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INTEGRATED NEW STANDARD FOR SMART MULTIMODAL CORRIDORS

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ABSTRACT

The compounding effects of COVID-19, climate change, ongoing wars, political tensions, and trade restrictions are exacerbating the global food crisis, and urgent actions are needed to holistically strengthen the resilience and sustainability of agrifood systems globally. This paper outlines the need to address and streamline the transportation and logistics system in the agrifood sector through the adoption of a smart multimodal corridor approach, which is resilient, green, and inclusive, to ensure that agrifood products reach those most in need swiftly and safely.

EXECUTIVE SUMMARY

The transportation and logistics system in the agrifood sector can be divided into six interrelated components, which form the foundation of a holistic framework: (i) infrastructure building; (ii) systems interoperability and data exchange, including for real-time tracking and tracing and end-to-end cold chain development; (iii) ethics and governance in robotics and artificial intelligence (AI) for automation and intelligence; (iv) human capacity development and continuous reskilling and upskilling; (v) safety, security, and well-being of the transportation and logistics workforce; and (vi) cooperation, data exchange, and collaboration for cross-border agrifood trade. These key principles of resilience building, green transition, and inclusion that should be embedded in the design and development of smart multimodal corridors cut across all components of the framework.

There is a significant advancement in the development of global standards for systems interoperability and data exchange across smart multimodal corridors. However, they do not address other components necessary for the successful development and deployment of resilient, green, and inclusive smart multimodal corridors. A comprehensive package of standards is needed for smart multimodal corridors that incorporate the principles of resilience, green transition, and inclusion and the six components of the framework for transportation and logistics systems for the agrifood sector, building on existing relevant standards developed by global standards-setting organizations.

1. INTRODUCTION

The United Nations estimates that the global population will reach almost 10 billion by 2050, with the majority living in lower- and middle-income countries in Africa and Asia. Yet, about a third of the world's food produced is lost due to poor handling, transportation and storage, and lack of cold chain logistics.[1] The rapidly growing population and longer life expectancy are creating greater demands for food and placing pressure on agrifood systems to increase production, reduce spoilage and wastage, and ensure that nutritious and safe food is accessible to everyone.

Now more than ever, agrifood systems need to be resilient to multiple and compounding shocks and crises, such as climate change impacts, pandemics, conflicts, wars, and trade restrictions that are transboundary in nature. Global standards are needed for harmonized and seamless transportation and logistics linkages across nations and regions to enhance the delivery of agrifood products. In addition to ensuring that agrifood products reach those most in need swiftly and safely, improvements in agrifood transportation and logistics systems can contribute to increased employment and better livelihoods, especially since two-thirds of the global extremely poor earn their livelihood in farming. Productivity growth in the agriculture sector appears to have the largest impact on poverty reduction when compared with other sectors.[2] Improvements in agrifood transportation and logistics systems will also support advancements in other sectors, such as healthcare, particularly in the delivery of medicine, vaccines, and other necessary perishables.

The agrifood transportation and logistics system is a complex system that involves the management of the flow of goods, resources, and information between the point of origin and the destination. It requires an integrated process of planning, optimizing, and implementing the multimodal transportation of goods by air, rail, road, sea, and/or inland waterways, as well as the various logistical operations, which include receiving and recording goods from different suppliers, storing goods at appropriate locations, retrieving and picking goods when they are needed, and preparing shipment to buyers. The agrifood supply chain requires careful temperature control across a cold chain, which adds to the complexity of the logistics.

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[1] Food and Agriculture Organization. *Seeking End to Loss and Waste of Food Along Production Chain*. [Online]. Available: https://www.fao.org/in-action/seeking-end-to-loss-and-waste-of-food-along-production-chain/en/

[2] World Bank. (2019). *Harvesting Prosperity: Technology and Productivity Growth in Agriculture*. [Online]. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/32350/9781464813931.pdf

Companies and countries are digitalizing their operations to enhance efficiency and gain a competitive advantage. However, the actors in a traditional logistics network are often siloed from each other—warehouse management has separate dashboards from freight forwarders. An integrated smart transportation and logistics system breaks these silos and gives each stakeholder in the logistics network end-to-end visibility. With enhanced visibility and transparency, trust can be built to share infrastructure and resources, such as warehousing and transportation facilities, across the supply chain through a digitally integrated cross-border transportation and logistics system.

This paper outlines the justification and need for an integrated framework for transportation and logistics systems for the agrifood sector, which adopts a smart multimodal corridor approach, and is resilient, green, and inclusive. Each of the terms will be unpacked in turn with highlights on existing bottlenecks and gaps that need to be addressed in order to ensure food security for all.

2. WHAT IS A SMART MULTIMODAL CORRIDOR?

This section discusses the characteristics of smart multimodal corridors.

2.1. SMART SYSTEMS

Smart implies fully and effectively leveraging frontier digital technology and data to meet the goals of providing resilient and sustainable agrifood transportation and logistics systems. Frontier digital technologies like artificial intelligence (AI), big data analytics, cloud computing, and the Internet of Things (IoT) are bringing enormous opportunities for transformation. But existing, small, cheap, and easy-to-manage systems, when integrated properly, also have a substantial role to contribute.

Smart means that systems and data related to all infrastructures and facilities along the agrifood transportation and logistics chain, such as roads, rail, inland waterways, sea and air routes, as well as ports, terminals, border post facilities, logistics parks and hubs, warehouses and cold storage facilities, and other logistics services, are digitalized and integrated with each other to provide real-time visibility and end-to-end transparency of operations for enhanced efficiency and effectiveness toward sustainable development.

However, as frontier digital technologies also present significant challenges and risks related to access, privacy, security, and trust, these challenges and risks need to be recognized and mitigated from the start in the planning and design of smart systems. There is a need to consider the persistent divides related to access to affordable digital connectivity, transportation, and logistics services. Legal, ethical, and accountability systems also need to be in place to protect people against maligned and inappropriate use of data and technologies, with assurance that people's rights, safety, and well-being are prioritized. The lack of such safeguarding systems could potentially erode trust in the smart system, resulting in stakeholders' reluctance to share infrastructure, resources, and data necessary for the successful implementation of end-to-end smart multimodal systems.

