The Evolution of Quality Infrastructure: Experiences and Prospects of Advanced Economies and Developing Countries

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Abstract

Quality infrastructure (QI) refers to the systems in place around metrology, standardization, accreditation, conformity assessment, and related activities and policy measures. This study analyzes the evolution and current state of national QI systems in both advanced and developing economies, tracing the trajectory of these systems and their foundational role in product safety, regulatory compliance, and trade. It also explores how QI systems in developing countries evolve through their own investments and through the support of specialized development cooperation programs.

Using seven country case studies, the study demonstrates that the development of QI does not follow a linear path with a country's progression in income levels. Rather, the development of QI is influenced by a country's economic structure, regulatory requirements, and culture around quality. The analysis stresses the importance of aligning QI with national priorities and global trends, while acknowledging challenges such as fragmented regimes and limited resources. The study concludes that internationally harmonized QI systems are essential for enabling developing countries to participate successfully in the international trade system, for helping domestic enterprises upgrade the quality of their products and services, and for ensuring that consumers have access to safe and good quality products and services.

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Contents

Standards: A Core Component of the Quality Infrastructure System

Standards are a key catalyst for growth and development. Standards, or *technical standards,*[1] as discussed in this study, are typically embedded within a wider system of quality infrastructure (QI). QI refers to an integrated system spanning technical components of metrology (the scientific study of measurement), standardization, accreditation, and conformity assessment (testing, inspection, and certification).[2] In addition to the technical components of QI, a nontechnical component, the promotion of quality, has recently been added (Harmes-Liedtke 2021d).

While the core elements of QI have developed organically over time in leading industrialized countries, particularly during the industrial revolution, the need for a cohesive and integrated system became apparent only with the rise of globalization and institutionalization of international trade. Institutions such as Germany's Physikalisch-Technische Bundesanstalt (PTB)[3] and the United Nations Industrial Development Organization (UNIDO)[4] have long assisted developing countries in promoting integrated national quality systems that were, at one time, referred to with different terms such as MSTQ (Metrology, Standardization, Testing and Quality) and SQAM (Standardization, Quality, Assurance and Metrology). However, these acronyms were difficult to understand, so leading experts later coined the term "quality infrastructure." *Quality infrastructure* refers to the technical systems that support the quality and safety of products, services, and processes. It differs from the term "quality of infrastructure," which refers to infrastructure such as roads, bridges, railways, or pipelines.

It is challenging to examine the elements of QI in isolation or to disentangle the effects of any single element from the rest, given how interconnected the elements are. "Quality" is technically defined as "the degree to which a set of inherent characteristics of an object satisfies requirements" [ISO 9000:2015, 3.6.2].[5] The requirements are defined by technical standards and assessed by technically competent and independent bodies known as conformity assessment bodies.[6] Accreditation bodies formally recognize the technical competence and independence of the conformity assessment bodies. The work of both conformity assessment bodies and accreditation bodies is based on standards developed by the International Organization for Standardization (ISO) Committee on Conformity Assessment (CASCO) (ISO/IEC 17000:2020). These efforts are all underpinned by metrology, given that accurate, traceable, and internationally recognized measurements are essential for developing standards, for ensuring the validity of conformity assessment results, and for evaluating the technical competence of laboratories and certification bodies through accreditation.

The link between standardization and metrology was already evident in the first standard published by ISO: ISO/R 1:1951.[7] This metrology standard defined 20 degrees Celsius as the standard reference temperature for industrial length measurements (Doiron 2007).[8] The standard represents the metrological basis of all laboratory tests and symbolizes ISO's mission to promote international harmonization.

The concept of QI as a system originally emerged in the context of development cooperation, with knowledge transfer traditionally flowing from developed to developing countries. However, in some cases, developing countries have leapfrogged stages of institutional development, offering valuable models for more advanced economies to consider. Only in recent years has QI as a whole gained prominence among industrialized countries, despite their long legacies adopting individual QI components. For example, the regional quality infrastructure organizations of Europe established a European Quality Infrastructure Network only in March 2024 (EURAMET 2024).[9] By contrast, regional QI coordination mechanisms in developing countries—such as the Pan-African Quality Infrastructure (PAQI) and the Quality Infrastructure Council of the Americas (QICA)—were established more than one decade ago (SIM 2024; Union Africaine 2023), while the ASEAN Consultative Committee for Standards and Quality (ACCSQ) of the Association of Southeast Asian Nations (ASEAN) has been in operation for more than three decades. Regional QI bodies are essential for advancing formal trade integration and the development of common markets, as seen in the European Union (EU), the African Continental Free Trade Area (AfCFTA), and ASEAN.

Beyond trade facilitation, the coordination of QI activities at the regional and subregional levels supports the exchange of knowledge, the harmonization of procedures and standards, and the advancement of joint regional interests in global forums. Regional organizations play a critical role in promoting system interoperability, particularly in the context of increasing digitalization. They can also incentivize national QI institutions to operate more efficiently. Many of these regional efforts have emerged from developing countries, highlighting significant opportunities for mutual learning and shared advancement across regions.

This study examines the importance of QI for developing countries, with an aim to determining how far the development paths of QI in these countries should align with those of their high-income counterparts or diverge from them. Developing countries face the challenge of creating well-functioning QI systems that respond to the needs of modern technologies, that meet stringent demands from international buyers and regulators concerning the quality of products and services, and that manage an array of international standards that are in some cases fragmented—including private sustainability standards that operate outside the formal framework of established QI institutions. At the same time, many of these countries struggle with limited fiscal resources, weak government capacity, constraints on human capital resources, and a need to prioritize initiatives that significantly improve their development. Accounting for these factors, the central question becomes: to what extent do QI systems in high-income countries that are recognized as international best practices apply to developing countries today?

The next section examines the global landscape of international cooperation and harmonization in QI, emphasizing the need for alignment across national, regional, and international levels. The third section introduces the concept of QI maturity and presents levels and pathways of QI development, including rankings and trajectories derived from comparative indexes. The fourth section draws on case studies of seven countries —Brazil, Colombia, Ethiopia, Kenya, the Republic of Korea, Malaysia, and Viet Nam—to highlight diverse experiences, examples of institutional evolution, and lessons learned in the development of QI. The fifth section examines broad patterns in the evolution of QI systems. The sixth section discusses strategies for promoting QI in developing economies, while the last section concludes with insights on the implications of QI for trade, innovation, and sustainable development, offering recommendations for policy implementation and cooperation.

International Cooperation and Harmonization

Given that QI emerged in the context of globalization, QI systems should be aligned at the national, regional, and international levels to ensure coherence, mutual recognition, and the ability to effectively support trade, innovation, and regulatory objectives.

At the international level, two key organizations—the International Laboratory Accreditation Cooperation (ILAC), which covers testing and inspection, and the International Accreditation Forum (IAF), which focuses on the accreditation of certification bodies for products, persons, and management systems—facilitate cooperation among accreditation bodies. National accreditation bodies become signatories to the ILAC Mutual Recognition Arrangements and the IAF Multilateral Recognition Arrangements after undergoing rigorous peer evaluations, ensuring their accreditation decisions are internationally recognized. The widely used slogan of accreditation bodies, "Accredited once, accepted everywhere," reflects their objectives of reducing transaction costs, eliminating duplicative conformity assessments, and facilitating smoother market access—without compromising on quality or safety (EA 2018).[10]

In the area of standardization, coordinated efforts between the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the International Telecommunication Union (ITU) contribute to international harmonization.[11] These organizations develop globally accepted standards through a consensus-based, multistakeholder process. National standards bodies participate as members or observers in these organizations, ensuring that international standards are informed by domestic priorities and, in turn, can be adopted or adapted nationally. This system fosters regulatory coherence, interoperability, and innovation, while reducing technical barriers to trade. The process also relies on collaboration with regional standardization bodies, periodic revisions of standards, and mutual recognition agreements to promote safety, sustainability, and economic integration.

With respect to metrology, global consistency and comparability are ensured through a system of traceability and mutual recognition. National metrology institutes maintain primary measurement standards that are traceable to the International System of Units (SI), overseen by the Bureau International des Poids et Mesures (BIPM). Participation in the International Committee for Weights and Measures (CIPM) Mutual Recognition Arrangement enables national metrology institutes to demonstrate international equivalence of their measurement capabilities. Meanwhile, the International Organization of Legal Metrology (OIML) works with national authorities to develop model regulations and guidance for legal metrology, supporting fair trade, consumer protection, and regulatory enforcement. Through these mechanisms, national metrology systems are integrated into the global framework, enabling trust in measurements across borders.

Together, these international institutions anchor national QI systems in a globally recognized and coherent framework.

National Quality Infrastructure Development: Levels and Pathways

Maturity of national quality infrastructure

The development of a national quality infrastructure (NQI) typically progresses through different phases. These four phases, along with seven components, are summarized in table 1, which is based on the work of the World Bank Group and PTB in various developing countries around the world.

Table 1. Maturity levels of quality infrastructure (QI) services

QI SERVICE	MATURITY LEVEL			
	Rudimentary QI (limited QI in place)	**Basic QI (approach in low- to middle-income countries)**	**Advanced QI (economy-wide approach, sectoral specialization)**	**Mature QI (innovative, cutting-edge technology and service delivery)**
Legal metrology	Weights and measures may be legally established, but the effect in the market is negligible.	Weights and measures are established for goods traded over the counter (such as mass and volume of consumer goods) with recognized services.	Weights and measures system is the same as under basic QI but it is extended to prepackaged goods, and water and electricity meters; the scope of law enforcement is selective and limited.	Measures cover the whole spectrum of trade, law enforcement, health, and safety.
Scientific metrology or national measurement standards	The working standards of the legal metrology department are the de facto national measurement standards.	A small number of basic metrology laboratories (including the metrological level) exist, with recognized services.	Laboratories (including the CMCs) are defined through economy-wide surveys and sectoral international benchmarks.	High-level laboratories exist for innovative sectors.
Standards	A government department is the de facto national standards body but lacks any infrastructure to develop and publish national standards. It may have a rudimentary information service.	Basic infrastructure to adopt and publish international standards exists, along with rudimentary information service. Country is a correspondent member of ISO and involved in IEC Affiliate Country Program.	More advanced infrastructure to develop and publish national standards exists, and information services are well developed. Country is a member of ISO; associate member of IEC; and a member of CAC.	Mature processes to develop and publish any standard required by industry and the authorities exist, along with an advanced information center. Country is a member of ISO, IEC, CAC, and ITU.
Accreditation	Accreditation is not considered a necessity, and therefore no services are obtained from outside the country.	Accreditation is provided by accreditation bodies from outside the country through a bilateral or regional arrangement.	An accreditation body is established and recognized only recently internationally. Accreditation services are still limited to main sectors.	An accreditation body is fully recognized by IAF and ILAC, providing the full range of accreditation services.
Inspection bodies	A few public sector inspection bodies exist.	A few public sector inspection bodies exist, providing recognized services.	Inspection is primarily done through public sector bodies, but with private sector inspection services starting to adopt regulatory work and work for major purchasers.	The supply of inspection services is fully determined by free-market principles.
Testing laboratories	One or two public sector laboratories may exist. They tend to be under-staffed and lack accreditation.	A few public sector testing laboratories may exist, providing recognized services,	Many public sector testing laboratories exist across various ministries and agencies, and private sector laboratories are starting to be established.	Multiple private sector testing laboratories exist that cater to the market. The importance of testing by public sector laboratories has considerably diminished.
Certification	No certification body is in operation.	The NSB provides product and system certification, with recognized services.	The NSB provides product and system certification, in competition with a small number of private sector certification bodies.	The supply of certification services is fully determined by free-market principles, with many multinational certification bodies in operation.

Source: Kellermann 2019, 32.
Note: CAC = Codex Alimentarius Commission; CMCs = calibration and measurement capabilities; IAF = International Accreditation Forum; IEC = International Electrotechnical Commission; ILAC = International Laboratory Accreditation Cooperation; ISO = International Organization for Standardization; ITU = International Telecommunication Union; NSB = national standards body; QI = quality infrastructure.

Although there is significant interdependence among the various QI elements, this does not imply that the development of each area is mutually dependent. In other words, a high level of development in one area of QI is not a prerequisite for reaching an advanced level in another (refer to the discussion on "Global rankings on QI" for further information). The coevolution of the supply and demand of QI services, along with economic development and a country's culture surrounding quality, is a dynamic process and is central to understanding the dynamics outlined in table 2. However, the relationship between a country's level of economic development and the maturity of its QI system poses a key tension. While the maturity of QI is typically defined by supply-side attributes (such as institutional capabilities, services offered, and international participation), demand for QI is largely driven by a country's economic structure, its regulatory needs, and its prevailing quality culture. If the maturity of QI is equated too closely with economic development, it risks obscuring the more nuanced and policy-relevant issue of a mismatch, where QI systems may either lag behind or advance ahead of a country's economic needs. This mismatch is precisely where QI can either constrain or enable development.

Table 2. Coevolution of demand for, supply of, and development of quality infrastructure (QI)

Maturity level	QI service supply	QI service demand	Economic development	Quality culture
Rudimentary QI	• Basic metrology, minimal testing labs. • Reliant on external support.	• Limited to regulatory compliance.	• Supports primary industries (e.g., agriculture, raw materials).	• Fragmented awareness; quality seen as a cost rather than value.
Basic QI	• Expanded testing/certification. Regional harmonization of standards.	• Driven by SMEs seeking market access.	• Enhances trade competitiveness in sectors with low value added.	• Growing recognition of quality as a market differentiator.
Advanced QI	• Sector-specialized services (e.g., pharma, automotive). Digitalized processes.	• Sophisticated demand from exporters and FDI-driven industries.	• Facilitates high-value exports and integration into global value chains.	• Quality is a strategic priority for firms and policy makers.
Mature QI	• Predictive analytics, smart metrology. Proactive innovation in standards.	• Driven by consumer preferences (e.g., for sustainability, safety).	• Fuels high-tech industries and circular economy models.	• Proactive quality mindset embedded in society; practice of continuous improvement.

