustainability principles in early corridor development stages. Coordination is crucial; failures in one transport mode can disrupt entire routes, as demonstrated by a Tanzanian case study estimating that severe road flooding could cost over USD 1.4 million per day. In contrast, integrated planning can prioritize essential investments, as shown by Hanaoka et al., who used simulation models to demonstrate that balanced infrastructure investments and organizational reforms maximize benefits for all countries involved.



Figure 2. The three main transport corridors in the Horn of Africa [15]

A corridor starts with a transport link connecting defined end-points, typically a port at one end and an economic centre at the other. In the Horn, the Port of Djibouti and the Port of Berbera serve as gateways to landlocked Ethiopia, South Sudan and parts of Uganda [16]. Ports handle container and bulk cargo, but can become bottlenecks without reliable connections. Railways and roads extend inland, each with unique requirements for infrastructure and management. Planners must address both physical systems and customs procedures to ensure efficient freight movement. When elements align, transportation becomes more predictable and cost-effective, benefiting communities with better access to jobs and services.

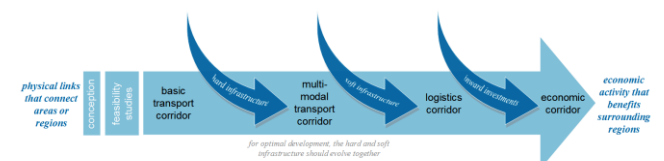


Figure 3. Evolution of a transport corridor [7]

Sustainability in corridors emphasizes low-carbon, energy-efficient logistics. Green corridors, as defined by UNCTAD, use clean energy and climate-resilient

infrastructure, primarily shifting from trucks to rail to lower CO₂ emissions. Electrified rail in Africa can notably cut emissions compared to truck transport. Logistics providers are optimizing routes and investing in cleaner vehicles, while ports and warehouses adopt renewable energy and cold-ironing. Integrating these practices supports climate and efficiency goals alongside economic growth. Modern corridors leverage information technology for better coordination and transparency. East African ports are implementing digital platforms to enhance efficiency and reduce costs. Successful corridor performance requires collaboration among public agencies, private businesses, and communities, with public-private partnerships essential for infrastructure funding and regional cooperation supported by organizations like UNCTAD. Engaging local stakeholders is crucial for greening corridors and improving cross-border coordination for regional benefits.

Well-functioning transport corridors can lower costs and improve access, aiding farmers and driving industrial growth. Sustainable transport frameworks emphasize affordability and accessibility, particularly for rural areas. Improved corridors have boosted exports of agricultural products and minerals while reducing food prices. However, poorly planned projects can harm local communities and ecosystems, and insufficient community engagement can worsen inequalities. There's often a disconnect between investors and governments, leading to negative consequences like deforestation. Studies highlight efficiency challenges, such as delays at border crossings. A simulation in East Africa showed that optimal investments can significantly enhance regional outcomes. Tanzania's multi-modal model also indicates that extreme flooding could result in daily losses over USD 2 million without adaptive measures. Therefore, efficiency metrics should include resilience, and continuous monitoring is crucial for transport system improvements.

Research Gaps and Future Directions. Although existing research highlights the role of transport infrastructure in regional development, it rarely addresses how integrated corridors can harmonise economic and environmental goals. This gap limits policymakers and stakeholders seeking actionable strategies for scalable, low-carbon transitions.

The key areas needing more research include:

- Integrated planning: Horn of Africa studies stress that sustainability and environmental criteria should be “integrated at early stages” of corridor design [17], but practical frameworks for doing so are still underdeveloped.
- Capacity and financing: Resource constraints limit the implementation of sustainable strategies. Inadequate institutional capacity and funding for maintenance or new technology hinder progress.
- Impact assessment: Many corridor projects lack comprehensive social and ecological assessments [18]. Research is needed on best practices for inclusive stakeholder engagement and impact mitigation.
- Digital infrastructure: While digitalization is promising, uneven ICT adoption leaves gaps. Studies suggest more analysis of how to bridge policy and technical barriers to port and customs digital platforms.

- Performance metrics: There is a need for standardized metrics that capture economic, social and environmental performance together. Existing work (e.g. network modelling) provides a start, but further data-driven evaluations are required.

In summary, existing research clearly shows that effective East and Horn of Africa corridors must knit together infrastructure, green technology, digital systems, and inclusive institutions. Studies consistently show that such integration can deliver economic and social benefits without sacrificing environmental goals. Achieving this vision will require sustained collaboration among countries, informed by ongoing research into corridor best practices and outcomes.