A United Nations report on the impact of COVID-19 on transportation and logistics shows that ports with "smart port" features generally fared better during the disruption caused by COVID-19. These ports had invested in digital infrastructure and connectivity and promoted data exchange among port authorities, shippers, and freight forwarders. Digital platforms facilitated the submission and processing of documentation, permits, operations, and certificates, while improved coordination between stakeholders and relevant public authorities kept information flowing and actions aligned.[3] A World Bank report also finds that end-to-end supply chain digitalization, especially in emerging economies, is allowing countries to shorten port delays by up to 70% compared to those in developed countries.[4]

2.2. MULTIMODAL CORRIDORS

Countries around the world have been adopting a multimodal corridor approach that links different infrastructure sectors together. It refers to the process of spatially organizing two or more transportation and logistics infrastructure assets into corridors to enhance the social and economic development of the corridor countries. This approach implies a deliberate focus on regional integration in which all the previously mentioned infrastructures and facilities complement one another.

Multimodal transport optimizes the use of different transport modes to provide an efficient use of relevant resources and reduce the cost of transportation and logistics, particularly for bulk products across long distances. Countries are promoting multimodal transport and shifting a large part of the freight

[3] United Nations Conference on Trade and Development. (May 17, 2022). *Sustainable and Resilient Transport and Trade Facilitation in Times of Pandemic and Beyond: Key Challenges and Opportunities*. [Online]. Available: https://unctad.org/system/files/official-document/cimem7d26_en.pdf

[4] World Bank. (Apr. 21, 2023). *Press Release: World Bank Releases Logistics Performance Index 2023*. [Online]. Available: https://www.worldbank.org/en/news/press-release/2023/04/21/world-bank-releases-logistics-performance-index-2023

journey away from the road to rail and waterway transport that is generally more environmentally friendly. Yet, multimodal transport is typically slower than road transport and considered unsuitable for the delivery of urgent or perishable products. For less-developed multimodal systems, there may be delays, lower levels of traceability, and higher risk of damage, especially in the transition to different transport modes. However, with digitalization and the use of technology, multimodal transport is becoming more efficient, reliable, and safe.

For the developing regions with large numbers of landlocked developing countries, like Eastern Africa, the United Nations underscores the importance of transportation corridors.[5] United Nations agencies and development banks have promoted infrastructure project preparation, funding, and maintenance based on a corridor approach to optimize access to landlocked developing countries. In Africa, the Programme for Infrastructure Development in Africa (PIDA), which is a flagship programme of the African Union to develop the infrastructure in transport, energy, information and communications technology (ICT), and transboundary water resources, has mainstreamed all projects along designated corridors.[6]

In the implementation of the multimodal corridor approach, the current trend points to the application of synchromodality, which is the synchronization of multimodal services with different speeds and lead times, and the alignment of equipment and services on corridors and hubs with the multimodal networks. For synchromodality, real-time information is needed for decision-making. The development of smart infrastructure and intelligent transportation systems using sensors, IoT networks, cloud technologies, and AI has enabled real-time monitoring and the application of synchromodality. In addition, these technologies that allow real-time monitoring have helped to optimize transportation and logistics operations, reduce the cost of infrastructure and equipment maintenance, enhance safety, and reduce carbon emissions.[7]

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[5] UN-OHRLLS. (2020). *Report on Best Practices for Effective Transit Transport Corridor Development and Management*. [Online]. Available: https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/lldcs_publications/corridor-report-_-final-_un-ohrlls_28may2020.pdf

[6] AU. (Feb. 27, 2020). *Strategic Note: The Integrated Corridor Approach: A Holistic Infrastructure Planning Framework to Establish PIDA-PAP 2*. [Online]. Available: https://pp2.au-pida.org/wp-content/uploads/2020/04/English-Strategic-Note_Integrated-Corridor-Approach-and-Selection-Criteria-AUC.pdf; and AU. (Feb. 27, 2020). *Elaboration of the 2021–2030 Priority Action Plan for the AU Program for Infrastructure Development in Africa (PIDA)*. [Online]. Available: https://pp2.au-pida.org/wp-content/uploads/2020/04/English-Analytical-Report-Integrated-Corridor-Approach-and-Selection-Criteria.pdf.

[7] Y. de Blic. (2018). *IT Technologies for Inland Waterway Transport*. European Regional Development Fund. [Online]. Available: https://duepublico2.uni-due.de/servlets/MCRFileNodeServlet/duepublico_derivate_00046730/ST4W_IT_Technologies.pdf

3. PRINCIPLES FOR DEVELOPING SMART MULTIMODAL CORRIDORS

This section discusses the key principles that should be embedded in the design and development of smart multimodal corridors. They include resilience building, green transition, and inclusion, and leave no one behind. These principles cut across all components of the framework for transportation and logistics systems for the agrifood sector discussed in Section 4.

The Global Report on Food Crises for 2023[8] highlights that the number of people experiencing acute food insecurity and requiring urgent food and livelihood assistance is on the rise, with over a quarter of a billion people now facing acute levels of hunger. Conflicts, the climate crisis, natural disasters, rising poverty, and deepening inequalities are some of the key drivers of global hunger.[9] In East Africa, for example, weather extremes including the severe, three-year drought across the Horn of Africa, economic challenges, and conflicts and insecurity affecting livelihoods, markets, and humanitarian access continue to drive dire levels of acute food insecurity across many countries.[10] The global food crisis is resulting in worsening levels of malnutrition and wasting with adverse effects on the overall physical and mental health of populations. Moreover, the World Food Programme reports that the cost of delivering food assistance is at an all-time high because food and fuel prices have increased.[11] For these reasons, urgent actions are needed to holistically strengthen the resilience, sustainability, and inclusiveness of agrifood transportation and logistics systems globally.

3.1. RESILIENCE BUILDING

Resilience can be defined as the ability to withstand, recover from, adapt to, and potentially transform amid change and uncertainty. The agrifood transportation and logistics system needs to be resilient to be able to recover quickly from crises and disasters and function optimally to deliver safe and quality agrifood supplies, particularly to those most vulnerable living in rural and remote areas.

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[8] Food Security Information Network and Global Network Against Food Crises. (2023). *Global Report on Food Crises (Rome)*. [Online]. Available: https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2023-compressed.pdf

[9] World Food Programme. (2023). *A Global Food Crisis*. [Online]. Available: https://www.wfp.org/global-hunger-crisis

[10] (2023). *Food Security Information Network and Global Network Against Food Crises, 2023 Global Report on Food Crises (Rome)*. [Online]. Available: https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2023-compressed.pdf

[11] World Food Programme. *A Global Food Crisis*. [Online]. Available: https://www.wfp.org/global-hunger-crisis

The COVID-19 pandemic has hindered the flow of goods, increased logistics costs, and imposed a higher risk on marginalized groups related to the shortage of food and other necessities. Similar pandemics and crises are likely to occur in the future, and the transportation and logistics sector needs to be prepared.