Source: Original research for the *World Development Report 2025.*
Note: FDI = foreign direct investment; QI = quality infrastructure; SME = small- and medium-size enterprise.

To highlight these frictions better, table 3 outlines the challenges that emerge along the development trajectory. These challenges, in turn, help explain why the supply of QI may be inadequate or misaligned with the demand, regardless of whether each stage of economic development is correlated with a suitable QI system.

Table 3. Typical demand for quality infrastructure (QI) and challenges along the development trajectory

	Rudimentary QI	Basic QI	Advanced QI	Mature QI
Features of the economy	• Primary industries. • Informal firms.	• Low-value added sectors.	• Diversified economy. • Higher economic complexity.	• Innovation-based economies. • Leading role in GVCs.
Demand for QI	• Firms to meet export market regulations. • Basic domestic regulation for safety and health (e.g., construction and food).	• Firms, particularly SMEs, need quality upgrading for market access. • Regulation expands to more sectors and goals (e.g., environment).	• Sophisticated demand from exporters and FDI-driven industries. • Quality-aware consumers. • More advanced regulations (e.g., IT security, consumer protection).	• Quality-oriented consumers. • Wide range of regulated areas (e.g., sustainability, advanced consumer protection).
Typical challenges in implementing QI	• Lack of laboratories and weak staff capacity. • Domestic market too small for private QI providers. • Firms do not adopt standards. • Government lacks enforcement capacity. • Reliance on foreign QI.	• Gaps in QI capacities. • Low levels of international recognition. • Strong presence of public sector in quality assurance. • International participation.	• Expansion of the scope of QI. • Public divestment from QI services. • Effective coordination between public and private QI institutions. • International participation.	• Digitalization of QI. • Adoption of QI for services. • Using QI for smart regulation. • Leadership in international QI forums.

Source: Original research for the *World Development Report 2025.*
Note: FDI = foreign direct investment; GVC = global value chain; IT = information technology; QI = quality infrastructure; SME = small- and medium-size enterprise.

The Rapid Diagnostic Tool (RDT), which has been applied by the World Bank Group and PTB in many countries,[12] can be used to determine the maturity of NQI systems (PTB 2022). This study traces the maturity level and development of NQI systems based on the experience of the World Bank Group and PTB, as well as the experience of seven countries from different regions and stages of development. The countries were selected because they have all made significant efforts to strengthen their QI, with support from members of the Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC). The results are summarized in table 4.

Table 4. Categorization of economies according to their level of quality infrastructure (QI) development

Country	QI level	Key strengths
Korea, Rep.	Mature	The Republic of Korea's QI is an advanced, internationally integrated system, supporting its status as a leading industrial and technological nation. QI is deeply embedded in the country's industrial and innovation policy. Its leadership in metrology (through the Korea Research Institute of Standards and Science, KRISS), standardization (through the Korean Agency for Technology and Standards, KATS), and accreditation (through the Korea Accreditation Board, KAB) reflects its early and sustained investment in high-quality institutions. This integration has supported the growth of high-tech industries and strong international engagement, making Korea a global benchmark in QI.
Malaysia	Advanced	Malaysia maintains a comprehensive and well-coordinated QI system, led by the Department of Standards Malaysia (DSM) for standards and accreditation and the National Metrology Institute of Malaysia (NMIM) for metrology. It demonstrates global leadership in niche areas such as halal certification and its QI system is well integrated into regional and global trade frameworks, supported by strong mutual recognition agreements and by alignment with initiatives of the Association of Southeast Asian Nations (ASEAN). In addition, Malaysia has been an early adopter of digital and green QI standards, reflecting its forward-looking industrial strategy.
Brazil	Advanced	Brazil's QI maturity is underpinned by robust national institutions: the National Institute of Metrology, Quality, and Technology (INMETRO) (public); the Institutes of Weights and Measures (IPEM-SP) (public entities at the level of federal states); and the Brazilian Association of Technical Standards (ABNT) (a private nonprofit). These institutions provide a solid foundation for metrology, standardization, and accreditation. QI is embedded in industrial and sustainability strategies, with targeted sectoral applications in agriculture, biofuels and energy transition, and aerospace, providing support for emerging and sustainable sectors. Brazil's longstanding participation in global QI agreements enhances its international credibility and underscores the strength of its technical capabilities.
Colombia	Advanced	Colombia has made significant strides in QI reform through institutional modernization under the National Quality Subsystem (SICAL) framework. This includes strengthening bodies such as the Colombian Institute of Technical Standards and Certification (ICONTEC) for standards; the National Accreditation Body of Colombia (ONAC) for accreditation; and the National Metrology Institute of Colombia (INM) for metrology. The country has actively aligned its QI with regional trade blocs and World Trade Organization (WTO) rules, and is increasingly engaging the private sector, particularly in value added agricultural exports, reflecting a growing demand for QI.
Viet Nam	Advanced	Viet Nam's QI system is led by the Ministry of Science and Technology and implemented through its two key QI institutions: the Directorate for the Standards, Metrology and Quality (STAMEQ) for hosting metrology, standardization and conformity assessment; and the Bureau of Accreditation (BoA) for accreditation. These institutions play a strategic role in supporting trade competitiveness, quality, and product safety. Viet Nam's alignment with international standards (such as those of WTO and the Codex Alimentarius [Food Code]) and its flexible sectoral strategy has allowed it to expand rapidly in emerging sectors such as electronics, halal certification, and renewable energy. Viet Nam's continued investment in modernization and digital alignment with global standards is helping to secure its position as a rising player in QI-led trade competitiveness.

Kenya	Basic (progressing to advanced)[a]	Kenya demonstrates regional leadership through its QI institutions (Kenya Bureau of Standards [KEBS] and Kenya Accreditation Service [KENAS]) and plays an active role in East African and other continental harmonization efforts. The country's growing private testing capacity complements public services, while its strategic use of donor-funded technical assistance has helped strengthen its institutional capacity and regulatory functions.
Ethiopia	Basic (progressing to advanced across some dimensions)[a]	Ethiopia has made significant state-led investments in QI, including institutions such as the Institute of Ethiopian Standards (IES) and the Ethiopian Accreditation Service (EAS). However, services remain limited in scope, with continued reliance on foreign laboratories and systems. Despite these shortcomings, Ethiopia is emerging as a regional actor and is building foundational capacity for the broader development of QI. The government's commitment to affordable QI access for small- and medium-size enterprises (SMEs)—particularly in agriculture and manufacturing—underscores its inclusive approach to the development of QI.

Source: Original research or the *World Development Report 2025,* based on Rapid Diagnostic Tool (RDT) Assessments and QI country studies.
Note: QI = quality infrastructure.
a. QI level is Based on the Pan-African Quality Infrastructure (PAQI) index. However, PAQI was designed to monitor the development of QI in Africa and is tailored to this regional context. Therefore, countries that are highly ranked on the PAQI index are not necessarily highly ranked in the global context. For example, Ethiopia is one of the highest ranked countries on the PAQI index, but it is ranked 83rd in the Global Quality Infrastructure Index (GQII). Similarly, Kenya is highly ranked on the PAQI index but is much lower ranked than Ethiopia (at 101st) on the GQII ranking.

The QI systems of these countries are at varying stages of maturity, reflecting differences in economic development, industrial structure, and institutional capacity. This variation is unsurprising, as the evolution of an NQI tends to align with a country's development trajectory and the specific needs of its domestic industries. For example, Korea has implemented a mature, innovation-driven QI system that is tightly integrated with high-tech sectors. On the other hand, Ethiopia is still in the foundational phase, albeit advancing by building basic institutional capacity and service coverage with the help of the "Quality Village" project.[13] Countries such as Malaysia, Brazil, and Viet Nam exhibit advanced QI systems shaped by targeted sectoral strategies and increasing international engagement. These differences highlight how QI development is not linear but rather coevolves with broader economic and policy contexts.

Components of the QI system

Although the main components of QI evolved independently at different times to solve specific problems and meet specific needs, the conceptualization of these components into a comprehensive system gained momentum only in the 1990s (Ramkissoon and Harmes-Liedtke 2023). Metrology is the oldest fundamental pillar of QI, with the first record of a permanent measurement standard dating back to 2900 BC, with the definition of the royal Egyptian cubit (Kellermann 2019). Modern metrology emerged during the French Revolution (Kellermann 2019). In 1791 the meter was defined, and in 1795, the decimal-based metric system was created. Nearly a century later, in 1875, the Metre Convention was signed, thereby establishing the metric system.

Standardization can be traced back to around 1000 BC, long before the first proper standards were developed (DKE 2020). It emerged from the necessity to have standardized weights and measures to facilitate trade and commerce. The modern concept of standardization rose to prominence during the Industrial Revolution (between 1760 and 1840) as the use of machinery increased and the first concepts of standards were introduced (DKE 2020). Standardization was applied to the electrotechnical sector in order to improve cost efficiency, optimize mass production, and facilitate the interchangeability of machine parts (DKE 2020). Standardization became increasingly important in the 20th century as globalization accelerated, and communication networks expanded.

Accreditation, a more recent phenomenon than standards and metrology, emerged in Australia during the second World War. The idea of "testing the testers" was born out of a necessity to ensure that the munitions being manufactured in Australia were of sufficiently high quality (NATA 2022). After the war ended, Australia continued to recognize the value of accreditation, as well as the possibility of its wider application, which led to the establishment of Australia's National Association of Testing Authorities (NATA) in 1945 (NATA 2022). From the 1960s onward, other countries followed Australia's example, developing their own accreditation institutions. In 1977, global interest in accreditation resulted in the convening of an international forum where the International Laboratory Accreditation Cooperation (ILAC) was created (NATA 2022).

Due to the interconnected nature of these components, several publications during the late 1990s and early 2000s in different parts of the world grouped metrology, standardization, accreditation, and conformity assessment into one system (Ramkissoon and Harmes-Liedtke 2023), including Metrology, Standards, Testing and Quality (MSTQ) (Lall 2000; Mans 1996; Meyer-Stamer 1998) or Standards, Quality Assurance, Accreditation and Metrology (SQAM) (Bentley West 2001).

Like the components that comprise it, QI systems emerged in different parts of the world as a result of the demands for high-quality products and services in international trade. After the Iron Curtain fell in 1989, trade between the East and the West resumed, almost doubling by 1995 and tripling by 2000 (Beestermöller and Rauch 2018). Due to rapid globalization, market share became increasingly determined by the quality of products and services, rather than their prices (Sanetra and Marbán 2007). This trend gave rise to the need for QI services by firms to ensure that they met, and could demonstrate, the quality requirements of export markets (Sanetra and Marbán 2007). Today, even low-income countries, especially in Africa, and very small countries, such as Small Island Developing States in the Caribbean and Pacific (Harmes-Liedtke 2021c), have at least a basic set of QI.

Rankings and trajectories

Regional rankings on QI: The PAQI index for Africa

QI in most African countries is less developed than in other regions. To address this gap, the Pan-African Quality Infrastructure (PAQI) Index was developed to specifically track the QI development of African countries, offering a more tailored assessment compared to global rankings, particularly for those with lower indicators. The exceptions are South Africa, the Arab Republic of Egypt, and Tunisia, which already have advanced systems. They ranked among the top 5 countries of the PAQI Index in 2023 and ranked well in the GQII 2023, with South Africa ranking 20th, Egypt 34th, and Tunisia 62nd.

The PAQI index has tracked the development of QI across member states of the African Union through four editions (2014, 2017, 2020, and 2023). It categorizes countries into five levels from well-developed QI to very limited QI (PAQI 2023). There has been an overall positive trend since 2014, with 32 African Union (AU) member states achieving at least a minimum threshold of adequate QI development in 2023, up from 25 in 2014 (refer to table 5). However, despite these advancements, many countries still struggle with limited QI development. Countries such as the Central African Republic, Chad, and Equatorial Guinea remain in the lowest categories, indicating limited progress over the years. Meanwhile, the QI maturity level in countries such as Angola, Burkina Faso, Mali, Mozambique, Niger, Senegal, and Togo has shifted internally within the "satisfactory" and "unsatisfactory" groups rather than making significant progress between levels.

Table 5. Maturity levels of quality infrastructure (QI) of African economies according to the PAQI index 2023

Category	Score range[a]	Economies
Well developed	3.3–4.0	Egypt, Arab Rep.; Ethiopia; Kenya; South Africa; Tanzania; Tunisia
Reasonably developed	2.5–3.2	Algeria; Botswana; Congo; Dem. Rep; Côte d'Ivoire; Ghana; Malawi; Mauritius; Morocco; Namibia; Nigeria; Senegal; Zambia; Zimbabwe
Partially developed	1.7–2.4	Angola, Benin, Burkina Faso, Eswatini, Madagascar, Mali, Mozambique, Niger, Rwanda, Seychelles, Sudan, Togo, Uganda
Limited	0.9–1.6	Burundi; Cameroon; Comoros; Congo, Rep.; Gabon; Gambia; Guinea; Guinea-Bissau; Lesotho; Liberia; Mauritania; Sierra Leone; South Sudan
None or very limited	0.0–0.8	Cape Verde, Central African Republic, Chad, Djibouti, Equatorial Guinea, Eritrea, Libya, Sahrawi Republic, São Tomé and Príncipe, Somalia

Source: PAQI 2023.
Note: PAQI = Pan-African Quality Infrastructure; QI = quality infrastructure.
a. Overall scores range from a low of 0 to a high of 4. The range for each category is shown in the table.

