

The Key Dimensions of Sustainability in Railways

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Abstract:

This manuscript focuses on the concept of rail transportation sustainability from the United Nations (UN) predefined dimensions: environmental, economic, and social, with an outlook on railways' influence towards achieving the worldwide settled UN sustainability goals. By synthesizing several existing literature and empirical reviews, the study aims to evaluate multiple railway aspects with possible sustainability integration, including Greenhouse Gas emissions, energy efficiency, and ground disturbance. The conclusions underscore, through a multidisciplinary approach, the essential advantages of railways, in reference to lower Carbon Dioxide emissions per passenger-kilometer, economic involvement to a higher Gross Domestic Product and sustainable development, and the social inclusion. Ultimately, this contribution highlights Algeria's potential sustainable urban railway transportation and offers insights for researchers, investors, industry stakeholders, and transport policymakers.

Keywords: Railways; Sustainable development; Transportation; environment.

JEL Classification Codes: L92, Q01, R41

Introduction

As the world is running out of resources that civilization relies on, building a sustainable future and cultivating efficient ways of living is becoming more than vital for humanity. The meeting between the two streamlines of nation development concept and the ecological awareness led the United Nations Brundtland Commission in 1987 to provide the following definition of sustainability: “*meeting the needs of the present without compromising the ability of future generations to meet their own needs.*” (United Nations, n.d.). The fervent competition for spoiling natural resources has negatively impacted the environment and created a worldwide threat of climate change; hence, concrete effort has to be made to ensure a better future for the next generations.

The Earth Summit of 1992 persuaded the entire world, mainly politicians, that the environment should no longer be considered the antithesis of economic growth. (*Developing-Renewable-Energies-as-an-Economic-Alternative-in-Light-of-Achieving-Sustainable-Development-in-Algeria..Pdf*, n.d., p. 944) During the same summit, the United Nations' Earth Summit first recognized the role of transport in sustainable development, strengthening its conclusion document, “Agenda 21.” Additionally, the UN General Assembly illustrated that transportation would be expected to be the primary driving force behind a growing world demand for energy over the next twenty years. (*Sustainable Transport | Department of Economic and Social Affairs*, n.d.),

Christian Wolmar, Britain's leading commentator, in his book “Blood, Iron & Gold, How the Railways Transformed the World” claimed that railways “*were the most important invention of the second millennium.*” (Martin, 2010) he also provided multiple narrations on how railways have changed human lives in several countries.

The significant technological revolution in the modern era has not spared the rail transportation industry by providing better-enhanced mobility through electrical traction or combustion engines, as well as the technological innovation that helped for efficient movements of passengers and goods and provided accessibility to a large variety of commercial and social activities, which allows rail transportation to play a noteworthy role in sustainable mobility and in developing socio-economic integration for numerous countries.

The 17 United Nations Sustainable Development Goals (SDGs) (*THE 17*

GOALS | *Sustainable Development*, n.d.), are considered as the framework for mitigating the man-made hazardous impact of climate change aiming to improve human life. There have been multiple conferences later that were meant to enhance the mechanism of sustainable development. The Rio De Janeiro 1992, for instance, developed a program to reconcile the three pillars of sustainable development: **Environmental** protection, **Economic** efficiency, and **Social** Equity.

In this context, this contribution attempts to provide an understanding of the concept of creating sustainable rail transportation and also to offer insights for policymakers, industry stakeholders, and researchers.

Moreover, we will try to provide a response to the following topic's main question: **Can railway transportation contribute to sustainable development?** Additionally, this paper will address the following topics: Greenhouse gas emissions in the global railway system within the environmental dimension and the socio-economic dimensions of sustainability in this means of transportation.

This contribution lies within the framework of demonstrating and synthesizing the concept of sustainability in the railways industry and the obstacles associated with achieving it.

To answer the above problematic, we will organize this paper into three main sections, following the United Nations' sustainability dimensions: environmental, economic, and social.