As disasters and crises can significantly impact infrastructure and services for transportation and logistics systems for the agrifood sector, it is important to assess, protect, and risk-proof infrastructure and facilities. Establishing diverse and redundant ICT and transportation networks and routes builds resilience. Ensuring a diverse warehousing system with warehouses that can hold food in any form along the supply chain, in ambient or cold-chain temperatures and for short- or long-term storage, further strengthens resilience.

Creating an inventory and the spatial mapping of transportation and logistics assets such as warehousing facilities, available cold chain infrastructure, and transport routes, including alternatives to road transport such as boat and barge capacities, as part of preparedness planning for crises, is essential.

The consequences of not investing in resilience mean that food and other necessities will not reach those who need them most during shocks and crises. The World Food Programme reported that when they were not able to reach Syrian refugees in 2015, the refugees had no choice but to leave the camps and seek help elsewhere, causing one of the greatest refugee crises in recent European history.[12]

3.2. GREEN TRANSITION

With most countries committed to achieving the climate goals of the Paris Agreement, agrifood transportation and logistics systems must be environmentally sustainable and powered by clean and renewable energy sources to achieve net-zero carbon emissions. Today, the transportation and logistics sector is one of the highest carbon emitters, contributing to around 24% of global carbon emissions, and is being increasingly pressured to reduce its carbon footprint.[13] According to a World Bank report, demand for green logistics is rising, with 75% of shippers looking for environmentally friendly options, including shifting to less carbon-intensive freight modes.[14]

[12] *Ibid*.

[13] CarbonCare. *Climate Change: The Responsibility of Transport and Logistics*. [Online]. Available: https://www.carboncare.org/en/climate-change.html

[14] World Bank. (Apr. 21, 2023). *Press Release: World Bank Releases Logistics Performance Index 2023*. [Online]. Available: https://www.worldbank.org/en/news/press-release/2023/04/21/world-bank-releases-logistics-performance-index-2023

To incentivize investment in reducing carbon emissions and adopting climate-friendly solutions, public and private organizations need to be aware of the climate and environmental costs of their interventions. This will require accurate and standardized measurement and reporting of carbon emissions and the quantification of climate-related costs, as well as guidelines for the conduct of cost–benefit analyses that include assessment of the lifetime costs of infrastructure and the integration of climate change scenarios. Such efforts need to be incorporated into the building of smart transportation and logistics systems and the integration of roads, railways, and waterways into comprehensive, multimodal transport systems, as well as in the development of green logistics parks and clusters.

3.3. INCLUSION AND LEAVE NO ONE BEHIND

Inclusion is generally defined as development that includes and pays special attention to the needs of the poor and the excluded, such as women, people living in rural and remote areas, micro-, small-, and medium-sized enterprises (MSMEs), and informal workers.[15] The implication here is that no real and sustained development can take place if certain segments of the population are excluded from the benefits of development. Inclusion and leave no one behind are embedded as key principles in the 2030 Agenda for Sustainable Development.[16] Inclusion in the development of smart multimodal corridors encompasses multiple dimensions related to stakeholders' gender, age, socioeconomic status, geography, ability, and skill set.

3.3.1. INCLUSIVE ACCESS TO SMART MULTIMODAL CORRIDORS

Smart multimodal transportation and logistics corridors must be accessible to all stakeholders, ensuring that small-scale farm producers can access affordable transportation and logistics services to ship their products, and last-mile deliveries can reach all consumers, including rural and remote areas, and conflict-affected areas.[17]

[15] (2020). *United Nations, the Academy of ICT Essentials for Government Leaders: An Overview of ICTs and Sustainable Development (Incheon, 2020)*. [Online]. Available: https://www.unapcict.org/sites/default/files/2020-09/An_Overview_of_ICTs_and_Sustainable_Development.pdf

[16] Together 2030. (2019). *Realizing the SDGs for All: Ensuring Inclusiveness and Equality for Every Person, Everywhere*. UN High-Level Political Forum on Sustainable Development. [Online]. Available: https://sustainabledevelopment.un.org/content/documents/23216Together_2030__Position_Paper__HLPF_2019.pdf

[17] (2020). *International Food Policy Research Institute, Global Food Policy Report 2020: Building Inclusive Food Systems*. Washington, DC, USA. [Online]. Available: https://www.ifpri.org/publication/2020-global-food-policy-report-building-inclusive-food-systems

Smart solutions must be able to operate in an environment with low and unreliable digital connectivity and be affordable to low-income economies. At the same time, innovations to reach remote areas, such as television white space, or the constellations of low-Earth-orbit satellites, can help to achieve universal connectivity.[18]

3.3.2. INCLUSIVE SKILLS DEVELOPMENT AND PARTICIPATION

The digitalization of agrifood transportation and logistics systems will increase automation, replace lower-skilled repetitive job roles, and increase demand for higher-skilled roles.[19] This can exacerbate and perpetuate labor market inequalities and further widen the development gaps between rural and urban areas. For example, the increasing demand for safe and traceable food can exclude small-scale producers and traders who lack the resources and capacity to comply with strict standards.[20]

Agrifood systems design and development need to include capacity building and meaningful participation of women, MSMEs, those living in rural and remote areas, and informal workers in transportation and logistics.

3.3.3. GENDER MAINSTREAMING

Since the transportation and logistics sector has traditionally been male-dominated, gender issues are often neglected.[21] Generally, women face significant barriers in accessing engineering and senior management roles that steer development in transport and logistics—women employed in the transportation and logistics sector tend to be engaged in lower-level jobs in administration, sales, and cleaning.[22]

Globally, there are no systematic gender inclusion protocols or procedures for transportation and logistics, neither in the training of professionals nor in the participation of users in the design and planning

[18] J. Brewer, Y. Jeong and A. Husar. (Dec. 2022). *Last Mile Connectivity: Addressing the Affordability Frontier*. Asian Development Bank Sustainable Development Working Paper Series. [Online]. Available: https://www.adb.org/publications/last-mile-connectivity-addressing-affordability-frontier

[19] (2021). *International Labour Organization, Changing Demand for Skills in Digital Economies and Societies (Geneva, Switzerland)*. [Online]. Available: https://www.ilo.org/wcmsp5/groups/public/—ed_emp/—ifp_skills/documents/publication/wcms_831372.pdf