While the increasing global demand for higher product quality and adherence to health and environmental standards highlights the importance of strong QI systems, quality assurance services in 23 African countries still require substantial improvement. Encouragingly, more countries have developed good to very good QI systems, particularly those that already had partially developed systems. Economies such as The Gambia, the Sahrawi Republic, and Sierra Leone have made noticeable progress.

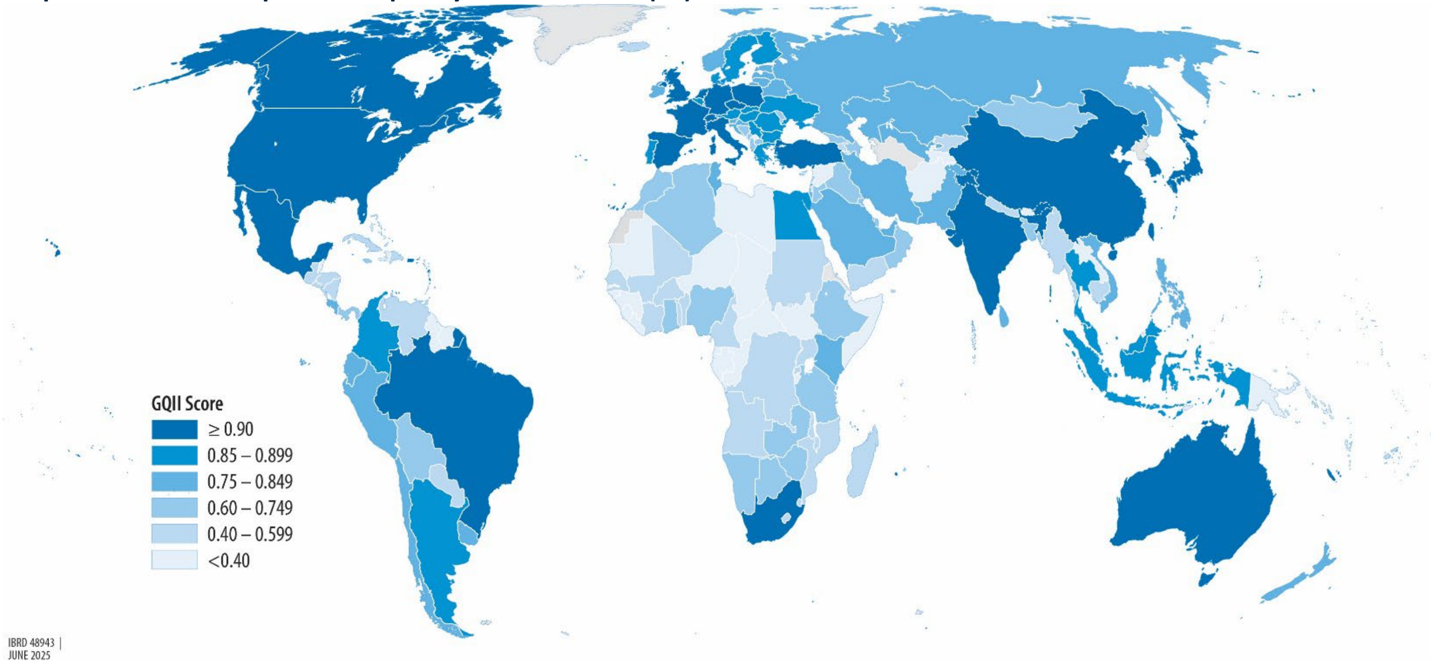
Conversely, QI systems have worsened in Cameroon, Eritrea, Gabon, Guinea, Libya, and São Tomé and Príncipe, highlighting the persistent disparities in the development of QI across the continent. The reasons for this decline vary by country, reflecting a range of structural, political, and economic challenges.[14] These cases demonstrate that improvements in QI must be achieved and sustained, as setbacks and reversals remain a real risk in the face of structural vulnerabilities. Despite these challenges, the overall trend in Africa remains positive.

Global rankings on QI

Several rankings exist that measure the QI systems of countries on a global basis. The Global Quality Infrastructure Index (GQII) evaluates and compares the state of the development of QI across 185 countries worldwide. As the first index of its kind, it draws on publicly available data covering key components of QI such as metrology, standardization, accreditation, and related international recognition (Harmes-Liedtke, Muñoz, and Waltos 2023).

Map 1 shows the state of the development of QI worldwide in 2023, as measured by the GQII. Countries such as Australia, China, India, the United States, Mexico, Brazil, and South Africa, as well as several European countries—are global leaders in QI. By contrast, many countries, particularly in Africa, have weak or poorly developed QI systems.

Map 1. Global development of quality infrastructure (QI)



Source: https://gqii.org/gqii-2023/.

Note: Darker color indicates better performance. Data for the Global Quality Infrastructure Index (GQII) are for 2023.

Table 6 highlights that a high overall rank in the GQII does not require consistently strong performance across all three components—metrology, standardization, and accreditation—even though they are weighted equally in the ranking. The last column shows the sum of the absolute differences between each sub-indicator rank and the overall rank. For example, Korea ranks 8th overall despite a significantly lower rank on accreditation (36th). Similarly, Brazil and Malaysia rank high overall, despite significant variation in their ranks on the subcomponents.

Table 6. Deviation between ranking on the overall GQII and ranking on the components

Country	Ranking on overall GQII (2023)	Ranking on metrology	Ranking on standardization	Ranking on accreditation	Absolute deviation from overall GQII rank
Korea, Rep.	8	6	6	36	32
Brazil	17	10	18	24	15
Malaysia	33	40	27	29	17
Colombia	39	41	44	31	15
Viet Nam	52	66	62	37	39
Kenya	56	51	64	64	21
Ethiopia	83	95	83	79	16

Source: https://gqii.org/gqii-2023/.

Note: GQII = Global Quality Infrastructure Index.

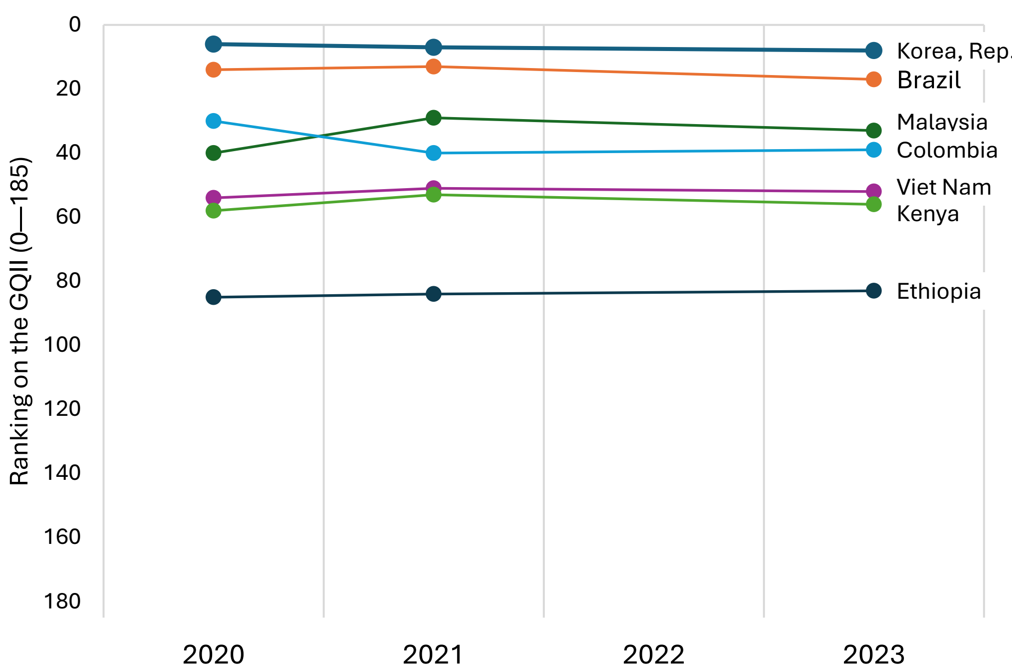
This pattern indicates that strategic strengths in one or two pillars can elevate a country's overall ranking, emphasizing the value of focused investment and development. This also suggests that a country does not need to be fully developed and equally strong across all QI components. Variation in the development of QI may reflect differing national priorities, historical trajectories, or context-specific needs, where certain areas were developed earlier or given greater emphasis based on strategic relevance.

The Quality Infrastructure for Sustainable Development (QI4SD) index links the development of QI with progress toward the United Nations Sustainable Development Goals (SDGs), thereby highlighting the role of QI as a key enabler of sustainable development.[15] The index, which is compiled by the United Nations Industrial Development Organization (UNIDO), maps key components of QI—metrology, standardization, accreditation, conformity assessment, and quality policy—to the People, Planet, and Prosperity pillars of the SDGs. This framework enables the evaluation of how national QI systems contribute to specific goals, including health (SDG 3), clean energy (SDG 7), industry and innovation (SDG 9), climate action (SDG 13), and others. Importantly, results from the QI4SD index are highly correlated with those of the GQII, reinforcing the consistency of both tools in assessing the maturity and relevance of national QI systems.

Trajectories in QI

A major limitation of research on QI is the lack of longer time series data. Available data of the GQII for four years indicate that most countries have maintained a similar ranking since 2020, as illustrated in figure 1. This finding is unsurprising, given the inertia surrounding institutional and legal changes, as well as the considerable investments in QI that are required to deliver results. In principle, it can be assumed that the provision of QI facilities and services tends to change slowly and is strongly influenced by the demand for the development of QI.

Figure 1. Trajectory of the development of quality infrastructure (QI) between 2020 and2023

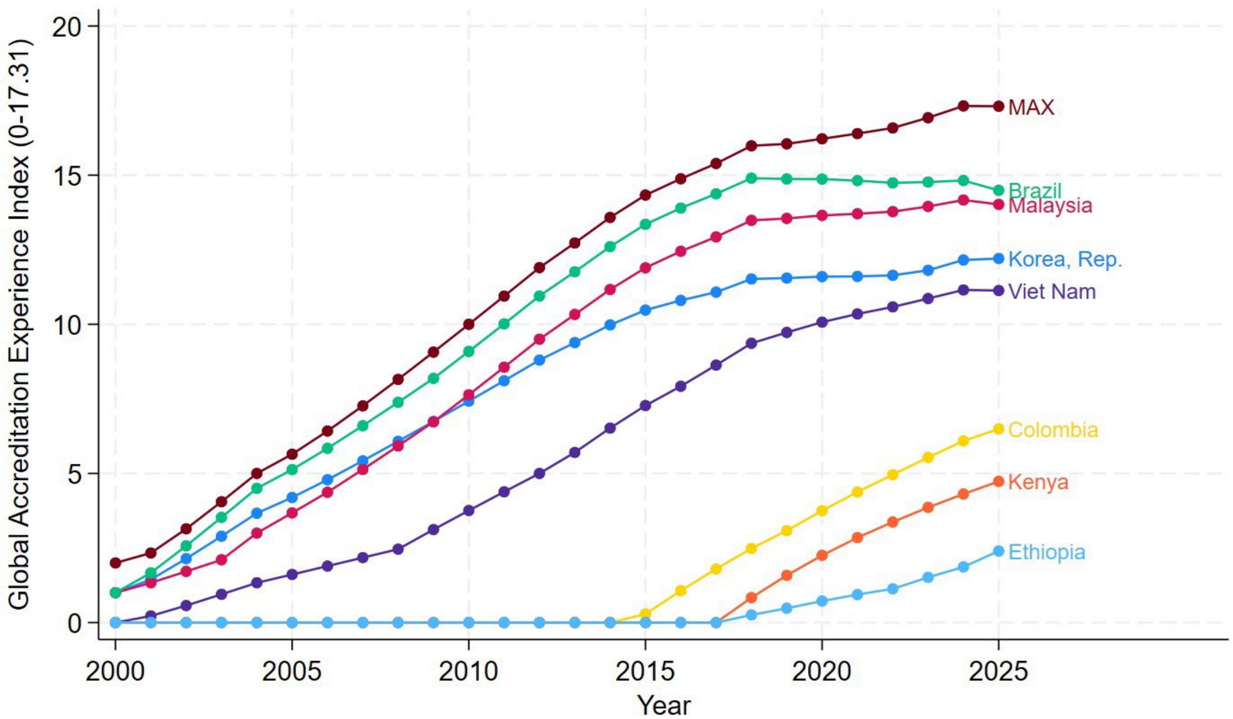


Source: https://gqii.org/.
Note: GQII = Global Quality Infrastructure Index.

Work is also underway to capture the development of individual QI components in different countries (Harmes-Liedtke and Ramkissoon 2025). Notably, the Global Accreditation Experience Index (GAEI) quantifies a country's accreditation experience over time,[16] building on the fact that accreditation bodies demonstrate their competencies by participating in international arrangements, such as the IAF Multilateral Recognition Arrangement and the ILAC Mutual Recognition Arrangement. Over the past few decades, the scope and competencies covered under these international arrangements have expanded. Using publicly available data on the signatories to the IAF Multilateral Recognition Arrangement and the ILAC Mutual Recognition Arrangement between 2000 and 2024, GAEI captures the interplay between the duration of an accreditation scope's existence and the length of time a country provides coverage for that scope. It considers Level 2 and 3 accreditation scopes under the IAF Multilateral Recognition Arrangement and the ILAC Mutual Recognition Arrangement, Level 5 scopes under the IAF Multilateral Recognition Arrangement, and accreditation scopes for private certification schemes (Riva 2025).[17]

Figure 2 shows the experience for the selected countries in the development of accreditation, which serves as a proxy for accreditation competence. All countries show continuous growth in accreditation competence. Brazil, Korea, and Malaysia built up their accreditation competence at a very early stage, followed by Viet Nam. Colombia, Kenya, and Ethiopia began the development of accreditation later, but the accreditation system is particularly dynamic in Colombia and Kenya.