1- The environmental dimension of sustainable railways

Carbon emission was and still is the principal criterion for several studies that have as subjects the selection of the most sustainable transport means along with – at a lower notch - fuel cost and energy efficiency, maintenance cost, and accident records. For instance, transportation generally accounts for about 29% of the total of the United States of America's Greenhouse gases (GHGs).(US EPA, 2015)

Reducing GHGs responsible for global warming, such as carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄), has been the universal milestone of the international community in addressing climate change. (Da Fonseca-Soares et al., 2024).

Among other means of transportation, rail transportation preserves the

environment more by reducing carbon emissions, while air transportation exerts the reverse effect.(Kwakwa et al., 2022, p. 5)

According to the European Environment Agency (EEA), the standard values for pollution figures of transportation per type are estimated to be as follows:(Gonçalves, 2019).

Table 01: Pollution figures per transport type

	Train	Small Car	Average Car	Bus	Two-wheel motor	Plane
The standard value of pollution CO₂ / passenger / Km	14 g	42 g	55 g	68 g	72 g	285 g

Source: Gonçalves, 2019

With regards to fuel consumption, rail transportation is known to be a fuel-efficient and the most energy-saving means of transportation; it requires 2 to 3 times less energy to power it compared to road transportation energy consumption. For the energy equivalent to 1kg of oil per ton of freight, a truck can travel about 58 kilometers while a train can move up to 111 kilometers. (*Transport Ferroviaire et Développement Durable*, n.d.) Despite the high capital costs of railway electrification, efforts are still ongoing to make rail transportation less dependent on fossil fuels in accordance with the *International Railway Association* (UIC) recommendations. UIC is an international rail transport industry body with about 240 members across 100 countries worldwide. In 2014, it proposed a challenging framework to control GHG emissions by reducing energy consumption by 50% in 2030 and 60% by 2050. It will also minimize carbon dioxide emissions by 50% in 2030 and reduce them by 75% in 2050. In the coming years, sturdier obligations to attain net-zero emissions are to be deployed worldwide. Nevertheless, even if fully implemented, the government commitments could fall behind the plan to achieve net-zero global energy-related CO2 emissions by 2050 and miss the chance to give the world a reasonable opportunity to keep a global temperature rise within 1.5 °C (*Sustainability in Railways and Freight Transport*, 2023).

Needless to mention about the surface ground disturbance low effect on railways compared to road transportation, as railways use less land and civil

work requirements compared to paved roads, which is another environmental advantage for railways.

It is evident that, except for the limited environmental noise, rail transportation remains nearly the consistently winning option over other large-scale transportation types, and achieving better results is still ongoing.

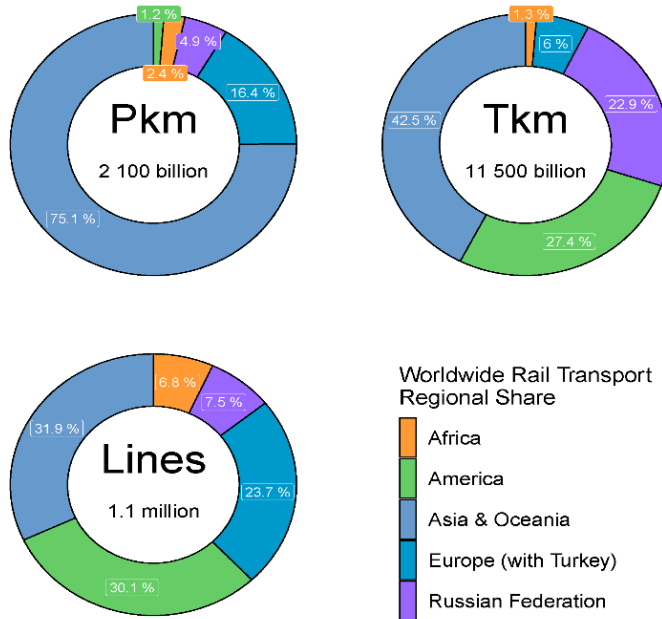
2- The economic dimension of sustainable railways

Nicholas Faith, in his book titled “The World the Railways Made” (2022) He started his introduction with the following substantial and informative verbiage: *“The modern world began with the coming of the railways. They turned the known universe upside down. They were the first technical invention which affected everyone in any country where they were built”*. Obviously, the railway industry is rising towards prominence in the transport world, leading to a vital change in the transport of freight and passengers, and they rapidly became essential to economic activity.