[20] (2019). *World Bank, Future of Food: Harnessing Digital Technologies to Improve Food System Outcomes (Washington, DC, USA)*. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/31565

[21] World Bank. (Jan. 30, 2023). *Making Way for Women in Transport and Logistics: Promising Practices in Europe and Central Asia*. [Online]. Available: https://www.worldbank.org/en/news/feature/2023/01/26/making-way-for-women-in-transport-and-logistics-promising-practices-in-europe-and-central-asia

[22] *Ibid*.

of systems, services, and equipment.[23] The design of machinery, vehicles, robotics, and wearables, for example, must ensure that they are gender-sensitive and safe for both women and men.[24]

4. COMPONENTS IN THE FRAMEWORK FOR TRANSPORTATION AND LOGISTICS SYSTEM FOR THE AGRIFOOD SECTOR

The framework for transportation and logistics systems for the agrifood sector can be divided into six interrelated components: (i) infrastructure building; (ii) systems interoperability and data exchange, including real-time tracking and tracing and end-to-end cold chain development; (iii) ethics and governance in robotics and AI for automation and intelligence; (iv) human capacity development and continuous reskilling and upskilling; (v) safety, security, and well-being of the workforce; and (vi) cooperation, data exchange, and collaboration for cross-border agrifood trade.

4.1. INFRASTRUCTURE BUILDING

The infrastructure component includes the critical infrastructures such as electricity and ICT networks to power and connect the smart technologies, as well as the network of IoT devices and sensors, and access to satellite systems and data centers for data collection, storage, and processing. In transportation and logistics, the road, rail, port, and terminal infrastructure, as well as the warehouses and cold storage facilities, and their digitalization are critical.

In East Africa, for example, access to digital connectivity and technology is generally low by international standards and unequal (between and within countries). Nevertheless, with COVID-19 lockdowns moving many essential services online, and the adoption of the African Union's Digital Transformation Strategy 2020–2030 that aims to bring universal digital access and develop a single pan-African digital market, the digitalization of logistics and transportation and the use of advanced technologies is recognized as a

[23] United Nations Economic Commission for Europe. *Gender and Transport*. [Online]. Available: https://unece.org/gender-and-transport

[24] Caroline Criado Perez. (Feb. 23, 2019). *The Deadly Truth About a World Built for Men—From Stab Vests to Car Crashes*. The Guardian. [Online]. Available: https://www.theguardian.com/lifeandstyle/2019/feb/23/truth-world-built-for-men-car-crashes

priority.[25] However, standards, incentives, and guidelines to incorporate the principles of resilience, green transition, and inclusion in infrastructure development for smart multimodal corridors are missing. In response, the African Development Bank[26] and the World Bank[27] have committed to promoting and supporting the development of resilient, green, and inclusive smart multimodal corridors to boost trade, socioeconomic development, and decent jobs.

Incentives and guidelines to promote and enable the co-deployment and sharing of infrastructure in which the road, rail, energy, and ICT sectors collaborate to jointly construct and share infrastructure, and build intelligent transportation systems are needed to accelerate the building and upgrading of infrastructure, particularly in rural and remote areas, in a cost-effective manner.[28] Studies have provided evidence of infrastructure co-deployment and sharing of infrastructure resulting in significant cost savings by avoiding duplication while undertaking construction works in the same corridor and reducing the number of permits and the fees for the use of rights-of-way.[29] The avoidance of duplication in construction works can also contribute to reduced social and environmental disruptions.

Standards and guidelines are needed for the upgrade and digitalization of strategic ports and terminals that serve as gateways for the efficient movement of agrifood cargo, and the prevention of damage, spoilage, or contamination of food during transportation and storage.[30] This will require modern cargo-handling equipment, cold storage warehouses, and advanced technology systems for tracking, monitoring, and managing agrifood cargo. Support is needed in assessing the type of facilities and amount of capacity needed based on current and future demands and volumes of traffic and in ensuring that the ports and terminals are environmentally sustainable and climate-resilient.[31]

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[25] African Union. (2020). *The Digital Transformation Strategy for Africa (2020–2030)*. [Online]. Available: https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030

[26] African Development Bank. (Jun. 7, 2023). *The African Development Bank to Boost Electricity and Transport Infrastructure, Value Chain Development and Trade Facilitation to Spur Regional Integration in East Africa in 2023–2027*. [Online]. Available: https://www.afdb.org/en/news-and-events/african-development-bank-boost-electricity-and-transport-infrastructure-value-chain-development-and-trade-facilitation-spur-regional-integration-east-africa-2023-2027-61854

[27] World Bank. *Transport and ICT*. [Online]. Available: https://www.worldbank.org/content/dam/Worldbank/Brief/TAI/Transport_ICT_brochure.pdf?hootPostID=ba43ddddb539f387adceff95f1ce76bd

[28] A. Husar, Y. Jeong and J. Garrity. (Jul. 2023). *Cross-Sector Infrastructure Co-Deployment: Closing Digital Connectivity Gaps through Collaboration and Sharing*. Asian Development Bank Sustainable Development Working Paper Series. [Online]. Available: https://www.adb.org/publications/cross-sector-infrastructure-co-deployment

[29] (2020). *Inter-American Development Bank, Digital Transformation Infrastructure Sharing in Latin America and the Caribbean (Washington, DC, USA)*. [Online]. Available: https://publications.iadb.org/en/digital-transformation-infrastructure-sharing-latin-america-and-caribbean

[30] T. Notteboom, A. Pallis and J.-P. Rodrigue. (2022). *Port Economics, Management and Policy (New York, NY, USA: Routledge)*. [Online]. Available: https://porteconomicsmanagement.org/pemp/contents/part2/digital-transformation/

[31] United Nations Economic and Social Commission for Asia and the Pacific. (Feb. 2021). *Smart Ports Development Policies in Asia and the Pacific*. [Online]. Available: https://www.unescap.org/sites/default/d8files/event-documents/SmartPortDevelopment_Feb2021.pdf

Standards and guidelines are also needed for the repair, reuse, recycling, and disposal of IoT sensors, robots, and digital devices in a responsible manner as they may cause harm, distress, and damage to human and animal welfare and the environment.[32] The improper disposal or the burning of electronic waste releases dust particles and toxins into the air, causing air pollution and creating numerous health risks such as respiratory diseases and cancer. Improper disposal of electronic waste can also lead to the contamination of groundwater and ultimately the depletion of safe and clean drinking water.