Figure 2. Trajectory of accreditation between 2000 and 2024, as captured by the Global Accreditation Experience Index



Source: Harmes-Liedtke and Ramkissoon 2025.
Note: MAX indicates the highest attainable score for the Global Accreditation Experience Index (GAEI). The highest score changes every year conditional on the number of accreditation scopes and their associated time weights. The GAEI is calculated using weights: each scope's weight is based on the number of years it has existed relative to the total years of existence of all scopes in that year. Newer scopes, introduced in 2024 or 2025, have existed for a shorter time and therefore carry lower weights.

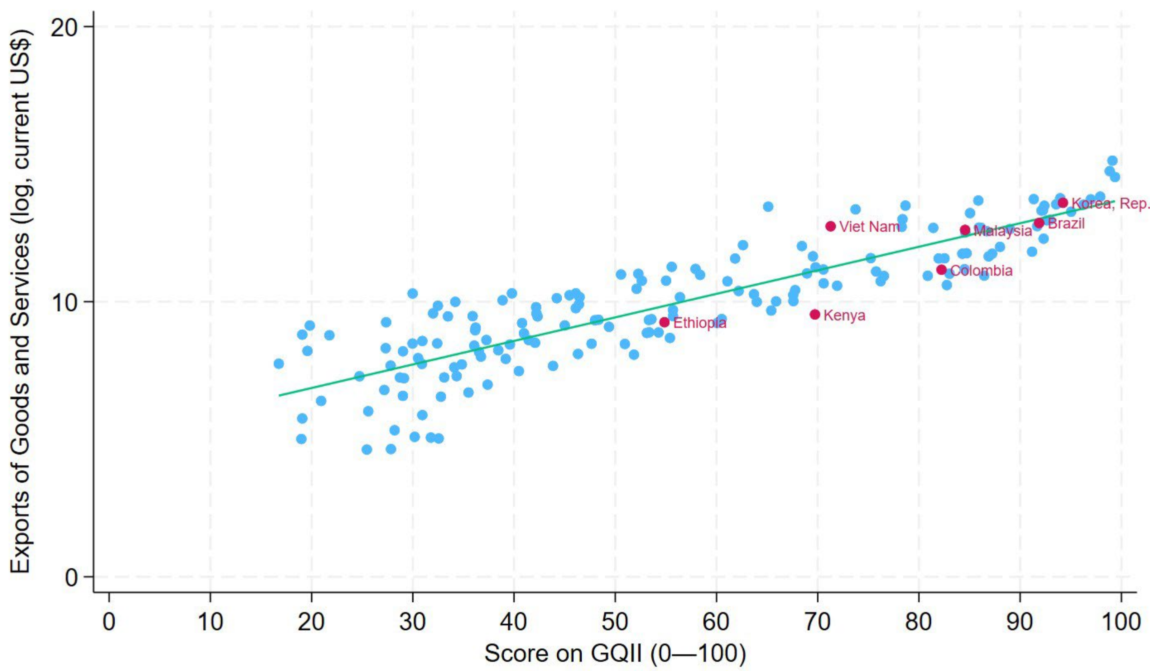
The growing gap between the highest attainable score (MAX) and the index value, especially for Brazil since 2018, is due to an increase in the accreditation of private certification schemes by IAF, which are mainly used in North American and European countries. With limited demand for these private certification schemes in specific sectors, countries often do not invest in building accreditation competencies in those scopes.

Relationship between QI, economic development, and complexity

National QI services typically develop in line with the demand of the export industry. However, the direction of the causality is not definitive: sometimes QI services offered follow the export opportunities; other times the available QI services are necessary to take advantage of the export opportunities in the first place. The latter pattern highlights the importance of the promotion of QI as a strategic development instrument. A robust QI system facilitates exports by reducing technical barriers, ensuring compliance with international regulations, and enhancing product credibility. It also lowers trade costs, prevents rejection of goods at borders, increases market access, and makes exports more competitive.

Highlighting the significant relationship between QI and export performance is a strong positive correlation (0.88) between the GQII and exports, illustrated in figure 3. Among the seven countries examined in case studies, Korea, Brazil, and Malaysia perform well on both measures. However, Brazil, despite its high ranking on the 2023 GQII (17th), exports at a similar level to Viet Nam (ranked 52nd). Viet Nam and Kenya offer a study in contrasts. Although they have similar rankings on the GQII (52nd and 56th, respectively), Viet Nam's exports are significantly higher. Ethiopia (ranked 83rd), has an export performance comparable to that of Kenya.

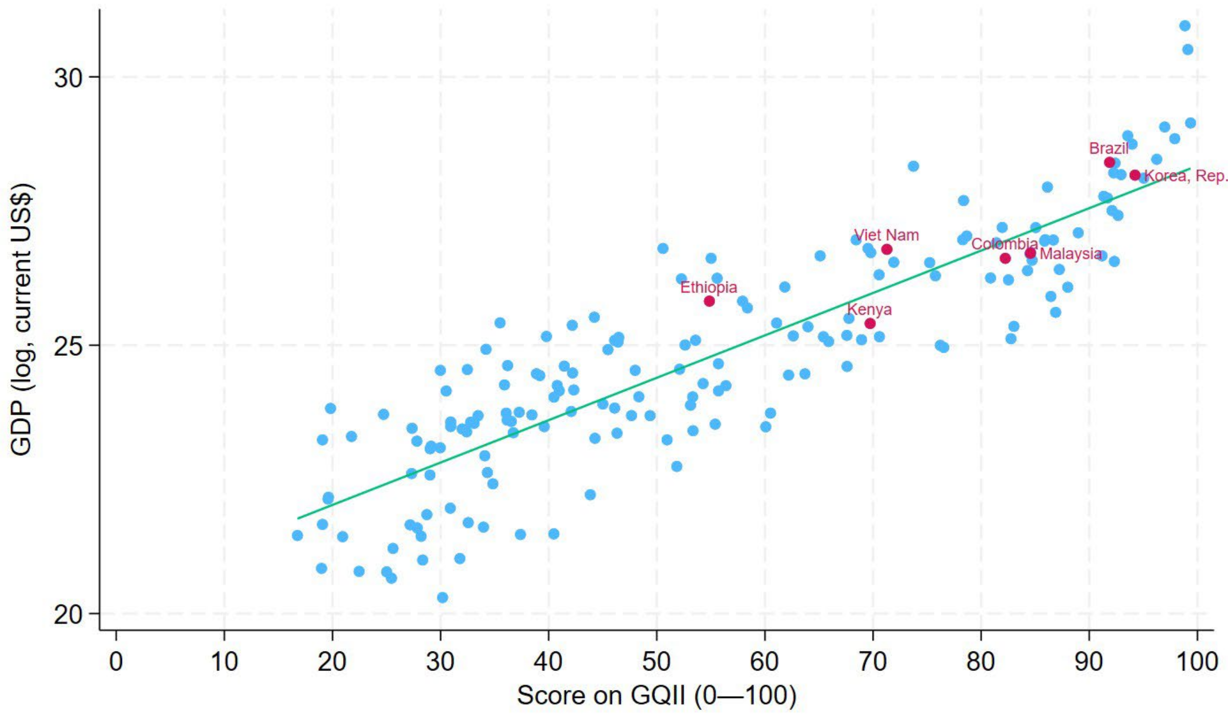
Figure 3. Correlation between development of QI and exports



Sources: For the GQII data, https://gqii.org/gqii-2023/. For the export data, https://data.worldbank.org/indicator/NE.EXP.GNFS.CD. Exports of goods and services are measured in terms of current US$ (log).
Note: Data for the GQII (Global Quality Infrastructure Index) and exports are for 2023.

There is also a strong positive correlation (0.85) between the development of QI and GDP (gross domestic product), illustrated in figure 4. However, Kenya, Colombia, and Malaysia fall below their peers relative to their level of QI development, while Ethiopia, Viet Nam, Brazil, and Korea perform better.

Figure 4. Correlation between the score on the GQII and GDP

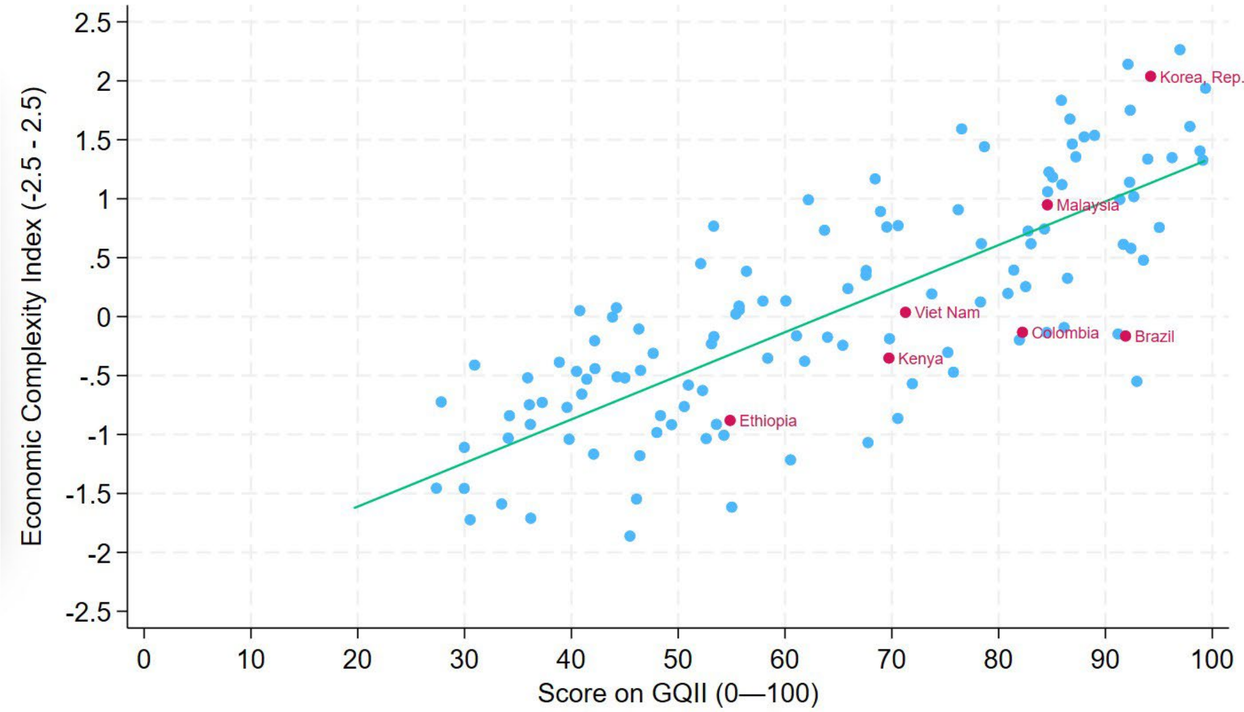


Sources: For the GQII data, https://gqii.org/gqii-2023/. For the GDP data, https://databank.worldbank.org/source/world-development-indicators.

Note: Data for the GQII (Global Quality Infrastructure Index) and GDP are for 2023. GDP = gross domestic product.

There is a strong positive correlation (0.73) between economic complexity and the development of QI, as illustrated in figure 5, indicating that countries with more advanced QI tend to have more sophisticated and diversified economies. Despite Brazil and Korea's similarly high rankings on the GQII, Korea has a high Economic Complexity Index (ECI), while Brazil's has a low one. The pattern is similar for Malaysia (high ECI) and Colombia (low ECI). This pattern suggests that while strong QI supports economic complexity, other factors such as industrial structure, innovation capacity, and trade policies also play a crucial role.

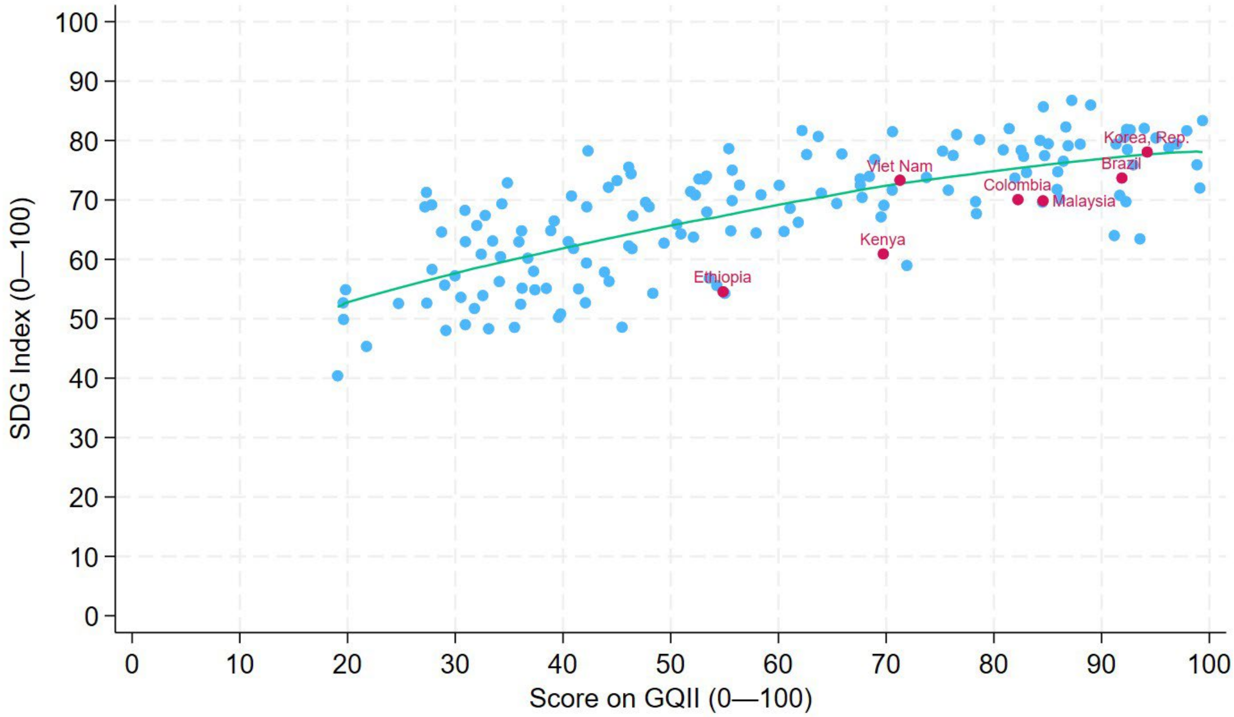
Figure 5. Correlation between the score on the GQII and the Economic Complexity Index



Sources: For the GQII data, https://gqii.org/gqii-2023/. For the Economic Complexity Index data, Observatory of Economic Complexity, https://oec.world/en/rankings/eci/hs6/hs96?tab=ranking.
Note: Data for the GQII (Global Quality Infrastructure Index) are for 2023.