3 RESEARCH OBJECTIVE AND SCOPE

This study examines the development of sustainable transportation corridors in the Horn of Africa, with an emphasis on integrating seaports, railways, and logistics practices. The research evaluates recent project outcomes, identifies persistent challenges, and assesses strategies for incorporating green logistics into regional planning. The primary geographic focus covers Djibouti, Eritrea, Ethiopia, and Somalia, with reference to the Poland corridor. The analysis spans the period from 2015 to 2025, concentrating on significant infrastructure developments within this timeframe. Key topics include seaports and dry ports, railway systems such as the Ethiopia–Djibouti line, and freight logistics involving road networks and cargo handling operations. Air transport and inland shipping are not considered. The research assumes a stable security and political context as of 2025. The focus remains on freight transport, with particular attention to policy coordination, infrastructure investment, and the adoption of green technologies. The objective is to support practices that lower carbon emissions, strengthen resilience to climate change, and advance the development of a collaborative and sustainable transport system in the Horn of Africa, following the example of Polish corridor.

4 METHODOLOGY

This study employed a combination of literature review, case analysis, and quantitative assessment to investigate sustainable transportation corridors in the Horn of Africa. Recent academic publications, government and development agency reports, and media sources were examined to gather data on transport projects, with attention to port throughput, railway capacity, transport costs, and energy use. Key sources included documents from the African Development Bank, World Bank, and authorities in Ethiopia, Djibouti, and Somalia, as well as articles addressing green logistics and corridor planning [9]. Case studies focused on the Ethiopia–Djibouti corridor (including the Addis Ababa–Djibouti Railway and Doraleh Port), and the Polish corridor. Each case was documented in terms of current and planned infrastructure, governance arrangements, and environmental measures. Data collection centered on freight volumes, travel times, fuel consumption, and

transport costs. Ethiopia's freight flow through Djibouti was recorded at approximately 25 million tonnes per year. Port expansion figures, such as Doraleh's increase from 6 million to 14 million tonnes annually, were documented. Comparative emissions data were used to estimate potential CO₂ reductions, with electric rail operations emitting about 60 gCO₂ per ton-kilometer, compared to 120–150 gCO₂ per ton-kilometer for diesel trucks. Policy statements and technical briefings from regional organizations, including IGAD and COMESA, as well as insights from logistics professionals, informed the analysis. Reports from the Djibouti Ports Authority and Ethiopian Railway Corporation detailed governance arrangements, noting that the Ethio-Djibouti Railway is 75% Ethiopian-owned and 25% Djiboutian, with full management to transfer to Ethiopia by 2024 [17]. Information on green logistics initiatives, such as port solar energy projects, was collected from regional authorities and non-governmental organizations.

4.1 Case Study 1: Djibouti–Ethiopia Corridor in the Horn of Africa

The transport corridor from Addis Ababa, Ethiopia, to Djibouti City is vital for Ethiopian trade, handling about 95% of its imports and exports through Djibouti's port. The old railway system became outdated in the early 2000s, prompting a shift to road transport, which caused delays. To address this, Ethiopia and Djibouti, with Chinese aid, launched the Addis Ababa–Djibouti Railway (AADR) in 2018, enhancing connectivity over 752 km. The railway, along with increased port capacity in Djibouti, facilitates efficient container transfers and reduces double handling. The Modjo Dry Port in Ethiopia acts as a key rail-connected hub, improving customs and storage efficiency. The corridor is co-owned by the Ethio-Djibouti Railway Share Company, ensuring synchronized operations and capacity planning. After an initial phase led by a Chinese contractor, operations transferred to the bi-national company by the end of 2023, with ongoing technical support, creating a cohesive logistics system for both nations.



Figure 4. Djibouti–Ethiopia Corridor in the Horn of Africa [19]

The Djibouti–Ethiopia corridor case study highlights a rapidly modernizing transport route that has improved logistics through port-rail integration and introduced greener transport methods. Early challenges, such as power issues and underutilization, are being tackled with operational adjustments and

planned expansions. Strong bilateral cooperation supports the corridor's success, making it a model for landlocked developing countries seeking sustainable access to trade. Focusing on institutional cooperation and increasing rail use for various cargo types will further enhance its role in regional development.