4.2. SYSTEMS INTEROPERABILITY AND DATA EXCHANGE

There are many types of transportation and logistics management systems for different modes of transport (e.g., air, rail, road, sea, and waterway) and for different operations along the logistics supply chain (warehouse management, order management, cargo tracking, customs management, cold chain management, etc.). Each mode of transport has its set of systems for different purposes, such as vessel and crew management systems for waterway transport and truck, driver, and traffic management systems for road transport. Ports and terminals also have their own operation and management systems.

For smart multimodal corridors, standards and protocols for interoperable systems and data exchanges across different transport modes, ports, and terminals, and logistical operations are important. Interoperable systems and data exchanges enable the sharing of data, particularly real-time data, to inform decision-making across sectors, corridors, countries, and regions. For example, predictive modeling of inland waterways can help optimize the management of water volume in inland waterways for navigation, energy production, irrigation, and climate actions across borders.

However, key challenges include large data gaps, especially in low-income countries where data processing is largely paper-based and not yet digitized; insufficient linkage of information systems; absence of data exchange framework and protocols; and limited data compatibility and standardization. The application of standards to ensure that the variety of data collected, including maps and images, are of high quality, accurate, and reliable (tamper-proof), and are exchangeable and interoperable across borders will help facilitate trusted cross-border transportation and logistics.

[32] Geneva Environment Network. (Jan. 16, 2023). *The Growing Environmental Risks of E-Waste*. [Online]. Available: https://www.genevaenvironmentnetwork.org/resources/updates/the-growing-environmental-risks-of-e-waste/

With multiple entities involved in data collection and storage, it is also essential that they adhere to data protection, privacy, and security principles and best practices and ensure appropriate confidentiality, time-bound retention, proper deletion of data, and effective handling of data breaches and cyberattacks. The growing network of connected devices and sensors are potential entry points for cyberattacks.

4.2.1. REAL-TIME TRACKING AND TRACING SYSTEM

In smart multimodal corridors, real-time data for tracking and tracing is important for optimizing the efficiency, reliability, and safety of multimodal transport, which is particularly critical for perishable agrifood products.[33] Various global positioning, navigation, and tracking systems together with IoT technology and predictive analytics using AI enable the monitoring of operations in real-time, improvements in logistics and transport route planning, and forecasting of changes in shipping demands and supply for better decision-making.

Tracking and tracing make supply chains visible through identification [e.g., barcodes and radio-frequency identification (RFID)], location [e.g., Global Positioning System (GPS)], and measurements (e.g., temperature sensors). Tracking refers to tracking the state (e.g., location or temperature) of a product, vehicle, or person in real-time or based on milestones. Based on this information, decisions can be made to efficiently manage operations. Tracing refers to storing tracking information for a specified time in such a way that it can be retrieved in the future for various purposes such as verification, reporting, audit, or dispute resolution. In agrifood transportation and logistics, a variety of tracking and tracking systems are needed for agrifood products and fleet management.

For agrifood management, tracking and tracing systems ensure that the agrifood product remains safe throughout the journey. They also provide verified information about the journey of an agrifood product across the supply chain, particularly with increasing consumer demand for products that are ethical, green, and organic, requiring verified information on labor protection, carbon emissions, and organic growing techniques, respectively. For fleet management (e.g., trucks and vessels), the GPS tracking system can enable real-time monitoring of the fleet and provide insights into ways to optimize route flow and safety.

[33] M. Remondino and A. Zanin, "Logistics and Agri-food: digitization to increase competitive advantage and sustainability. Literature review and the case of Italy," *Sustainability*, vol. 14, no. 2, p. 787, 2022. [Online]. Available: https://www.mdpi.com/2071-1050/14/2/787

Although all participants in modern supply chains are expected to have effective practices in place that allow for the rapid identification, location, and withdrawal of agrifood products when problems are suspected or confirmed, this is an ongoing challenge for many. Ensuring such practices is recognized by organizations and the United Nations.[34] Standards and guidelines for integrating the network of fleet, warehouses, cold storage, and distribution centers, as well as the laboratories for food safety analysis in the track and trace system, are therefore needed to enable all participants in the agrifood sector to track and trace throughout the entire supply chain.

4.2.2. END-TO-END COLD CHAIN SYSTEM

The agrifood logistics supply chain differs from other supply chains in its requirement for careful temperature control to maintain the freshness of perishable agrifood products along a cold chain, which adds to its complexity.

Cold chain is the use of thermal and refrigerated packing methods, as well as temperature-controlled transportation and storage services, to guarantee the integrity of perishable agrifood products.[35] This requires the building of cold chain distribution centers or logistics hubs near key ports, and investment in refrigerated trucks and cargo containers, as well as capacity building to develop a cadre of cold chain professionals.[36]

Standards and guidelines are needed for establishing an integrated end-to-end system of traceable and monitored cold logistics, cold storage facilities, and cold transport to ensure safe and secure delivery of perishable agrifood products,[37] as well as address environmental concerns.[38] The lack of end-to-end process control creates fragmented and inefficient cold-chain logistics.[39]

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[34] Food and Agriculture Organization. *Food Safety and Quality*. [Online]. Available: https://www.fao.org/food-safety/food-control-systems/supply-chains-and-consumers/traceability-and-recalls/en/

[35] J.-P. Rodrigue, *The Geography of Transport Systems*, 5th ed. New York, NY, USA: Routledge, 2020. [Online]. Available: https://transportgeography.org/contents/applications/cold-chain-logistics/

[36] K. Lucenti and E. Feijóo. (Apr. 25, 2018). *Waste Not, Want Not: Strengthening LAC Agrifood Exports Though Robust Cold Chain Logistics*. Inter-American Development Bank. [Online]. Available: https://blogs.iadb.org/integration-trade/en/agrifood-exports-cold-chain-logistics/

[37] *United Nations Environment Programme and Food and Agriculture Organization, Sustainable Food Cold Chains: Opportunities, Challenges and the Way Forward (Nairobi and Rome, 2022).* [Online]. Available: https://www.fao.org/3/cc0923en/cc0923en.pdf

[38] J.-W. Han, "A comprehensive review of cold chain logistics for fresh agricultural products: Current status, challenges, and future trends," *Trends Food Sci. Technol.*, vol. 109, pp. 536–551, Mar. 2021. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S0924224421000728

[39] K. Lucenti and E. Feijóo. (Apr. 25, 2018). *Waste Not, Want Not: Strengthening LAC Agrifood Exports Though Robust Cold Chain Logistics*. Inter-American Development Bank. [Online]. Available: https://blogs.iadb.org/integration-trade/en/agrifood-exports-cold-chain-logistics/

4.3. ETHICS AND GOVERNANCE IN ROBOTICS AND AI FOR AUTOMATION AND INTELLIGENCE

As mentioned previously, smart implies fully and effectively leveraging frontier digital technology and data to automate tasks and perform tasks associated with intelligence. It includes algorithms for data analytics and AI to analyze the massive amount of data gathered from one or more data sources to gain insights and support decision-making.