There is a strong positive correlation (Spearman's rho = 0.7301) between the development of QI and the SDG Index, illustrated in figure 6, indicating that countries with well-established QI systems tend to perform better in achieving the SDGs. While Viet Nam and Korea do well on this measure, the other five countries analyzed in this study do not.[18] This may be due to factors such as economic inequalities, environmental challenges, or governance gaps that hinder progress on social and environmental goals. Developed QI systems support industries, but do not automatically ensure improvements in other areas of national well-being such as education, health, or sustainability.

Figure 6. Correlation between the score on the GQII and progress on the Sustainable Development Goals (SDGs)



Sources: For the GQII data, https://gqii.org/gqii-2023/. For the SDG index data, https://www.sdgindex.org.
Note: Data for the GQII (Global Quality Infrastructure Index) are for 2023 and for the SDG index are for 2023.

Lessons from the Experiences of Selected Countries: Brazil, Colombia, Ethiopia, Kenya, Korea, Malaysia and Viet Nam

Country QI portraits

Korea's QI development journey: From rudimentary to mature

Korea is a country that has successfully developed in a relatively short period of time, transitioning from a developing country to a high-income donor country; it has been a member of the OECD DAC since 2010 (Korea, Ministry of Foreign Affairs, n.d.; Seo, Bahng, and So 2013). The development of Korea's QI since the end of the second World War reflects a remarkable evolution from a rudimentary system to a mature, state-of-the-art framework. This evolution from fragmented beginnings to a cohesive, innovation-driven QI framework has been instrumental in Korea’s rise to an economy whose GDP topped $1.7 trillion and whose annual exports exceeded $754 billion in 2023.[19]

While Korea’s trajectory of the development of QI appears mainly to be “pulled” by economic advancement, some “push” elements also played a significant role. Korea’s experience is also distinct due to the leading role of the government and the sequencing of its development of QI. The trajectory of Korea’s development of QI is characterized by early government leadership, close public-private coordination, and a sector-prioritized approach that evolved over time. After the Korean War in the late 1950s and early 1960s, the country's NQI was rudimentary, with minimal institutional structures for standardization, metrology, or accreditation. The country recognized the need for standardized quality to drive industrial growth and export competitiveness and subsequently began developing a basic QI framework in the 1970s (NIST 1972).

A defining aspect of Korea's development of QI was the sequencing of its components. The country first focused on metrology, signing the Metre Convention in 1959 (Yoo 2019). It then established the Korea Research Institute for Standards and Science (KRISS) in 1975 to provide high-precision measurement capabilities to support industrial manufacturing (Choi 2013; Seo, Bahng, and So 2013). Only later were national standards and accreditation systems more formally structured, with the establishment of the Korean Agency for Technology and Standards (KATS) in 1983, the Korea Laboratory Accreditation Scheme (KOLAS) in 1992, and the Korea Accreditation Board (KAB) in 1995.

This "pull-driven" development of QI was closely aligned with a pattern of industrialization led by large conglomerates (chaebols). In the early period between the 1960s and 1980s, QI institutions were built in tandem with the country's export-oriented industrial policy, primarily serving the needs of chaebols in key sectors such as electronics, automotive, and shipbuilding (Seo, Bahng, and So 2013). Standards, testing, and certification often mirrored the international compliance needs of these large exporters. Agencies such as the Korea Testing Laboratory (KTL) and the Korea Testing and Research Institute (KTR) evolved to support chaebols in achieving access to the global market and developing bespoke electronics, shipbuilding, and automotive production services.

However, Korea's trajectory in the development of QI also contains important "push" elements. From the late 1990s, concerns about over-reliance on chaebols led the government to promote innovation and employment through the development of small and medium enterprises (SMEs). This shift also reshaped the priorities on QI. The Ministry of SMEs and Startups created dedicated programs to increase access to testing, certification, and metrology services for SMEs. Agencies like KTL and KRISS launched outreach and training initiatives tailored to the needs of SMEs, including regional access through techno parks and innovation centers (Seo, Bahng, and So 2013). Despite these efforts, SMEs continued to face challenges, including uneven awareness and accessibility of QI services among SMEs and the chaebols' domination around standardization.

As the Korean economy diversified and its technological capabilities expanded between the 1980s and 1990s, its quality assurance system evolved accordingly. Since the 2000s, Korea's QI system has matured through active participation in international standardization and accreditation bodies. For example, its participation in ISO and IEC facilitated its alignment with global standards. Furthermore, investment in advanced research and development has made Korea a leader in emerging sectors such as information technology and biotechnology, and its QI framework has adapted to support these industries.

Countries with advanced QI services: Brazil, Malaysia, Colombia, and Viet Nam

Despite following different development paths, Brazil, Malaysia, Colombia, and Viet Nam share several important structural characteristics: they are middle-income countries with export-driven growth strategies, sectoral specialization, and strategic investments in QI to enhance competitiveness. These countries have recognized that alignment with international standards, credible conformity assessment services, and internationally recognized metrology systems are crucial tools for accessing and maintaining their position in global markets.

Malaysia and Viet Nam, in particular, have benefited from relatively fast-paced industrialization and deeper integration into global value chains, giving them an advantage in efficiency and innovation-driven improvement in the quality of their goods and services. In this context, efficiency refers to how effectively the QI systems of Malaysia and Viet Nam deliver timely, coordinated, and industry-responsive services, such as testing, certification, and alignment of standards, particularly in high-export sectors. Their integration into global value chains pushed them to streamline their QI processes, reduce turnaround times in the provision of QI services, and adopt international best practices more rapidly than peers. By contrast, although Brazil and Colombia have made significant strides in institutional capacity-building, they continue to face persistent challenges in regulatory coordination, economic diversification, and ensuring comprehensive regional coverage of QI services.

Brazil, Malaysia, and Colombia were early supporters of the multilateral trade system and founding members of the WTO in 1995. Brazil joined the General Agreement on Tariffs and Trade (GATT) in 1948, followed by Malaysia in 1957, and Colombia in 1981. Viet Nam joined the WTO more recently, in 2007. Nevertheless, it has rapidly aligned its QI institutions to meet the demands of its high-performing export sectors.

Brazil has the longest experience in setting up QI institutions of the countries examined in the case studies (Harmes-Liedtke 2021a). The country (then the Empire of Brazil) was one of the first signatories to the Metre Convention (May 20, 1875). However, progress was repeatedly interrupted, requiring efforts to be revisited and renewed over time. For example, the National Council of Metrology, Standardization and Industrial Quality (CONMETRO) did not meet from 2017 until its relaunch in April 2023.

Brazil established CONMETRO in 1973 as the collegiate body responsible for formulating and supervising national QI policy. In the same year, it created the National Institute of Metrology, Quality, and Technology (INMETRO) as its national metrology institute, with a mandate that has since expanded significantly. Operating under a model that is heavily driven by regulation, Brazil’s QI has emphasized consumer protection, industrial development, and compliance with national technical regulations. This model contributed to the consolidation of multiple QI functions within INMETRO, including scientific, industrial and legal metrology, accreditation (via the General Coordination of Accreditation, CGCRE), product regulation, and conformity assessment.

INMETRO now accredits more than 3,400 conformity assessment bodies and manages a network of testing and calibration laboratories aligned with international standards recognized by the IAF, ILAC, and IAAC. It has also led flagship initiatives such as the Brazilian Labelling Program (PBE), which promotes energy efficiency and has helped reduce energy consumption. More recently, INMETRO has taken on a proactive role in innovation and sustainability, supporting Brazil’s transition to a green economy through projects on the circular economy, electric mobility, green hydrogen, and energy efficiency. The institute also played a key role in the formulation of the National Quality Infrastructure Strategy (ENIQ), in collaboration with the Ministry of Development, Industry, Trade, and Services (MDIC).

Complementing INMETRO’s work, the Weights and Measures Institutes (IPEMs) operate at the federal state level to ensure legal metrology and market surveillance. Meanwhile, the Brazilian Association of Technical Standards (ABNT), officially recognized by CONMETRO in 1992, serves as Brazil’s national standardization body. ABNT develops and publishes more than 9,000 Brazilian technical standards, more than one-third of which are harmonized with international standards from ISO, IEC, and MERCOSUR.

This integrated structure centered around regulation has enabled Brazil to build a robust and centralized QI system. Brazil's rank on the GQII is among the highest in Latin America. However, challenges remain such as regulatory overlaps, regional disparities in service coverage, and institutional continuity. To address these gaps, CONMETRO’s Resolution No. 1 of 2023 formally launched the ENIQ development process, involving government agencies, the private sector, and civil society. ENIQ seeks to modernize and strengthen the QI system by improving governance, promoting innovation, and enhancing competitiveness. Consultations have included webinars, workshops, seminars, and public feedback. According to the 2024 public consultation, ENIQ is expected to improve the coherence of stakeholder actions, foster innovation, and enhance the competitiveness of Brazilian products and services in global markets (Brazil, MDIC 2024). Importantly, the strategy also aims to align the development of QI with broader public policy objectives under Brazil's industrial strategy—Nova Indústria Brasil (Brazil, MDIC 2025)—by positioning QI as a critical enabler of digital transformation and green technologies. The development process ended in May 2025, when CONMETRO approved two resolutions, establishing ENIQ and its 2025-2026 Action Plan, leading to the start of its implementation stage.

Malaysia started developing its QI system in 1964, soon after gaining independence in 1957, and as part of its export-oriented industrialization strategy (Harmes-Liedtke et al. 2022). Since then, Malaysia's QI has evolved organically in response to growing demand without adhering to a formally defined policy on QI. Intensive cooperation with Japan accelerated the development of its national QI institutions. Today, the Department of Standards Malaysia (DSM) is the central institution and operates under the direction of the Ministry of Investment, Trade and Industry.

In the 2000s, the country harmonized its standards with ASEAN and global trade agreements and increased the number of Mutual Recognition Arrangements. Since the 2010s, Malaysia has become a global leader in halal certification, through a system managed by the Department of Islamic Development Malaysia (JAKIM). The Malaysia Halal Standard (MS 1500) is widely accepted internationally, influencing halal standards and regulations in many countries. The country has also led the way in halal logistics, cosmetics, and pharmaceuticals standards, solidifying its position as a global halal hub. In recent years, Malaysia has embraced digital transformation in QI, promoting smart metrology, blockchain-based halal traceability, standards for green technologies, and quality assurance driven by artificial intelligence (AI).

Colombia has evolved it QI system in response to both global trade imperatives and internal productivity challenges. Initially driven by the export needs of traditional sectors such as coffee, flowers, and raw materials (Gallego and Gutiérrez 2016), the country intensified its efforts to promote QI following its economic liberalization in the 1990s, which created greater demand for standards, conformity assessment, and technical regulation.

While Colombia established the Colombian Institute of Technical Standards and Certification (ICONTEC) as early as 1963, the development of a comprehensive NQI system gained momentum only in the 2000s. In 2007, it established the National Accreditation Body of Colombia (ONAC)and in 2011, the National Metrology Institute of Colombia (INM). These institutions were integrated into a coherent institutional framework that coordinates quality assurance, standardization, metrology, accreditation, and regulatory oversight.

In addition, Colombia emphasizes harmonization with international trade obligations (notably, the WTO Agreement on Technical Barriers to Trade, Pacific Alliance), public-private collaboration, and the expansion of sector-specific QI services in priority sectors such as agroindustry, pharmaceuticals, and construction materials. The system has been strengthened by ONAC's international recognition through ILAC and IAF, and INM's participation in the CIPM Mutual Recognition Arrangement.

In 2015, under Decree 1074, Colombia formalized the National Quality Subsystem (SICAL), which has developed dynamically since then.[20] Over the past five years, SICAL's articulation with the productive sector has deepened in three key areas: (1) the development of new services aligned with emerging national priorities such as climate change, health and life sciences, and the energy transition; (2) increased global engagement of QI institutions in regional and international forums; and (3) the steady rise in the number of accredited conformity assessment bodies.