4.2 Case Study 2: Poland's Sustainable Transport Corridors

Poland is strategically located in Central Europe, serving as a bridge between Western and Eastern Europe. Key transport corridors include the Baltic–Adriatic Corridor, connecting Gdańsk and Gdynia with Warsaw and the Adriatic Sea, and the North Sea–Baltic Corridor, linking Polish ports to Germany. Poland is essential for China–Europe rail freight, with Małaszewicze as a key entry point from Belarus. The transport sector contributes 5–6% to GDP, and Polish companies manage about one-third of EU international road freight. In 2021, Poland's main seaports processed around 97 million tonnes of cargo, with Gdańsk being the Baltic Sea's largest container port, necessitating strong road and rail connections.

In Poland, recent infrastructure investments have focused on improving port-rail integration, addressing past weaknesses in connections to ports. The modernization of railway line 201, linking the hinterland to the Port of Gdynia, involves adding a second track and electrification, supported by a €480 million European Investment Bank loan in 2024. This upgrade will improve speed and capacity, reducing reliance on trucks for cargo transport. Similar upgrades are planned for Gdańsk and the Szczecin–Świnoujście complex, with all major ports expected to meet core rail standards by 2030. Logistics hubs near Poznań and Łódź are enhancing container handling between trucks and trains, while new intermodal terminals along the Polish–Ukrainian border are in development. Despite challenges like capacity limitations and a strong trucking sector, Poland is taking strategic actions to modernize and integrate its transport corridors while pursuing sustainability goals. These efforts aim to secure Poland's role as a key logistics hub in Central Europe amidst rising freight demand.

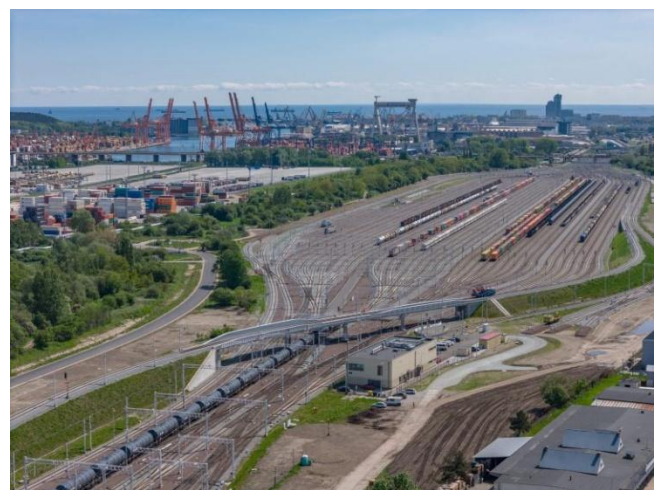


Figure 5. Polish Port of Gdynia, Image: © Budimex

5 RESULTS AND DISCUSSIONS

The Horn of Africa's transport network currently consists of several parallel systems. The primary corridor is Djibouti–Ethiopia. Addis Ababa (Ethiopia's capital) is ~750 km from the Port of Doraleh in Djibouti. In 2018, a new electrified standard-gauge railway opened along this route. It replaced a dilapidated metre-gauge line. The railway's travel time from Addis to Djibouti City is about 12 hours (at 120 km/h design speed), versus roughly three days by heavy truck. This corridor handles the vast majority of Ethiopia's foreign trade: about 95% of its imports and exports use Djibouti's ports, and Ethiopia provides ~70% of the port of Djibouti's throughput.

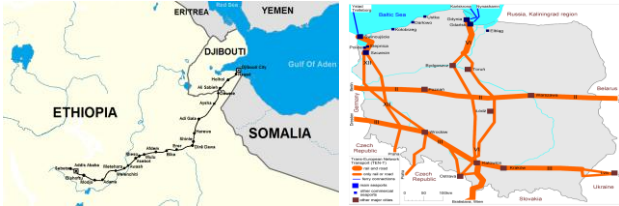


Figure 6. Ethiopia-Djibouti railway and Polish railways [2], [20]

The Horn of Africa features key transport corridors like the Berbera Corridor, which connects Berbera Port (Somaliland) and is being expanded with DP World's involvement to accommodate 300,000–400,000 TEU. It links Berbera to Ethiopia's Somaliland region, avoiding Eritrea. A proposed rail link to Ethiopia is still in the planning stages. Another crucial route is the Mogadishu–Ethiopia corridor, allowing freight movement from Ethiopia to Mogadishu by road, although security and quality concerns affect its utility. Major rehabilitation of Mogadishu Port began in 2017, yet cargo volumes remain below those at Djibouti. Eritrea's ports (Massawa, Assab) are connected via a narrow-gauge railway to Asmara but lack operational links to Ethiopia or Somalia. Access through Assab was cut off during the Eritrea–Ethiopia conflict (1998–2018), and while there are discussions to revive connections since the peace agreement in 2018, no significant projects have been initiated yet.