Widespread research offers evidence that economic growth and development have a negative impact on the environment (Kalimeris et al., 2020). Transportation has been intimately connected with the development of several countries and continues to play the lifeblood of economic growth, such as in the United States, China, and India.

Rail transportation has several aspects that make it economically beneficial; as we can see from the below figures (1&2), rail transportation is well spread all over the world, and it facilitates freight and passenger transportation; for instance, railway freight occupies 85% of the total transported freight volume in China, mainly large goods transported in a bulk mode such as coal, petroleum, grain minerals, and timbers. (Luo et al., 2009, p. 3).

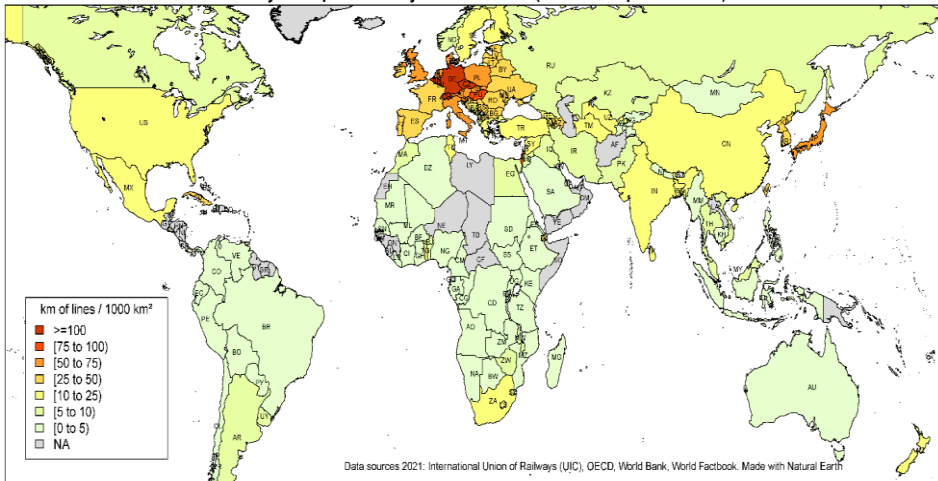
Figure 01: Worldwide Rail Transport Regional Share – 2021 (Pkm: Passenger/kilometers, Tkm: Tonne/kilometers and Line kilometers)



Source:(railways, 2024)

Figure 02: Railway Transport - Density of the network - 2021

Railway Transport: Density of the Network (km of lines per 1000 km²)



Source: (railways, 2024)

The dilemma is that transportation is also contributing to this negative impact on the environment; hence, the world's efforts to select and promote the most environment-friendly way of transportation and finding a solution to balance the increasing human needs requirements versus rationalizing natural resource utilization, which is and still subject of continuous debate on the new concept of a green economy. Fortunately, railway networks are considered opportune fields of sustainable development that contribute effectively to several countries' economies and consequently increase the Gross domestic product (GDP) (Luo et al., 2009, p. 1).

Railway infrastructure is considered pricey to implement and sustain, which is why it remains unchanged in the long run (De Jorge- Moreno & Garcia-Cebrian, 1999, p. 337), and any policy readjustment to improve the railway's performance, tackling the considerable investment in operations and infrastructures, would not be observable in the short run (Hadjar Soumai & Yassine, 2021, p. 657).