Other significant policy initiatives have further reinforced QI. The National Quality Policy, adopted in 2017, laid a foundational vision for QI, while the National Laboratory Policy (adopted through CONPES 3957 of 2019) elevated the role of laboratories in meeting demands for compliance. Integration has also improved between SICAL and broader competitiveness and innovation policies. For instance, QI agencies now participate in the technical committees of the National Competitiveness and Innovation System, supporting coordinated public-private action to strengthen industrial performance.

The country's most influential business association (National Business Association of Colombia, ANDI) is actively involved in governance structures, serving on the boards of ONAC and ICONTEC and participating in the Metrology Advisory Council of the INM. Moreover, since 2018, the INM has been recognized as a research center by the Ministry of Science, Technology and Innovation, enabling collaboration with universities and access to R&D (research and development) funding.

INM's inclusion in the National Commission on Sanitary and Phytosanitary Measures since 2021 marks a growing role in agricultural health and food safety. Colombia's recent National Reindustrialization Policy further institutionalizes QI as a strategic enabler of industrial transformation (Colombia, CONPES 2023). Between 2024 and 2027, INM aims to close critical metrological gaps by creating or improving measurement methods to support sectors such as energy transition, health, and agribusiness. At the same time, Colombia intends to strengthen the Colombian Metrology Network through knowledge transfer from INM and partner institutions to universities, laboratories, and industry professionals, alongside training for postgraduates in the relevant fields to ensure that a strong talent pool exists for new magnitudes and technologies. Meanwhile, between 2024 and 2026, the Ministry of Trade, Industry and Tourism (MinCIT) plans to launch a national standardization program incorporating a metrological component to ensure that Colombian Technical Standards (NTC) meet the traceability requirements of international markets. Additionally, ONAC is developing a methodology to measure the use of QI in the priority sectors of the reindustrialization policy. Finally, MinCIT will extend the Quality for Reindustrialization program until 2033, providing cofinancing and support to more companies to strengthen the quality of production, thereby accelerating the diversification and sophistication of export products.

This architecture enables the country to manage the entire measurement-standardization-accreditation-application cycle: the INM generates technical capabilities, MinCIT and ICONTEC codify these advances in standards, ONAC ensures their international recognition, and the extension of the Quality for Reindustrialization program makes these tools available to businesses. The result is a coordinated approach that establishes QI as the backbone of the new industrial policy and a driving force for regional and global competitiveness.

Despite this progress, persistent challenges remain, notably regional disparities in laboratory infrastructure, which limit access to accredited testing and calibration services outside urban centers. There is still a need to develop incentives for the different economic sectors to use the QI's services more intensively, and to publicize the country's conformity assessment capabilities more widely. To address these challenges, Colombia is expanding lab capabilities in strategic areas and promoting a broader culture around quality to ensure that the benefits of QI are accessible across all regions and economic sectors.

Colombia's QI is evolving into a multidimensional policy tool that supports trade facilitation, innovation, consumer protection, and sustainable development—all critical elements for building a modern, inclusive, and globally competitive economy. For example, Colombia's government plans to update its 2017 National Quality Policy to address digital transformation, artificial intelligence, and the circular economy.

Viet Nam has significantly developed it QI system over the past 60 years. Between the 1950s and 1970s, the QI system in the country's then northern half was based on a centrally planned economy model, with QI primarily supporting the defense and industrial needs of the state sector. In the 1970s, the country established its initial framework for standardization and metrology, still primarily focused on state-controlled industries. The mid-1980s marked a shift toward Viet Nam's integration with global markets with the establishment of the Directorate for Standards, Metrology, and Quality (STAMEQ), now the National Commission for Standards, Metrology, and Quality, under the Ministry of Science and Technology (MOST). During that period, Viet Nam also began adopting ISO- and IEC-based standards and it strengthened its QI system to support its comprehensive economic liberalization (referred to as Đổi Mới) and trade agreements, joining organizations like the WTO and enhancing accreditation through the Bureau of Accreditation (BoA).

In the 2010s and beyond, Viet Nam has continued to modernize its QI system by aligning its national standards with international benchmarks such as ISO, IEC, and the Codex Alimentarius (Food Code). The country expanded its testing and certification services among the public conformity assessment bodies under STAMEQ. Its recent developments on QI have focused on supporting digital transformation, sustainable development, and innovation ecosystems. And its ongoing alignment with ASEAN and international free trade agreements (such as EVFTA [European Union-Vietnam Free Trade Agreement], CPTPP [Comprehensive and Progressive Agreement for Trans-Pacific Partnership], and RCEP [Regional Comprehensive Economic Partnership]) has driven the demand for high-quality, internationally recognized QI services.

During the last decade, Viet Nam strengthened its NQI in sectors that include electronics, food, automotive, and renewable energy. This emerging trend shows that Viet Nam identifies business opportunities and leverages QI to explore new sectors or market segments. For instance, Viet Nam—a non-Muslim country—has recently adopted halal certification to support its increasing exports to Muslim-majority markets such as Malaysia, Indonesia, and the Middle East. Viet Nam has actively promoted compliance with halal standards by developing a national strategy, establishing the certification body HALCERT, and boosting trade promotion efforts—with an aim to enhance exports in food, cosmetics, pharmaceuticals, and the international tourism sectors. The increasing demand for halal-certified food, accommodations, and services from incoming Muslim travelers has led to the expansion of halal certification among hotels, restaurants, and travel agencies in the country.

Over the years, STAMEQ has received bilateral and multilateral support in developing its QI capabilities. In the area of QI for halal, it has received assistance recently from the United Arab Emirates' Ministry of Industry and Advanced Technology; the Saudi Standards, Metrology and Quality Organization (SASO);, and the Moroccan Standards Institute (IMANOR) to develop halal standards, enhance certification capabilities, and improve conformity assessment systems for halal products. The Asian Productivity Organization (APO), the Japan International Cooperation Agency (JICA), and the Korea Productivity Center (KPC) have also provided support for firms to enhance their productivity through technical assistance, training, and collaborative projects with the larger aim of boosting national productivity, particularly within Industry 4.0 frameworks. Germany's PTB and UNOPS (United Nations Office for Project Services) are partnering with STAMEQ to strengthen Viet Nam's QI in renewable energy, especially solar photovoltaics (PV), by developing standards, improving metrology and conformity assessment, and building institutional capacity.

As of mid-2025, in order to institutionalize these activities, policy makers are considering several provisions related to Viet Nam's NQI for inclusion in the draft Law on Product and Goods Quality. These legal provisions aim to establish the central role of QI in enhancing product quality, safety, and the economy's competitiveness, while ensuring consistency with international practices and integration requirements.

Countries with rudimentary or basic QI service systems: Ethiopia and Kenya

In recent years, the African Continental Free Trade Area (AfCFTA) has boosted the development of QI in Africa. A common economic area requires the harmonization of standards and technical regulations, as well as the establishment and expansion of conformity assessment services.

Kenya has a basic (progressing toward advanced) QI system (Harmes-Liedtke 2021b). It ranked 1st in the 2023 PAQI Index, along with South Africa and Tunisia, but ranked 56th globally in the GQII. The central institution is the Kenya Bureau of Standards (KEBS), responsible for standardization, scientific and industrial metrology, and the provision of conformity assessment services. The Department of Weights and Measures, under the Ministry of Investments, Trade and Industry, coordinates legal metrology and oversees 47 county offices. In addition, the Kenya Accreditation Service (KENAS), an independent body, has been internationally recognized under various schemes since 2014.

The conformity assessment landscape in Kenya is characterized by a large number of private laboratories, and the country's IAF/ILAC-recognized accreditation system and private sector engagement position it as a regional leader in East Africa, with strong representation at the pan-African level.

However, Kenya's institutional structure has not significantly changed since 2020, despite efforts to initiate reform. According to public reporting, KEBS, through its governing body, the National Standards Council (NSC), recommended maintaining the current enforcement-based QI structure for the next 15 years, citing the need to build voluntary systems and institutional capacity before transitioning toward more market-driven arrangements (Obura 2020).

The KEBS-led approach emphasizes the importance of continued government support, particularly for micro, small, and medium-size enterprises (MSMEs), which have benefited from certification and quality incubation programs. For instance, in fiscal year 2019/20, the government supported 786 MSMEs, and 13,754 products (from both small and large firms) held valid certification permits.

More recently, in 2023–24, Kenya began drafting a national quality policy (the Kenya Quality Policy), but the institutional arrangements remain unchanged.

In summary, although Kenya's QI system is slowly progressing, it still faces structural challenges such as limited inclusiveness, long-term sustainability, and potential conflicts of interest, as KEBS combines standardization, conformity assessment, and regulatory roles without a well-defined framework for regulatory coordination or separation of functions.

Ethiopia recognized the need for standardization as early as the 1950s, driven by challenges in agricultural exports and the modernization of the capital city of Addis Ababa. This led to the establishment of the

Institute of Ethiopian Standards (IES) in 1970. In 1987, IES was restructured into the Ethiopian Authority for Standardization (EAS), broadening its scope to include metrology, quality assurance, and certification. A further restructuring occurred in 1998 with the creation of the Quality and Standards Authority of Ethiopia (QSAE), which consolidated QI functions under one umbrella.

In 2010, Ethiopia undertook a major reform by disaggregating QSAE into four specialized institutions: the Ethiopian Standards Institute (ESI), the Ethiopian Metrology Institute (EMI), the Ethiopian Accreditation Service (EAS), and the Ethiopian Conformity Assessment Enterprise (ECAE). This reform followed international best practices and significantly improved the clarity of roles, accountability, and technical specialization (World Bank 2024).

Since 2011, Ethiopia has embarked on a reform process of its historically fragmented QI system, aimed at aligning it with global best practices. The ongoing development of the “Quality Village,” a consolidated physical and institutional hub for QI services, is a significant milestone. It aims to integrate metrology, testing, and conformity assessment in one center of excellence to enhance service delivery and efficiency.

Ethiopia is increasingly active in regional standardization and metrology initiatives (for example, through ARSO [African Organisation for Standardisation], EASC [Euro-Asian Council for Standardization, Metrology and Certification], and COMESA [Common Market for Eastern and Southern Africa]). Long-term technical support from PTB and UNIDO has enabled capacity building in laboratory infrastructure and human resources.

In 2021, the Ethiopian Standards Agency was restructured again, re-established as the Ethiopian Standards Institute (IES) under Proclamation No. 1263/2021, now reporting to the Ministry of Trade and Regional Integration.

The government has invested in QI services to support agro-exports such as coffee, sesame, and horticultural products. These services include testing, certification, and standardization aligned with international requirements. The Ethiopian National Metrology Institute (EMI) and other QI bodies are increasingly involved in supporting compliance with Sanitary and Phytosanitary (SPS) measures for agricultural exports (UNIDO 2023).

Ethiopia ranked 5th in the 2023 PAQI Index and 83rd in the GQII, reflecting its leadership in regional development but also its continued dependence on donor support and challenges in scaling up private sector engagement. ECAE, a state-owned enterprise, continues to dominate the conformity assessment market, with about half of its services delivered to public entities and the remainder to the private sector. The government subsidies to ECAE indicate that conformity assessment services are available at reduced rates. For example, conducting an aflatoxin test in Ethiopia costs less than 5 percent of such tests in Kenya, which raises questions about market access for other providers and long-term fiscal sustainability.[21]

Overall, despite persistent underfunding and the lack of a comprehensive sustainability strategy, Ethiopia's realignment toward specialization, institutional clarity, and regulatory cooperation signals a more progressive orientation when compared to Kenya’s relatively static model.

Broad Patterns in the Evolution of QI Systems

Evolution of QI systems along economic development phases

The development of QI systems is a dynamic process shaped by prevailing economic, social, and political paradigms. Drawing on the meta-level dimension of the systemic competitiveness framework (Schoen 2020), it is evident that the trajectory of QI in any given country is influenced by the broader policy and institutional environment during its foundational stages. The experiences of Brazil, Colombia, Ethiopia, Kenya, Korea, Malaysia, and Viet Nam illustrate how shifting global economic paradigms since the period following the second World War have introduced distinct incentives and constraints that shaped the establishment and evolution of QI systems in each context.

Table 7 illustrates the different stages of development for advanced economies and developing countries. Countries such as Germany, the United Kingdom, and the United States are global role models, but they have also changed and developed their systems over time. This study has focused on the development of QI systems in developing countries, which is unfolding amid the tension between following best practices of advanced economies and developing their own systems that are tailored to their domestic needs and capabilities.

Table 7. Phases of economic development in advanced economies and developing countries, 1950–2025

	1950-1970 **Post-war industrial modernization**	1970-1990 **Trade expansion and regional integration**	1990-2010 **Global value chains**	2010-today **Resilience and geopolitical shifts**
Advanced economies	• Built foundational QI during the post-war period • Mass production and mechanization need standards and metrology • Rise of the consumer	• Trade liberalization, emergence of regional integration (e.g., EU) • Increase in role of standards and accreditation	• International harmonization of QI, notably through WTO • Rise of private standards and certification, including for sustainability • Increased use of QI in regulation	• QI as a pillar for supply chain resilience, green transition, and digitalization • Geopolitical shifts and rise of questions of decoupling

	1950-1975 **Decolonialization and import substitution**	1975-1995 **Structural adjustment**	1990-2010 **Integration into global value chains**	2010-today **Economic upgrading and geopolitics**
Developing countries	• Nascent QI institutions from the colonial legacy • Focus on import inspections	• Adoption of international standards under pressure to liberalize • QI development often donor-driven and compliance-focused	• QI systems development for integration into GVCs • Fragmentation of market access standards an increasing challenge • Donor support for QI systems development • QI for national branding	• QI increasingly used for broader set of goals, including competitiveness, health, and environment • Regional cooperation and participation in international QI institutions

Source: Original research for the *World Development Report 2025.*
Note: EU = European Union; GVCs = global value chains; QI = quality infrastructure; WTO = World Trade Organization.