5.1 Efficiency Gains from Port–Rail Integration

Our analysis indicates that integrating ports and rail systems can significantly enhance efficiency. For instance, the new rail line in the Djibouti–Ethiopia corridor has reduced journey times by over 80%, cutting trips from three days by truck to about 12 hours by electric train. Rail freight costs are also much lower, estimated at one-third of road transport expenses per ton. Although the railway can handle nearly 25 million tonnes per year, only 0.7 million tonnes were transported by rail in the first half of 2020 due to logistical issues. Furthermore, the Doraleh port expansion in Djibouti aims to boost capacity from 6 million to 14 million tonnes annually to better accommodate rising rail traffic. Ethiopia's total trade reached about 17 million tonnes in 2020, mainly through Djibouti. Shifting freight from road to rail could significantly reduce carbon emissions, as Ethiopia's electric trains operate on a grid that is 90–95% renewable [21]. Heavy trucks emit about 120 gCO₂ per tonne-km, while electric rail emissions can be

below 30 gCO₂ per tonne-km (IPCC, 2018). Shifting 5 million tonnes per year from trucks to trains on the Addis–Djibouti route could reduce annual CO₂ emissions by 200,000–300,000 tonnes, surpassing a 50% reduction. This transition supports national climate goals and decreases road wear and accidents, particularly in mountainous regions [19].

5.2 Reflections from the case studies

The Ethiopia–Djibouti corridor is a model of integration, characterized by effective governance, connectivity, performance, and cost-effectiveness. Jointly owned by Ethiopia (75%) and Djibouti (25%), it's operated by the Ethiopia–Djibouti Standard Gauge Rail Transport S.C. Training for local operations is set for 2024. The network connects key stations like Addis Ababa and Modjo to the Port of Doraleh, though the railway currently ends a few kilometers from the container terminal. Plans for a spur line to improve cargo transfer are underway. This collaboration highlights the potential for success when ports and rail infrastructure are developed together, although challenges like funding issues and management complexities remain. Effective multimodal logistics planning is crucial, as infrastructure alone is insufficient without addressing bureaucratic and demand-related barriers.

Comparing Poland's experiences with the Horn of Africa offers valuable insights. Poland's focus on electrified rail systems and intermodal terminals highlights the benefits of multimodal transport in reducing carbon emissions and increasing efficiency. Adopting similar, region-specific strategies in the Horn of Africa could help resolve logistical challenges and environmental issues. Investing in renewable energy like geothermal and solar power, could facilitate the electrification of transport corridors. Additionally, creating policies that promote public-private partnerships and international cooperation would be key to replicating Poland's successes.

Both case studies demonstrate the link between sustainability and efficiency in transport corridors. Reducing bottlenecks and improving integration enhance trade economically and environmentally. The Horn of Africa corridor shows how modern infrastructure can support sustainable trade, while Poland highlights the need for continuous improvement and policy support. Developing regions can learn from Djibouti–Ethiopia's success in sustainable infrastructure, while developed areas can draw lessons from Poland's modernization efforts. Successful corridors require strong infrastructure, efficient operations, and supportive policies for global applications.