It also includes the application of AI to machinery. Robotics is a form of functional AI that can be leveraged to automate and improve the performance of repetitive, physically onerous, and dangerous logistics operations. In smart warehouses, for example, solutions include autonomous forklifts to load and unload goods , as well as stocktaking robots for inventory monitoring in large storage spaces. IoT technology can be used to detect and communicate open spaces in a warehouse for transportation systems and manage energy use in warehouses, including lighting, heating, and cooling to conserve energy. For last-mile deliveries, drones and autonomous delivery vehicles/robots are being used.

Policies and guidance are needed to monitor and detect biases in datasets and algorithms to ensure that they are not leading to discrimination against certain social groups and exacerbating inequalities, for example, in managing the transportation and logistics workforce, or in expanding service coverage. The application of standards, such as the Institute of Electrical and Electronics Engineers Standards Association (IEEE SA) AI Ethics and Governance Standards,[40] to ensure that ethical principles are incorporated in AI and algorithm design and development, is necessary.

4.4. HUMAN CAPACITY DEVELOPMENT AND CONTINUOUS RESKILLING AND UPSKILLING

There is a human resource crisis in transportation and logistics, which has been exacerbated by the pandemic. There are reports of driver shortages and low staffing levels in warehouses, as well as shortages of qualified logistics managers in both developed and developing countries.[41] These are due to a combination of various factors such as uncompetitive pay, poor and unsafe working conditions, an aging

[40] IEEE SA. *IEEE GET Program for AI Ethics and Governance Standards*. [Online]. Available: https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=93

[41] World Economic Forum. *Supply Chains: Human Resource Issues*. [Online]. Available: https://intelligence.weforum.org/topics/a1Gb0000000pTDoEAM/key-issues/a1Gb0000005QyaFEAS

workforce, the inability to attract young talent, and a lack of training and career progression. There is an urgent need to attract and retain more skilled workers in logistics management roles.[42]

Increases in technological sophistication of agrifood logistics operations and complexity of supply chains call for new and varied skills at operational and managerial levels, which require reskilling and upskilling of existing human resources.

A holistic skills and competencies framework for reskilling and upskilling personnel along the agrifood transportation and logistics system is needed for conducting training needs assessments and developing a certification system that incorporates digital skills building and gender-sensitive, green, and safe operations along smart multimodal corridors.[43] This will enable the collaboration with different actors to build a cadre of certified professionals that can facilitate agrifood system transformation across the supply chain. Proactive efforts are needed to build the capacity of women, MSMEs, those living in rural and remote areas, and informal workers in transportation and logistics.

4.5. SAFETY, SECURITY, AND WELL-BEING OF WORKFORCE

The fact that the transportation and logistics workforce is classified as front liners during emergencies to ensure the continuity of supply chains means that they need to be well protected from harm. Port and warehouse staff tend to operate in relatively dangerous environments with heavy machinery and equipment,[44] and delivery workers' visits to multiple sites expose them to multiple health risks during pandemics. Keeping the supply chains moving will rely on prioritizing the health, safety, and well-being of the transportation and logistics workforce.[45]

Some countries have started introducing wearables to improve the safety and productivity of their workers.[46] Smart wristbands, helmets, glasses, and protective gears equipped with sensors can capture biometric and environmental data to identify when a worker has fallen, shut down machinery if a worker

[42] A. McKinnon et al., *Logistics Competencies, Skills, and Training: A Global Overview*. Washington, DC, USA: World Bank, 2017. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/27723

[43] *Ibid*.

[44] *International Labour Organization, Safety and Health in Ports (Revised 2016) (Geneva, 2018)*. [Online]. Available: https://www.ilo.org/wcmsp5/groups/public/—ed_dialogue/—sector/documents/normativeinstrument/wcms_546257.pdf

[45] Frances House. (Mar. 31, 2020). *The Invisible Transport Workforce Keeping Supply Chains Moving*. Institute for Human Rights and Business. [Online]. Available: https://www.ihrb.org/other/supply-chains/commentary-invisible-transport-workforce-keeping-supply-chains-moving

[46] V. Patel et al., "Trends in workplace wearable technologies and connected-worker solutions for next-generation occupational safety, health, and productivity," *Adv. Intell. Syst.*, vol. 4, no. 1, Jan. 2022, Art. no. 2100099, doi: /aisy.202100099.

gets too close, indicate sickness at the start of a shift, or alert workers when they get too close to each other to comply with social distancing rules. To raise workers' productivity, barcode scanners on wrists and fingers can eliminate manual data entry, while smart glasses can help workers identify packages and products simply by looking at them.[47]

As these devices track movement, location, and biometric data that can be used to identify trends and gain insights into workers' health and productivity, wearables have raised privacy concerns.[48] For example, the number of steps taken by an employee with the wearable device can be monitored and tallied for a task being performed, and this information can be used to determine how the movement of the employee throughout the facility can be modified to improve performance. This same data, however, can also be used to penalize the lack of productivity of individual workers.

Truckers or pilots could be required to wear devices that monitor alertness or alcohol in the system. New sweat sensors can now not only detect alcohol but also a huge range of biomarkers that measure health and the potential for disease.[49] While wearables may be deployed to improve safety and warn employees to preempt medical conditions, their reliability and privacy need to be carefully assessed.