Between the 1950s and the mid-1970s, developing countries operated primarily under models of decolonization and import substitution and QI systems remained rudimentary. Between the mid-1970s and the mid-1990s, structural adjustment policies reshaped the QI landscape across the developing countries. Pressures to liberalize and adopt international standards led to a compliance-focused and often donor-driven QI development model. The period from the early 1990s to 2010 saw the integration of developing countries into global value chains, prompting more systemic efforts to strengthen QI institutions. The establishment of the WTO and the proliferation of private standards introduced new pressures for regulatory harmonization and compliance. After 2010, the strategic importance of QI deepened in the context of economic upgrading, regional integration, and geopolitical realignments. The 2008 global financial crisis triggered renewed interest in industrial policy and highlighted the role of QI in supporting resilient and innovation-driven development. Since 2016, the rise of protectionist and nationalist economic policies, combined with the COVID-19 pandemic and the acceleration of digital and green transitions, has further elevated the role of QI. Countries are using QI strategically to assert technological leadership, build economic resilience, and support their goals on sustainability.

Evolution of QI systems in terms of ownership, organization, maturation, and financing

Typically, the establishment of quality infrastructure (QI) systems begins with the creation of public institutions responsible for legal metrology and the formation of national standards bodies, reflecting the need for initial government oversight and coordination. As the QI system evolves, there is a discernible shift toward the involvement of mixed public-private entities and purely private entities. Specifically, a significant proportion of conformity assessment bodies emerge as private organizations, while standardization institutes often display a balance between public and private sponsorship.

The introduction of national quality awards and the development of proficiency testing and certified reference materials tend to occur later and are usually managed by public or mixed-ownership institutions.

Overall, the progression underscores a global trend in which governments lay the groundwork for core QI systems, with a transitional phase of mixed ownership, followed by a growing role for the private sector in service provision and innovation as institutional capacity expands.

Table 8 presents the sequence of key milestones in the development of national quality infrastructure (NQI) systems across the seven case study countries. While there are country-specific differences, a broadly similar order of events can be observed.

Figure 7 illustrates the typical development and financing of QI systems as it proceeds in three distinct phases: foundation, expansion, and diversification. The foundation phase is characterized by the establishment of core public institutions, such as national standards bodies, metrology institutes, and accreditation bodies, which lay the groundwork for a functioning QI system. During the expansion phase, the system grows to include a broader range of services, with increasing involvement from private and mixed-ownership organizations, particularly in conformity assessment activities like testing, inspection, and certification. The diversification phase introduces new QI elements, such as proficiency testing and the production of certified reference materials, reflecting the growing complexity and specialization of the system. This phased approach underscores the dynamic and adaptive nature of QI development, with public institutions leading in the early stages, followed by a gradual transition toward greater private sector participation and market-based service provision as the QI system matures.

Table 8. Milestones in the development of national quality infrastructure (NQI)

Event	Korea, Rep.	Malaysia	Viet Nam	Brazil	Colombia	Ethiopia	Kenya
Introduction of legal metrology	1961: KATS	1975: MDTCA	2000: STAMEQ	1973: INMETRO	1970s: SIC	1970: QSAE	1974: KEBS
Introduction of national standards body	1962: KSA[a]	1966: SIM/SIRIM	1975: STAMEQ	1940: ABNT	1963: ICONTEC[b]	1970: IES	1974: KEBS
Introduction of testing institution	1967: KTL	1975: SIRIM	1990: STAMEQ	1973: INMETRO	1970s–80s: ICONTEC/ Ministries	2000s: ECAE	1974: KEBS
Introduction of inspection institution	1970s: KATS/KTL	1990s: SIRIM and MDTCA	1990s–2000s: STAMEQ	1970s: INMETRO /agencies	1990s–2000s: SIC	2000s: ECAE	1980s: KEBS
Introduction of certification institution	1970: KATS	1975: SIRIM	1990s: STAMEQ	1973: INMETRO /ABNT	1990s: ICONTEC	2000s: ECAE	1980s: KEBS
Introduction of national metrology institute	1975: KRISS	1977: NML/NMIM	1962: VMI	1973: INMETRO	2011: INM	2010: EMI	1990s: KEBS Metrology
Introduction of national accreditation body	1992: KOLAS	1987: In SIRIM	1995: BoA	1998: INMETRO	2007: ONAC	2010: EAS	2009: KENAS
Introduction of conformity assessment body	1980s–90s	1980s–90s	Late 1990s	1990s–2000s	1990s–2000s	2010s: limited	1990s onward
Development of proficiency testing	1990s: KTL	1990s: SIRIM	2000s: STAMEQ	1990s: INMETRO	2010s: ONAC/INM	2010s: Donor-based	2010s: KEBS/KENAS
Introduction of production of certified reference materials	1990s: KRISS	2000s: NMIM	2022: NIFC	2000s: INMETRO	2010s: INM	Not systematic	2020s: Developing
Introduction of national quality awards	1992: KQA/KSA	1991: MQA/MPC	1996: STAMEQ	1990s: PNQ	1990s: ICONTEC	2010s: Government	1994: KEBS
Adoption of national quality policy/ strategy	None	In elaboration since 2023	In progress	ENIQ 2025	2017	2012	2023

Public Private Mixed public/private

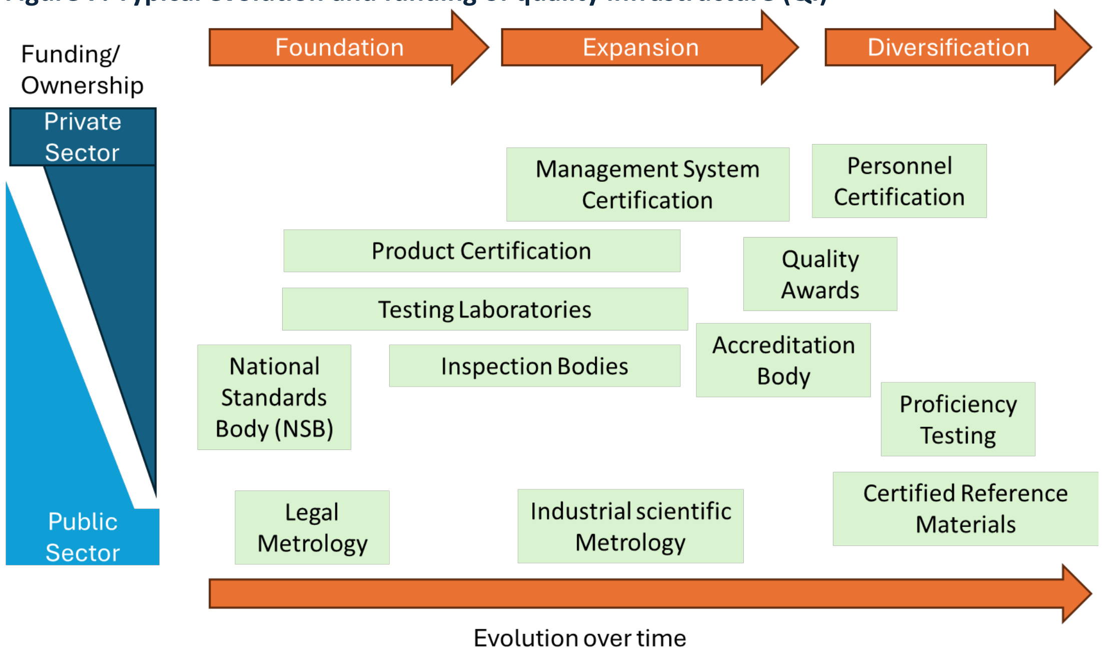
Source: Original research for the *World Development Report 2025.*
Note: ABNT = Brazilian Association of Technical Standards; BoA = Bureau of Accreditation; ECAE = Ethiopian Conformity Assessment Enterprise; EMI = Ethiopian National Metrology Institute; ENIQ = National Quality Infrastructure Strategy; ICONTEC = Colombian Institute of Technical Standards and Certification; IES = Institute of Ethiopian Standards; INM = National Metrology Institute of Colombia; INMETRO = National Institute of Metrology, Quality, and Technology; KATS = Korean Agency for Technology and Standards; KEBS = Kenya Bureau of Standards; KENAS = Kenya Accreditation Service; KOLAS = Korea Laboratory Accreditation

Scheme; KQA = Korea Quality Assurance; KRISS = Korea Research Institute of Standards and Science; KSA = Korea Standards Association; KTL = Korea Testing Laboratory; MDTCA = Ministry of Domestic Trade and Consumer Affairs; MPC = Malaysia Productivity Corporation; MQA = Malaysian Qualification Agency; NIFC = National Institute for Food Control; NMIM = National Metrology Institute of Malaysia; NML = National Metrology Laboratory; ONAC = National Accreditation Body of Colombia; PNQ = National Quality Award; QSAE = Quality and Standards Authority of Ethiopia; SIC = Superintendence of Industry and Commerce; SIM = Standards Institution of Malaysia; SIRIM = Standard and Industrial Research Institute of Malaysia; STAMEQ = Directorate for the Standards, Metrology and Quality; VMI = Vietnam Metrology Institute.

a. Private, government mandate.

b. Private, government designated.

Figure 7. Typical evolution and funding of quality infrastructure (QI)



Source: Based on Racine 2011.

The evolution of QI systems in member countries of the EU (European Union) and the OECD (Organisation for Economic Cooperation and Development) demonstrates this process (Racine 2011). Governments initially played a central role in establishing QI organizations to provide the technical support necessary for economic and industrial development. As industries matured and reached a critical mass, there was a shift from government-led, subsidized QI services to commercially operated organizations providing services at market prices, especially around conformity assessment. In large, highly industrialized economies such as the United States, most QI institutions now operate in the private for-profit or not-for-profit sector.

Lessons learned from the development of QI

The development of QI reflects national economic and industrial strategies

The evolution of QI is fundamentally shaped by national economic and industrial strategies. In Korea, the early integration of QI into a state-driven industrial policy enabled the rapid establishment of robust institutions that underpinned the country's transformation into a global industrial leader. Malaysia and Viet Nam similarly embedded QI into their export-oriented development models, using it to facilitate international market access and regional integration. By contrast, Brazil's more fragmented and inward-focused economic trajectory resulted in a slower and less cohesive evolution of QI.

QI systems evolve in response to changing economic and technological demands

QI systems are not static; rather, they evolve alongside shifts in economic structure, regulatory requirements, and technology. The experiences of Viet Nam and Malaysia illustrate how continuous adaptation and expansion of QI institutions can support new sectors and respond to changing demands in trade. Viet Nam's transformation from a centrally-planned QI system to a globally oriented framework and Kenya's rapid scaling of laboratory accreditation and development of standards during the COVID-19 pandemic highlight the importance of flexibility and responsiveness in QI systems.

Institutional maturity, service breadth, and international recognition are central to QI effectiveness

The effectiveness of national QI systems depends not only on the existence of core institutions, but also on their technical competence, breadth of services, and international credibility. Korea's mature and internationally recognized QI bodies facilitated both domestic innovation and access to global markets. Malaysia's leadership in halal certification, including the use of digital traceability, and Colombia's Flor Verde sustainability standard supported by domestic accreditation, demonstrate how sector-specific QI capacities can enhance competitiveness and credibility.

International and regional cooperation strengthen QI systems

International and regional cooperation are paramount in strengthening QI systems. Participation in global standardization bodies and regional networks, as demonstrated by Korea's international exchanges and Kenya's adaptation of guidance from the ISO and WTO, provided these countries with access to best practices and facilitated mutual recognition. Viet Nam's collaboration with PTB to upgrade its QI for the renewable energy sector further highlights the value of international partnerships in building capacity and supporting sectoral development.

QI plays a pivotal role in crisis response, public health, and sustainability transitions

Recent events, particularly the COVID-19 pandemic, have highlighted the critical role of QI institutions in responding to crises and public health. Brazil's rapid certification of medical equipment and Kenya's streamlined accreditation for testing labs exemplify how agile QI systems can address urgent societal needs. Moreover, QI is increasingly being leveraged to support sustainability agendas, as seen in Viet Nam's use of QI for renewable energy under the Just Energy Transition Partnership and in Brazil and Colombia's integration of QI into their circular economy initiatives.

Pathways for the development of QI are shaped by context and sectoral priorities

There is no single pathway for the development of QI; rather, approaches are shaped by national context, institutional capacities, and sectoral priorities. Malaysia's focus on halal certification, Brazil's emphasis on the energy transition, Korea's specialization in electronics, and Kenya and Viet Nam's support for agro-exports demonstrate the benefits of tailoring QI to key sectors. The contrasting experiences of Kenya and Ethiopia with external development cooperation further show how local context and private sector engagement influence the sustainability and impact of QI reforms.

Promoting QI

Governments in developing countries are increasingly recognizing the establishment and expansion of national QI systems as a key policy area. Supported by international development agencies, many governments are developing national QI policies as a framework for QI investments. At the same time, most QI institutions face resource constraints, making it difficult to retain or attract qualified staff and make the necessary investments. Often, revenues generated by the QI institutions must be paid into the national treasury, diverting funds from their investment.