Table 1. Summary of Djibouti–Ethiopia and Poland corridor comparison

Aspect	Djibouti–Ethiopia Corridor	Poland Corridors
Integration	New electrified rail directly linked to port; inland dry port (Modjo) creates seamless ship–train–truck interface.	Existing infrastructure is being retrofitted for better integration; projects to double-track and electrify port rail links (e.g. Gdynia).
Transit Time	~12–14 hours by rail (Addis to port) vs 3–4 days by road; major improvement in reliability and speed.	Rail freight is relatively slow (~23 km/h avg.); trucking is faster for many routes, though new investments aim to cut rail transit times.
Bottlenecks	Initial: Border delays (addressed by joint operations), power outages are slowing trains. Still underutilization (35% capacity used) due to missing feeder lines.	Port last-mile rail capacity (being upgraded); border crossing constraints at the eastern border; frequent maintenance slowdowns. Truck–road dominance is causing highway congestion.
Freight Volume	~1.7 million tons on rail in 2021/22 (growing ~22% annually); 95% of Ethiopia’s trade flows on the corridor (road + rail).	~82.6 million tons carried by rail for international trade in 2021 vs ~237.9 million by road (for exports/imports). Rail share is relatively low, but absolute volume is large; huge trucking volumes.
Environmental Impact	Electrified rail powered by renewables → ~61k tons CO ₂ saved/yr; thousands of trucks off roads, less local air pollution. Green branding (WFP “going green” aid via rail).	Rail electrification is high (99% core lines), but electricity is largely fossil until the grid is green. Road freight = 25% of transport emissions. Push for modal shift and e-trucks to cut emissions; EU climate policies enforcing change.
Governance	Bi-national railway company (EDR) and bilateral agreements; proposed corridor authority for holistic management. Djibouti Ports & Free Zones Authority coordinates the network corridor forums; port–rail.	National ministries & agencies with EU corridor governance overlay; compliance with EU laws (e.g. TEN-T standards). Coordination through the EU’s core network corridor forums; domestic intermodal strategy since 2019.
Key Best Practices	Joint investment in port and rail capacity to ensure balance. Leapfrogging to electric rail to future-proof environmental performance. Bilateral cooperation (shared ownership) ensures commitment. Use of dry ports to extend reach inland.	Systematic upgrading of legacy infrastructure to meet modern standards (e.g. 740m trains). Leveraging supranational funding and rules (EU) to drive improvements. Emphasis on intermodal solutions (terminals, incentives) to shift freight off roads. Monitoring via KPIs and strategic planning to target bottlenecks.

5.3 Green Logistics Initiatives

In the Horn of Africa, green logistics strategies are gaining traction, particularly through the electrification of rail and vehicles. The Addis–Djibouti

Railway, operating on 25 kV AC, utilizes Ethiopia’s renewable energy, providing a low-carbon transport option. Future projects like the Addis–Mekele line are also planned to be electric. While diesel is still predominant in road transport, some countries are testing CNG buses and electric trucks, reducing fuel imports and air pollution in cities like Addis and Djibouti [22]. Renewable energy is also being integrated at corridor ports, with countries like Djibouti and Berbera installing solar farms to power operations. Estimates suggest these measures could reduce port emissions by 20–30% [23]. In road logistics, stricter fuel economy standards and the importation of newer Euro-4 engines in Ethiopia support fuel efficiency. Discussions are ongoing in Djibouti and Somalia about low-sulphur fuel mandates. Operational efficiency is being enhanced through measures like Djibouti’s Single Window cargo clearance system, which speeds up customs and reduces idle time, thus saving fuel. The Rim initiative aims for digital cargo tracking to streamline operations. Recent port contracts are incorporating environmental clauses, and waste management is becoming part of logistics practices. Although formal Green Corridor agreements haven’t been established yet, the region is moving toward more sustainable logistics solutions.

6 CONCLUSIONS AND FUTURE DIRECTIONS

The Horn of Africa is at a pivotal moment, with the potential to develop sustainable transport corridors that enhance the economy while minimizing environmental impacts. Integrated projects like the Addis Ababa–Djibouti Railway and Berbera Port modernization highlight steps toward better connectivity, though environmental sustainability remains a challenge due to rising emissions. Lessons from Poland’s multimodal transport solutions and green logistics can guide the Horn of Africa in improving trade efficiency and economic development. Success depends on stakeholder alignment, adequate financing, and adaptive planning for climate risks. While Ethiopia’s renewable energy grid and solar power in Djibouti and Somaliland are positive strides, inconsistent road transport practices remain carbon-intensive, especially in Somalia and rural Ethiopia. The comparison between the Horn of Africa and Poland shows that basic principles for corridor development are universal. Strategic infrastructure can catalyze growth, especially when sustainability is prioritized. Future efforts should involve lifecycle analyses of transport projects, explore alternative fuels, and promote cross-border collaborations for harmonized standards and knowledge sharing. By viewing corridors as integrated, living systems, sustainable development can be achieved while preserving the environment.