Reducing the cost of rail transportation is the paramount challenge to meet the upgraded regulations that aim for sustainable development. It is well known that Rail transport is provided over a dedicated network of infrastructure, and the challenge resides in the optimization and the control of the operating cost and maintaining the infrastructure such as rails, cables, Tramways and subways, cabins and locomotives, maintenance hubs, and passenger stations,

It has also long been recognized that these infrastructures are an essential component of economic growth and are the main drivers for this industry (Ng et al., 2017, p. 7). Controlling these infrastructures smartly by applying innovative solutions will help achieve the UN 9th Sustainable Development Goal related to “Industry, Innovation and Infrastructure” which states in sub-target 9.1, *“Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all”* also in 9.4 *“By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes”*(Goal 9 | Department of Economic and Social Affairs, n.d.)

The route-kilometre, being the measuring unit of rail transportation project cost, has also been a field of study and interest of cost-benefit analysts and policymakers; the total capital costs per route-kilometre, counting stations

and rolling stock, may vary depending on projects in different countries as the cost breakdown takes into consideration several variables such as the ratio of under-ground to above-ground structures, soil nature, station locations and spacing, safety and environmental constraints and manpower cost (Flyvbjerg et al., 2008, p. 2). However, the surface land used for the railway industry remains limited and lower compared to other transportation means, such as transportation on paved roads.

3- The social dimension of sustainable railways

The actual era has seen exponential technological development for the primary purpose of improving society's welfare and behavior; research done by Matusitz (2009) Studied the impact of railroads on American Society and concluded that the propagation of rail transportation brought the distribution of families across states and continents.

As mentioned previously, railways were not spared from this technological boom, and the railway industry has ambitions to contribute significantly to the fulfillment of the UN strategy of creating durable socio-economic and energetic sustainability. Railways are considered the main public transportation for several countries, and play a vital role in achieving the UN Sustainability Development Goals (SDGs), directly and indirectly.

Starting with the simple commute that skilled workforces take all over the world on a daily basis, to the ease of access to education and jobs, and the cultural exchange. All of that is considered as a social cohesion that contributes to sustainable economic growth. (*Achieving Sustainable Development Goals in the Rail Industry Requires a Total Systems Approach* - Arup, n.d.).

Research done by Watson and Ali (2017) on the Social Sustainability of High-Speed Railways (HSR) concluded that HSR transportation benefits society by improving mobility and accessibility, promoting regional growth, supporting local communities, contributing to regional transformation, and promoting economic development.

Furthermore, Utsunomiya's (2020) Research has also concluded, based on quantitative analysis, that service levels of two regional railways subject to the study have greatly improved and led to results of 50-60 percent variations in travel behavior among the participants; it has also positively impacted the social capital of inhabitants sideways their lines with a possibility of reducing consequently the risk of social exclusion on non-

workers like pensioners (retired seniors) in regional areas whom significantly gave positive responses to changes in the relationship with others for all the studied cases, which is an achievement to the UN SDG No.10, precisely sub-goals 10.2 & 10.3. (*Goal 10 | Department of Economic and Social Affairs, n.d.*).

From another perspective, safety is essential in many human activities and is of the foremost importance in transportation; railways show significantly lower accident rates than road traffic. According to a study done by Miller et al. (1994) on railroad injuries in the United States of America, compared the railway's toll to other transport modes, revealed that according to US Federal Railroad Administration data, railway injuries and illness cause an average of USD 3 billion in fatalities and cost USD 650 million in non-fatal incident costs annually. The main takeaway of this study is that rail transport was ranked the second safest mode of transport per passenger-mile after commercial air travel.

4- Conclusion

The present paper may be considered as a contribution towards exposing the broad scope that railways can contribute by articulating the three sustainability principles to achieve most of the predefined goals set by the United Nations regarding sustainable transportation. In this manuscript, railways sustainability is discussed from the perspective of the three main dimensions of sustainability to respond to this contribution's problematic.

Despite being the field of study and discussion in academia for years, rail transport practitioners and policy decision-makers are still reluctant to discuss its effects and benefits as public transportation. This is most probably due to the fact that the targeted market individuals depend heavily on other means of transportation and show resistance to changes. Extensively for freight transportation, even though the railway network density is the highest in the European Union and Europe precisely compared to other continents (figure 2 above), only 17% of goods are transported by rail. In comparison, 77% is left with the trucking transportation option. (*Road Transport vs Rail Transport | DHL Freight, 2023*).