4.6. COOPERATION AND COLLABORATION FOR CROSS-BORDER AGRIFOOD TRADE

As multimodal corridors require collaboration between countries, standards and models are needed for intergovernmental agreements on issues such as border crossing point infrastructure, infrastructure capacity, design standards, control systems, and so on.[50] Policy and regulatory harmonization are needed to facilitate efficient movement along multimodal corridors and at border crossings. This could include streamlining administrative procedures, standardizing rules and documentation, and simplifying border control and procedures.[51]

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[47] Helen Colam. (Oct. 26, 2020). *The Benefits of Wearable Devices in Logistics*. Supply Chain News Africa. [Online]. Available: https://scnafrica.com/2020/10/26/the-benefits-of-wearable-devices-in-logistics/

[48] R. J. Bowman. (Oct. 22, 2022). *How Wearables Are Transforming Transportation and Logistics*. Supply Chain Brain. [Online]. Available: https://www.supplychainbrain.com/articles/32065-how-wearables-are-transforming-transportation-and-logistics

[49] Craig Guillot. (May 21, 2019). *Wearables in the Warehouse Bring Privacy Concerns to the Forefront*. Supply Chain Dive. [Online]. Available: https://www.supplychaindive.com/news/wearables-IoT-tracking-workers/555232/

[50] United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States. (2020). *Report on Best Practices for Effective Transit Transport Corridor Development and Management*. [Online]. Available: https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/lldcs_publications/corridor-report-_-final-_un-ohrlls_28may2020.pdf

[51] United Nations Economic and Social Commission for Asia and the Pacific. (2019). Developing Coordination and Institutional Arrangements for the Management of Intermodal Transport Corridors in the ESCAP Region. [Online]. Available: https://www.unescap.org/sites/default/files/Finalized%20study%20report%20on%20intermodal%20corridors%20December%202019%20%20.pdf

A key barrier to cross-border agrifood trade is the lengthy and complicated border control and customs clearance processes. Traders are often faced with a host of repetitive fees, permissions, redundant documentation procedures, and uneven certificate-of-origin requirements, each of which may constitute a small delay or expense to traders, but collectively, they represent a significant barrier to trade.[52] Even when single windows have been introduced to fulfill import, export, and transit-related regulatory requirements, the multiple documents required, for example, import declaration forms, origin certificates, invoices, import permits, and standards compliance, can be burdensome for traders.[53] Additionally, small cross-border traders may be unable to provide all of the information. There is, therefore, an urgent need to streamline, standardize, and simplify border control and customs clearance processes for agrifood products to reduce logistics costs and delivery times, as well as avoid food losses.

5. PROGRESS IN THE DEVELOPMENT OF STANDARDS FOR SMART MULTIMODAL CORRIDORS

A comprehensive package of standards for smart multimodal corridors that incorporates the principles of resilience, green transition, and inclusion (described in Section 3) and the six interrelated components of the framework for transportation and logistics in the agrifood sector (described in Section 4) is needed.

Although globally there are examples of corridors such as the Pan-European Corridors, African Central and Northern Corridors, Trans-Kalahari Corridor, Corridor of the Coordinating Committee of the Trans-Siberian Railway, New Eurasian Land-Bridge Economic Corridor, and China-Mongolia-Russia Economic Corridor, and countries generally recognize the benefit of planning for smart multimodal corridors, they are often not planned and designed in a holistic manner. As a result, they are not operating optimally toward the achievement of Sustainable Development Goals. For example, the Strategy Plan 2021–2025 of the African Central Corridor[54] notes that more than 90% of current traffic on the Central Corridor is carried by road, resulting in high trade logistics costs, low reliability in the delivery of shipments due to congestion, and negative social and environmental impacts. The strategy plan is taking a step toward more holistic

[52] United Nations Economic and Social Commission for Asia and the Pacific. (Oct. 2020). *Learning Materials on Transport Corridors*. [Online]. Available: https://www.unescap.org/sites/default/files/Learning%20Material%20-%20Transport%20Corridors.pdf

[53] World Customs Organization. *Understanding Single Window Environment: Part 1, Volume 1*. [Online]. Available: https://www.wcoomd.org/-/media/wco/public/global/pdf/topics/facilitation/instruments-and-tools/tools/single-window/compendium/swcompendiumvol1parti.pdf

[54] Central Corridor Transit Transport Facilitation Agency. (2021). *The Strategic Plan 2021–2025*. [Online]. Available: https://centralcorridor-ttfa.org/download/ccttfa-5-year-strategic-plan-2021-2025/

planning of a smart multimodal corridor, and a comprehensive package of standards for smart multimodal corridors will support this process.

This comprehensive package of standards for smart multimodal corridors should build on existing relevant standards developed by various standards-setting organizations. Organizations such as the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), International Maritime Organization (IMO), World Customs Organization (WCO), and International Organization for Standardization (ISO) have been supporting the accelerated digitalization of transportation, logistics, and trade processes and documentation, particularly during the COVID-19 pandemic. They have also been developing transportation-, logistics-, and trade-related data standards for harmonization, interoperability, and easy exchange across systems and countries. The objectives have been to not only keep trade flowing in current and future crisis events but also protect frontline logistics workers while enabling remote working, with contactless digital solutions replacing paper documents.

UN/CEFACT, a subsidiary intergovernmental body of the United Nations Economic Commission for Europe (UNECE), is actively engaged in this area and has published a package of standards for the digitalization of multimodal transport data and document exchange.[55] The package of standards comprises technical specifications and supporting tools for digital documents accompanying goods transported across different modes of transport—air, rail, road, inland waterway, and sea—along corridors. The package of standards has been piloted in several countries.[56]

IMO is a specialized agency of the United Nations that sets standards for the safety and security of international shipping and prevents marine pollution from ships. The IMO Compendium on Facilitation and Electronic Business[57] is a tool for software developers used to design the systems required to support the transmission, receipt, and response via electronic data exchange of information needed for the arrival, stay, and departure of ships, persons, and cargo to a port and facilitate the development of smart corridors.

[55] United Nations Transport and Trade Connectivity in the Age of Pandemics. (Feb. 11, 2022). *UNECE Publishes a Package of Important Standards for the Digitalization of Multimodal Transport Data and Document Exchange*. [Online]. Available: https://unttc.org/news/unece-publishes-package-important-standards-digitalization-multimodal-transport-data-and

[56] United Nations Transport and Trade Connectivity in the Age of Pandemics. *Electronic Trade and Transport Documents and Data*. [Online]. Available: https://unttc.org/stream/electronic-trade-and-transport-documents-and-data and UNECE. (Oct. 31, 2022). *International High-level Conference on Digital Transformation of Information Exchange in Supply Chains Using United Nations Standards*. [Online]. Available: https://unece.org/info/Trade/events/372145

[57] IMO. *The IMO Compendium on Facilitation and Electronic Business*. [Online]. Available: https://www.imo.org/en/OurWork/Facilitation/Pages/IMOCompendium.aspx

WCO is an intergovernmental organization that supports the simplification and standardization of customs technology and regulations. For data standardization and harmonization, WCO offers the WCO Data Model, which is a set of data requirements for meeting the procedural and legal needs of cross-border regulatory agencies, such as customs, and export, import, and transit transactions.[58]

ISO is an independent, nongovernmental international organization. Some relevant ISO standards for smart multimodal corridors include ISO/TS 24533:2012, Intelligent transport systems—Electronic information exchange to facilitate the movement of freight and its intermodal transfer; ISO 23354:2020 Business requirements for end-to-end visibility of logistics flow; and ISO/DIS 23355, visibility data interchange between logistics information service providers that is still being developed.