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REFERENCES

- [1] S. Hanaoka, M. Sota, T. Kawasaki, and R. G. Thompson, "Performance of cross-border corridors in East Africa considering multiple stakeholders," *Transp. Policy*, vol. 81, no. December 2018, pp. 117–126, 2019, doi: 10.1016/j.tranpol.2019.06.003.
- [2] T. Bocheński, T. Palmowski, and T. Studzieniecki, "The development of major seaports in the context of national maritime policy. The case study of Poland," *Sustain.*, vol. 13, no. 22, pp. 1–20, 2021, doi: 10.3390/su132212883.
- [3] I. Jacyna-Golda, N. Shmygol, N. Gavkalova, and M. Salwin, "Sustainable Development of Intermodal Freight Transportation—Through the Integration of Logistics Flows in Ukraine and Poland," *Sustain.*, vol. 16, no. 1, 2024, doi: 10.3390/su16010267.
- [4] "African Development Bank Group Annual Meetings," Abidjan, Côte d'Ivoire, 2025.
- [5] X. W. Che Kingsley Chenikwi, "Possible Sustainability of Intermodal Transportation in Africa," *Open J. Appl. Sci.*, vol. 9, pp. 139–158, 2019, doi: 10.4236/ojapps.2019.94013.
- [6] A. Bulzomi, P. Danssaert, S. Finardi, and K. Matthysen, *Supply Chains and Transport Corridors in East Africa*. 2014.
- [7] A. Hope and J. Cox, "Development Corridors, Coffey International Development," no. December, pp. 1–74, 2015.
- [8] J. P. Rodrigue, *The geography of transport systems*. 2024. doi: 10.4324/9781003343196.
- [9] M. D. Mutie, S. Odock, and K. Litondo, "Green Logistics Practices and Firm Performance: The Mediating Effect of Economic Performance Among Logistics Firms in Kenya," *Eur. Sci. J. ESJ*, vol. 16, no. 25, pp. 142–159, 2020, doi: 10.19044/esj.2020.v16n25p142.
- [10] M. M. Kunambi and H. Zheng, "Optimizing African Port Hinterland Connectivity Using Markov Processes, Max-Flow, and Traffic Flow Models: A Case Study of Dar es Salaam Port," *Appl. Sci.*, vol. 15, no. 4, 2025, doi: 10.3390/app15041966.
- [11] B. Nitsche, "Embracing the potentials of intermodal transport in Ethiopia: Strategies to facilitate export-led growth," *Sustain.*, vol. 13, no. 4, pp. 1–22, 2021, doi: 10.3390/su13042208.
- [12] A. S. M. Abdul Quium, "Transport corridors for wider socio-economic development," *Sustain.*, vol. 11, no. 19, 2019, doi: 10.3390/su11195248.
- [13] D. Kuteyi and H. Winkler, "Logistics Challenges in Sub-Saharan Africa and Opportunities for Digitalization," *Sustain.*, vol. 14, no. 4, 2022, doi: 10.3390/su14042399.
- [14] B. Nitsche, H. K. Mensah, F. Straube, and V. Barigye, "Leveraging the Potential of the African Continental Free Trade Area: Logistics Challenges and Development Paths for Future Value Chains in Africa," *Logistics*, vol. 8, no. 1, 2024, doi: 10.3390/logistics8010025.
- [15] "Africa Intelligence," 2024.
- [16] H. Z. Kine, Z. Shiferaw, G. Gebresenbet, L. Tavasszy, and D. Ljungberg, "GIS based multi-criteria decision-making approach for dry port location analysis: The case of Ethiopia," *Res. Transp. Bus. Manag.*, vol. 60, no. April 2024, p. 101370, 2025, doi: 10.1016/j.rtbm.2025.101370.
- [17] *Economic Development in Africa Report*. 2023.
- [18] D. Juffe Bignoli et al., "Towards more sustainable and inclusive development corridors in Africa," *Environ. Res. Infrastruct. Sustain.*, 2024, doi: 10.1088/2634-4505/ad7887.
- [19] W. Bank, "World Development Report 2019," 2019.
- [20] "Ethiopia-Djibouti Rail Way." [Online]. Available: en.wikipedia.org
- [21] IEA, "World Energy Outlook 2021. International Energy Agency." <https://www.iea.org/reports/world-energy-outlook-2021>, IEA Publ., p. 15, 2023.
- [22] A. Jugović, M. Sirotić, T. P. Jugović, and D. Žgaljić, "Green Shipping Corridors: A Bibliometric Analysis of Policy, Technology, and Stakeholder Collaboration," *Appl. Sci.*, vol. 15, no. 6, 2025, doi: 10.3390/app15063304.
- [23] UNECA, *Africa Sustainable Development Report* 2017. 2018.