The decline of passenger volume and the turnover quantity of railways, year by year, in countries populated like China (Luo et al., 2009, p. 3) This raises a concern and requires policymakers to work on developing society's mindset towards the use of public transportation and prioritizing rail over less efficient modes of transport, and using all necessary methods to

enhance public embracement for this sustainable solution for a better future. For instance, offering free rail transport for limited seasonal periods could be a possible solution to convince passengers to shunt their minds on railways rather than a different transportation mode. These offer periods could be extended and funded by applying extra environmental taxes on diverse transportation modes that contribute to increasing greenhouse gas emissions per passenger-kilometre.

As for the case of Algeria, despite the lack of willingness to develop railway transportation (Contribution-Du-Transport-En-Commun-Au-Développement-Durable-Du-Tourisme-Littoral-Cas-Du-Transport-Ferroviaire-En-Algérie.Pdf, n.d., p. 283), and being one of Africa's most developed countries with a less dense railway network due to its large land area (figure 2), regional and inter-city railway networks can be considered as budget-devouring projects compared to urban railways. Noticeably, most of the heavily populated Algerian cities, require a fundamental shift towards sustainable urban railway transportation to provide efficient solutions to the ever-growing issue of traffic congestion and all its drawbacks. Tramlines or Tramways are the appropriate, durable, and cost-saving solution to address the issue. It is worth future academic studies to assess the benefits achieved from this public conveyance existing already in some Algerian cities, which may also be applied to the remaining larger cities using a sustainable approach that covers the three pillar dimensions examined in this paper.

Bibliography

1. *Achieving sustainable development goals in the rail industry requires a total systems approach*—Arup. (n.d.). Retrieved 28 April 2024, from <https://www.arup.com/perspectives/achieving-sustainable-development-goals-in-the-rail-industry-requires-a-total-systems-approach>
2. *Contribution-du-transport-en-commun-au-développement-durable-du-tourisme-littoral- -cas-du-transport-ferroviaire-en-algérie.pdf*. (n.d.).
3. Da Fonseca-Soares, D., Eliziário, S. A., Galvinctio, J. D., & Ramos-Ridao, A. F. (2024). Greenhouse Gas Emissions in Railways: Systematic Review of Research Progress. *Buildings*, 14(2), 539. <https://doi.org/10.3390/buildings14020539>
4. De Jorge- Moreno, J., & Garcia- Cebrian, L. I. (1999). Measuring of production efficiency in the European railways. *European Business Review*, 9(5), 332–344. <https://doi.org/10.1108/09555349910288219>
5. *Developing-renewable-energies-as-an-economic-alternative-in-light-of-achieving-sustainable-development-in-algeria..pdf*. (n.d.).
6. Flyvbjerg, B., Bruzelius, N., & Wee, B. V. (2008). Comparison of Capital Costs per Route-Kilometre in Urban Rail. *European Journal of Transport and Infrastructure Research*. <https://doi.org/10.18757/EJTIR.2008.8.1.3327>