TABLE 1 Summary of relevant standards and gaps in the development of smart multimodal corridors

Organization	Standard	Scope
UN/CEFAT	• Package of Standards for the Digitalization of Multimodal Transport Data and Document Exchange • United Nations Rules for Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) • Traceability of Sustainable Value Chains	Data and document exchange and system interoperability
UN/CEFAT and OASIS	• Electronic Business XML (ebXML)	Data exchange and system interoperability
IMO	• IMO Compendium on Facilitation and Electronic Business	Data exchange and system interoperability
WCO	• WCO Data Model for Cross-Border Regulatory Agencies	Data exchange and system interoperability
ISO	• ISO 15000-1:2021: Electronic business eXtensible Markup Language (ebXML) — Part 1: Messaging service core specification • ISO/TS 24533:2012 Intelligent transport systems — Electronic information exchange to facilitate the movement of freight and its intermodal transfer • ISO 23354:2020 Business requirements for end-to-end visibility of logistics flow	Data and document exchange and system interoperability

[58] WCO. *WCO Data Model*. [Online]. Available: https://www.wcoomd.org/DataModel

Organization	Standard	Scope
	• ISO/DIS 23355 Visibility data interchange between logistics information service providers (forthcoming)	
ISO	• ISO 22301:2019 Security and Resilience — Business continuity management systems	Infrastructure building to ensure the security and resilience of management systems
Gaps in Standards		
▪ Infrastructure building, sharing, and digitalization of smart multimodal corridors. ▪ End-to-end system of traceable and monitored cold logistics, cold storage facilities, and cold transport to ensure safe and secure delivery of perishable agrifood products. ▪ Ethics in robotics and AI design. ▪ Human capacity development. ▪ Safety, security, and protection of the workforce along smart multimodal corridors. ▪ Cooperation and collaboration across transport modes, sectors and industries, and countries.		

These standards are largely focused on systems interoperability and data exchange across different transport modes, sectors, and countries along the supply chain. However, they do not holistically address other components necessary for the successful development and deployment of smart multimodal corridors, including infrastructure building; ethics in robotics and AI design; human capacity development; safety, security, and protection of the workforce; and cooperation and collaboration across transport modes, sectors and industries, and countries.

When these components are not holistically considered, the effectiveness, sustainability, and resilience of the smart multimodal corridors could be jeopardized. For instance, investment in digital technologies must go hand in hand, with addressing the anxiety of employees who worry about job losses and their careers, and the difficulties, especially for aging workers, both technically and psychologically, to adapt to this transformation. Without this holistic approach, the digital and socioeconomic divides are likely to widen, and inequalities further exacerbated.

6. CONCLUSION

This paper calls for a comprehensive and holistic package of standards for smart multimodal corridors that incorporates the principles of resilience, green transition, and inclusion (described in Section 3) and the six interrelated components of the framework for transportation and logistics system for the agrifood sector (described in Section 4), building on existing relevant international standards.

There is a significant advancement in the development of global standards for systems interoperability and data exchange across smart multimodal corridors (described in Section 5). However, they do not holistically address other components necessary for the successful development and deployment of resilient, green, and inclusive smart multimodal corridors. The comprehensive package of standards also needs to accomplish the following:

- Prioritization of digital solutions that strengthen resilience, benefit vulnerable groups, advance environmental and social sustainability, and promote economic efficiency.
- Promote the development of inventories and the spatial mapping of transportation and logistics assets such as warehousing facilities, available cold chain infrastructure, and transport routes, including alternatives to road transport such as boat and barge capacities, as part of preparedness planning for crises.
- Incorporate standardized measurement and reporting of carbon emissions and the quantification of climate-related costs, as well as guidelines for the conduct of cost–benefit analyses that include assessment of the lifetime costs of infrastructure and the integration of climate change scenarios.
- Ensure inclusive access to smart solutions, as well as capacity building and meaningful participation of women, MSMEs, those living in rural and remote areas, and informal workers in transportation and logistics.
- Promote and enable the co-deployment of infrastructure in which infrastructure sectors (e.g., road, rail, energy, and ICT) collaborate to jointly construct and share resilient, green, and inclusive infrastructure.
- Support the upgrade and digitalization of strategic ports and terminals, including assessing the type of facilities and amount of capacity needed based on current and future demands and volumes of traffic and ensuring that the ports and terminals are environmentally sustainable and climate-resilient.

- Incorporate standards and guidelines for the repair, reuse, recycling, and disposal of digital devices, including IoT sensors and robots.
- Enshrine global standards and best practices for data security, privacy and protection, and ethics in AI (such as the IEEE SA AI Ethics and Governance Standards).
- Provide step-by-step guidelines in developing and integrating real-time end-to-end track and trace systems to ensure safe and secure delivery of perishable agrifood products.
- Develop a holistic skills and competencies framework for reskilling and upskilling personnel along the agrifood transportation and logistics system for conducting training needs assessments and developing a certification system that incorporates digital skills building and gender-sensitive, green, and safe operations along smart multimodal corridors.
- Promote the standardization, simplification, and digitalization of border control and customs clearance processes for agrifood products through initiatives like single window systems, ensuring the interoperability and cybersecurity of systems.
- Promote the maintenance of open and transparent agrifood markets, exempt agrifood products from sanctions, and refrain from imposing export bans and other trade-restrictive measures.
- Support developing countries, particularly least developed countries and landlocked developing countries, in applying the comprehensive package of standards for smart multimodal corridors.

Application of this comprehensive and holistic package of standards for smart multimodal corridors will support the creation of resilient and sustainable agrifood systems that can withstand future crises and ensure that safe and nutritious food is available to all during normal times and crises. More broadly, it will contribute to improved livelihoods and achievement of the Sustainable Development Goals.

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