Some recent impact studies have been carried out to demonstrate the return on investment in national QI (Ramkissoon 2023). For example, a study by the Centre for Economics and Business Research (Cebr 2023) assesses the economic impact of standards in six developing countries (Brazil, Colombia, Indonesia, Jamaica, Senegal, Uganda) using the ISO methodological framework (ISO 2022), and finds that an increase in the stock of standards is positively associated with labor productivity growth. Elasticities range from 0.02 percent in Jamaica to 0.16 percent in Indonesia. The study estimates that standards contribute significantly to GDP growth in the examined countries, with increases ranging from 0.3 percentage points (Colombia) to 0.99 percentage points in Brazil. While the study confirms the economic benefits of standards in developing economies, it highlights limitations due to short periods of analysis, issues in the availability of data, and variations in implementation of standards systems.

Supporting development cooperation

Over the past half a century, the promotion of QI has become a specialized field of development cooperation. In the 1960s and 1970s, national metrology institutes such as Germany's PTB (INTI 2017; Schiel 2018) and the US National Bureau of Standards (now NIST)[22] began assisting developing countries to establish foundational metrology and quality infrastructure systems, often through bilateral technical assistance and training programs funded by their respective governments. Over the following decades, United Nations organizations—particularly UNIDO—emerged as leading multilateral actors, supporting partner countries with comprehensive development of QI to enhance competitiveness, trade, and industrialization.

More recently, the World Bank Group has incorporated QI into its global development agenda, providing funding, technical expertise, and policy support to integrate QI principles into sustainable infrastructure and economic growth projects worldwide. Today, according to a 2020 World Bank Group survey, 14 bilateral and multilateral development partners have committed $255 million to the promotion of QI (Harmes-Liedtke 2025; Zhai and Aranki 2020).

Despite this commitment, the promotion of QI remains a niche area of development cooperation and is not systematically embedded in promoting the economy and competitiveness. Furthermore, its promotion often focuses on developing and expanding QI services without sufficiently considering the demand for such services.

Opportunities for regional cooperation

While QI rests on regional and international cooperation, it is important to distinguish between technical cooperation for harmonization and mutual recognition of service provision at the regional level. In regions with countries that have low demand for QI at the national level, a critical mass of services can be provided at the regional level. This is particularly the case for accreditation, where the Southern African Development Community Accreditation Services (SADCAS) has been established as a multi-economy accreditation body that can provide internationally recognized accreditation of conformity assessment bodies to 13 countries in the region that lack their own accreditation body.

Another example is the GCC Accreditation Centre (GAC), the first regional accreditation body to offer services to the member countries of the GCC (Gulf Cooperation Council) and the Republic of Yemen. As the regional market for accreditation grew, some countries in the region decided to establish their own national accreditation bodies. The regional and national accreditation bodies cooperate through the Arab Accreditation Cooperation (ARAC), one of the main pillars of the pan-Arab QI.

Regional QI bodies can thus contribute to the cost-effective provision of services and, at the same time, serve as incubators for new national bodies.

Conclusion and Outlook

QI is necessary for trade and sustainable development for all economies, regardless of their level of development. The supply of QI services should reflect the demand for such services, support the ambitions of the domestic economy, and protect the interests of domestic consumers.

A better understanding of the interplay between the supply and demand for QI services is needed. QI bodies should be able to identify future technology trends and market potential and provide relevant information to businesses and economic policy makers. In contrast to developed countries, QI institutions in developing countries must play a stronger role as enablers of high-quality production. But the fiscal constraints that most governments face is a major obstacle to the ability of QI institutions to fulfil this role. As a result, it is even more important to identify the development and expansion of QI as a high-return investment, aided by macroeconomic and microeconomic impact studies. Communicating the economic, social, and environmental benefits of QI remains a key task for governments and international development institutions.

International cooperation has often paved the way for the establishment of QI in developing countries. It is important to provide tailored support for QI according to the different maturity levels, but it should be part of broader support efforts. This requires close coordination among donors and international and regional QI institutions.

The World Bank Group is a key promoter of QI in developing countries. However, this role should be more clearly defined and institutionalized. The World Bank Group can use its reputation and expertise as a trusted broker by providing key data on QI on its Open Data platform and supporting research to better understand the impact of QI. In addition, the World Bank Group can contribute to addressing the data gaps that hinder QI research by incorporating modules related to QI in World Bank Group surveys, such as the Business Ready (B-READY) and Enterprise Surveys.

Notes

[1] A standard is a technical document, established by a consensus of subject matter experts and approved by a recognized body, that provides guidance on the design, use, or performance of materials, products, processes, services, systems, or persons ("Consumers and Standards: Partnership for a Better World," International Organization for Standardization). The primary types of technical standards define terminology and measurement unit(s), specify sets of requirements, and include test methods and standards operating procedures or conformity assessment procedures.

[2] The International Network on Quality Infrastructure (INetQI) has a broader definition that includes market surveillance: "The system comprising the organizations (public and private) together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes…It relies on metrology, standardisation, accreditation, conformity assessment, and market surveillance" (INetQI 2022). "Market surveillance" refers to the mandatory regulatory area of technical regulations for safety, security, health and environmental protection, but can also be considered to be a user of QI.

[3] PTB is the National Metrology Institute of the Federal Republic of Germany and at the same time an implementing organization of Germany's official development assistance (ODA). Since the 1960s, Germany's Physikalisch-Technische Bundesanstalt (PTB) has supported international development cooperation by strengthening quality infrastructure systems in developing countries. Initially focused on technical assistance in metrology, PTB's work expanded to include institutional development and regional cooperation.

[4] UNIDO (United Nations Industrial Development Organization) has been promoting quality infrastructure (QI) in developing countries since the 1970s, aligning this work with its broader mandate to support inclusive and sustainable industrial development. UNIDO recognized early on that robust QI systems are essential for enhancing productivity, ensuring product safety, facilitating trade, and supporting industrial upgrading.

[5] ISO (International Organization for Standardization). n.d. "Quality Management: The Path to Continuous Improvement." ISO, Geneva. https://www.iso.org/quality-management.

[6] Conformity assessment may be done through the first-party (self-declaration), second-party/parties (such as buyers or regulators), or third-party/parties. While third-party conformity assessment is the most rigorous and cost-intensive, it is the best suited to address issues of trust—especially in contexts with limited technical capacity, which is the case in many developing countries. Nonetheless, concerns about trust are universal, making third-party testing a valuable tool across all settings.

[7] ISO/R 1:1951 is now known as ISO 1:2022.

[8] While 20°C was adopted as the international reference temperature for industrial length measurements in ISO/R 1:1951, the choice was not universally accepted as ideal. Some metrologists advocated for 0°C, arguing that it aligned more closely with thermometric standards and scientific conventions, given its reproducibility and use as the freezing point of water. Others raised concerns about the practicality of enforcing a single reference temperature globally, particularly in regions with climates significantly different from temperate zones. In tropical or polar environments, maintaining 20°C required additional energy costs or technical adaptation, making it less suitable as a "universal" ambient condition. Ultimately, the decision to adopt 20°C reflected a compromise between scientific reasoning, practical considerations, and geopolitical consensus-building, following the precedent set by the International Committee for Weights and Measures (CIPM) in 1931 (Doiron 2007).

[9] The Regional Quality Infrastructure Organisations of Europe was established in March 2024 by the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), the European Cooperation for Accreditation (EA), the Association of National Metrology Institutes in Europe (EURAMET), and the European Cooperation in Legal Metrology (WELMEC) (EURAMET 2024).

[10] While the slogan reflects the ambition of international accreditation cooperation, in practice, many regulators continue to require testing or certification both in the country of origin and locally. This remains the case even within the European Union (EU), where market access for certain regulated products depends on assessment by Notified Bodies, which excludes internationally accredited conformity assessment bodies that are not specifically

notified. Concerns have been raised about such requirements undermining the core principles of international systems such as ILAC and IAF, which promote global trust based on peer-reviewed accreditation and mutual recognition arrangements and multilateral recognition arrangements. By not accepting the results of internationally accredited conformity assessment bodies, the EU is seen by some as introducing technical barriers to trade that are procedural rather than based on actual safety or quality concerns, potentially violating the spirit of the World Trade Organization Agreement on Technical Barriers to Trade.

[11] The study focuses only on the formal international standard organizations that have joined the World Standards Cooperation (WSC). These organizations describe themselves as the key organizations of the voluntary consensus-based international standard system. For more information, see https://www.worldstandardscooperation.org.

[12] Physikalisch-Technische Bundesanstalt (PTB) has applied the tool in 11 countries (Bolivia, Côte d'Ivoire, Ecuador, the Arab Republic of Egypt, Ethiopia, Guatemala, Nicaragua, Rwanda, Senegal, Tunisia, Zambia). It has also applied the tool to 8 selected member countries of ECOWAS (Economic Community of West African States) (Benin, Burkina Faso, Guinea, Liberia, Mali, Niger, Sierra Leone, Togo); to 12 selected countries in East Asia and the Pacific as part of the MEDEA project (Metrology–Enabling Developing Economies in Asia) (Bhutan, Cambodia, China, Indonesia, Kiribati, Malaysia, Mongolia, Pakistan, the Philippines, Sri Lanka, Thailand, Viet Nam); and 5 selected countries in Eastern Europe and Central Asia (Armenia, Azerbaijan, Georgia, Moldova, Ukraine). The World Bank Group has applied the tool in 10 countries (Gabon, Ghana, Jordan, Mozambique, Nigeria, Pakistan, Saudi Arabia, Somalia, Uganda, Viet Nam).

[13] Quality Village is a collection of QI facilities in Addis Ababa that provides quality assurance services in Ethiopia.

[14] In Cameroon, institutional inefficiency, a lack of reform momentum, and chronic underfunding—particularly in metrology—have hampered progress. Eritrea’s political isolation, limited engagement with international organizations, and low levels of investments in quality infrastructure (QI) have impeded development. Gabon’s economic dependence on oil, governance challenges, and the absence of a comprehensive QI system beyond standardization underscore the risks of limited diversification. Guinea continues to face fragile institutions, weak regulatory coordination, donor dependence, and a very limited QI system beyond its standards body. In Libya, ongoing conflict and weakened institutions have created a fragmented governance environment, with QI development largely stalled. In São Tomé and Príncipe, the combination of a small market size, limited industrial base, low demand for QI services, and reduced donor engagement present major constraints.

[15] For more information, please see https://hub.unido.org/qi4sd/about.

[16] The Global Accreditation Experience Index (GAEI) is an indicator of a state/economy’s development in accreditation. Work is being undertaken to create similar county-level timeseries data for metrology and standardization.

[17] The International Accreditation Forum (IAF) endorses private certification schemes, which are developed by industrial sectors, stakeholders, and nongovernmental organizations. These schemes, like FSSC 22000, provide a framework for third-party management system certifications, particularly for food chain organizations. IAF's Multilateral Recognition Arrangement (MLA) ensures that the accreditation bodies signatory to the MLA are recognized for their competence, promoting international trade and trust in these schemes.

[18] The SDG (Sustainable Development Goals) index is not normally distributed and exhibits clustering in specific parts of the distribution. SDG index scores are right-skewed (that is, a larger number of countries score lower, with fewer achieving higher scores). This reflects the global disparity in progress in achieving sustainable development. With respect to clustering, countries tend to cluster in certain score ranges, particularly at the lower end, indicating that many countries face similar challenges in achieving the SDGs. The Global Quality Infrastructure Index (GQII) is also right skewed, with clustering based on performance. In the GQII, there are three main clusters: high (advanced economies with well-developed QI systems); middle (lower-middle and upper-middle-income countries strengthening their QI systems); and low (fragile states, Small Island Development States, or countries with underdeveloped or fragmented QI systems). Given that the relationship between the SDG Index and the GQII is not linear, Spearman’s rank correlation was used instead of Pearson’s correlation. Spearman’s method is better suited to capture monotonic relationships—where variables move in the same direction, but not necessarily at a constant rate—making it more appropriate for this type of analysis.

[19] See https://data.worldbank.org/indicator.

[20] Before the creation of the National Accreditation Body of Colombia (ONAC) in 2007 and National Metrology Institute of Colombia (INM) in 2011, Colombia's accreditation and metrology functions were handled by other institutions. The Superintendence of Industry and Commerce (SIC) began accrediting conformity assessment bodies in 1994, accrediting a total of 357 conformity assessment bodies by 2009. While it built significant technical capacity, international peer assessments identified structural limitations in independence and autonomy that prevented international recognition of SIC as a national accreditation body. In the area of metrology, scientific and industrial metrology activities were carried out in a more fragmented manner across various public and academic institutions, without a unified national metrology institute responsible for traceability or international representation.

[21] Based on an interview conducted with the Ethiopian Conformity Assessment Enterprise (ECAE).

[22] In the 1970s, USAID (United States Agency for International Development) funded the National Bureau of Standards to help strengthen standardization and measurement systems in support of the industrialization of eight developing countries: Bolivia (*Standardization and Measurement Services in Bolivia, June 9–22, 1974*, NBSIR 76-1099); Ecuador (*A Report on a Survey in Ecuador on Standardization and Measurement Services in Support of Industrialization Goals, May 1–12, 1972*, NBSIR 10-881); Guyana (*Standardization and Measurement Services in Guyana, July 11–17, 1976*, NBSIR 76-1180); Indonesia (*Report on Standardization and Measurement Services in Indonesia, May 30–June 11, 1977*, NBSIR 78-1583 Korea (*Standardization and Measurement Services in Korea, June 19–30, 1972*, NBSIR 73-135); the Philippines (*Report to AID on a Philippines Survey on Standardization and Measurement Services, May 4–17, 1975*, NBSIR 76-1083); Thailand (*Report on an NBS/AID Survey of Standardization and Measurement Services in Thailand, May 22–June 1, 1973*, NBSIR 76-1190); and Turkey (*Standardization and Measurement Services in Turkey, October 14–2 S,1972*, NBSIR 73-172).

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