7. Goal 9 | Department of Economic and Social Affairs. (n.d.). Retrieved 3 May 2024, from https://sdgs.un.org/goals/goal9#targets_and_indicators
8. Goal 10 | Department of Economic and Social Affairs. (n.d.). Retrieved 3 May 2024, from https://sdgs.un.org/goals/goal10#targets_and_indicators
9. Gonçalves, A. (2019, January 28). Planes Or Cars - Which Pollutes The Most? Which Is More Sustainable? *Youmatter-Dev*. <https://youmatter.world/en/category-environment/plane-or-cars-which-means-of-transport-pollutes-the-most/>
10. Hadjar Soumai, A., & Yassine, B. (2021). Measuring the Technical Efficiency of Railways in Developing Countries: A Two Stage- Bootstrap Data Envelopment Analysis. *Dirassat Journal Economic Issue*, 12(1), 661–679. <https://doi.org/10.34118/djei.v12i1.1119>
11. Kalimeris, P., Bithas, K., Richardson, C., & Nijkamp, P. (2020). Hidden linkages between resources and economy: A “Beyond-GDP” approach using alternative welfare indicators. *Ecological Economics*, 169, 106508. <https://doi.org/10.1016/j.ecolecon.2019.106508>
12. Kwakwa, P. A., Adjei-Mantey, K., & Adusah-Poku, F. (2022). The effect of transport services and ICTs on carbon dioxide emissions in South Africa. *Environmental Science and Pollution Research*, 30(4), 10457–10468. <https://doi.org/10.1007/s11356-022-22863-7>
13. Luo, J., Xue, F., & Peng, Q. (2009). Theoretical Analysis of Railway Transportation Sustainable Development. *International Conference on Transportation Engineering 2009*, 1890–1895. [https://doi.org/10.1061/41039\(345\)313](https://doi.org/10.1061/41039(345)313)
14. Martin, B. (2010). *How the railways transformed the world*.
15. Matusitz, J. (2009). The impact of the railroad on American society: A communication perspective of technology. *PASOS Revista de Turismo y Patrimonio Cultural*, 7(3), 451–460. <https://doi.org/10.25145/j.pasos.2009.07.032>
16. Miller, T. R., Douglass, J. B., & Pindus, N. M. (1994). Railroad injury: Causes, costs, and comparisons with other transport modes. *Journal of Safety Research*, 25(4), 183–195. [https://doi.org/10.1016/0022-4375\(94\)90043-4](https://doi.org/10.1016/0022-4375(94)90043-4)
17. Nations, U. (2024). *Sustainability*. United Nations; United Nations. <https://www.un.org/en/academic-impact/sustainability>
18. Ng, C. P., Law, T. H., Wong, S. V., & Kulanthayan, S. (2017). Relative improvements in road mobility as compared to improvements in road accessibility and economic growth: A cross-country analysis. *Transport Policy*, 60, 24–33. <https://doi.org/10.1016/j.tranpol.2017.08.004>
19. Nicholas, F. (2022). The World the Railways Made. In *The World the Railways Made* (p. 360). New York: Carroll & Graf Publishers. https://books.google.com.om/books?hl=en&lr=&id=L7CfEAAAQBAJ&oi=fnd&pg=PT10&dq=history+of+railways&ots=ULdli3mjUJ&sig=HenVdEFsvVoyMmjBuWMBbTSY2T8&redir_esc=y#v=onepage&q=history%20of%20railways&f=false
20. Railways, U.-I. union of. (2024, April 27). *Statistics*. UIC - International Union of Railways. <https://uic.org/support-activities/statistics/>
21. *Road Transport vs Rail Transport* | DHL Freight. (2023, July 20). <https://dhl-freight-connections.com/en/solutions/road-transport-vs-rail-transport-head-to-head-comparison/>
22. *Sustainability in Railways and Freight Transport*. (2023, December 5). Railway International. <https://www.railway-international.com/market-overview/74880-sustainability-in-railways-and-freight-transport>

23. *Sustainable transport* | Department of Economic and Social Affairs. (n.d.). Retrieved 3 May 2024, from <https://sdgs.un.org/topics/sustainable-transport>
24. *THE 17 GOALS* | Sustainable Development. (n.d.). Retrieved 3 May 2024, from <https://sdgs.un.org/goals>
25. *Transport ferroviaire et développement durable*. (n.d.). Retrieved 20 April 2024, from <http://www.vedura.fr/environnement/transports/transport-ferroviaire-train>
26. US EPA, O. (2015, September 10). *Carbon Pollution from Transportation* [Overviews and Factsheets]. <https://www.epa.gov/transportation-air-pollution-and-climate-change/carbon-pollution-transportation>
27. Utsunomiya, K. (2020). The impact of regional railways on travel behaviour and social capital. *Research in Transportation Economics*, 83, 100945. <https://doi.org/10.1016/j.retrec.2020.100945>
28. Watson, I., & Ali, D. A. (2017). *Social Sustainability of HSR-Comparative Study*.