

Improving Quality Infrastructure in the OIC Member Countries



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LIST OF ACRONYMS

A2LA - American Association for Laboratory Accreditation

AI - Artificial Intelligence

AMP - Advanced Manufacturing Partnership

ANSI - American National Standards Institute

ASEAN - Association of Southeast Asian Nations

ASN - Association Sénégalaise de Normalisation (Senegalese Association for Standardization)

BIPM - Bureau International des Poids et Mesures (International Bureau of Weights and Measures)

BSN - National Standardization Agency of Indonesia

C2C - Cradle to Cradle

CPS - Cyber-Physical Systems

DTI - Department of Trade and Industry

DSM - Department of Standards Malaysia

EAEU - Eurasian Economic Union

ECA - Europe and Central Asia

ECOWAS - Economic Community of West African States

EGAC - Egyptian Accreditation Council

EMS - Environmental Management Systems

EMPIR - The European Metrology Programme for Innovation and Research

ENEA - Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile
(Italian National Agency for New Technologies, Energy and Sustainable Economic Development)

EOS - Egyptian Organization for Standardization and Quality

ESALA - East and South Asia and Latin America

ESMA - Emirates Authority for Standardization and Metrology

FDI - Foreign Direct Investment

GDP - Gross Domestic Product

GQII - Global Quality Infrastructure Index

IAF - International Accreditation Forum

IEC - International Electrotechnical Commission

ILAC - International Laboratory Accreditation Cooperation

IMQ - Istituto Italiano del Marchio di Qualità (Italian Institute for Quality Branding)

INRIM - Istituto Nazionale di Ricerca Metrologica (National Metrology Institute of Italy)

IoT - Internet of Things

ISO - International Organization for Standardization

ISO 9001 - International Standard for Quality Management Systems

ISO/IEC 17011 - International Standard for Accreditation Bodies

ITU - International Telecommunication Union

KAN - National Accreditation Committee

LCA - Life Cycle Assessments

LEED - Leadership in Energy and Environmental Design

MEMS - Microelectromechanical Systems

MID - Measuring Instruments Directive (Directive 2004/22/EC)

MRAs - Mutual Recognition Agreements

NCWM - National Conference on Weights and Measures

NIST - National Institute of Standards and Technology

NMS - National Measurement System

NQI - National Quality Infrastructure

NQP - National Quality Policy

NTTAA - National Technology Transfer and Advancement Act

OECD - Organisation for Economic Co-operation and Development

OIC - Organization of Islamic Cooperation

OIML - International Organization of Legal Metrology

PPE - Personal Protection Equipment

PPP - Public-Private Partnership

QED-C - Quantum Economic Development Consortium

QI - Quality Infrastructure

RMNs - Regional Metrology Networks

SDGs - Sustainable Development Goals

SI - International System of Units (Système International d'Unités)

SIM - Società Italiana di Metrologia (Italian Society of Metrology)

SMEs - Small and Medium-sized Enterprises

SMIIC - Standards and Metrology Institute for Islamic Countries

SRMs - Standard Reference Materials

SSA - Sub-Saharan Africa

TSE - Turkish Standards Institution (Türk Standartları Enstitüsü)

TURKAK - Turkish Accreditation Agency (Türk Akreditasyon Kurumu)

UAE - United Arab Emirates

UNCTAD - United Nations Conference on Trade and Development

WTO - World Trade Organization

EXECUTIVE SUMMARY

The immutable evolution of global trade with the high pace of technological changes and market digitalization has brought the core mission of the NQI to the forefront—assurance of product quality, safety, and competitiveness.¹ With modernization, forces driven by urbanization, changes in demographic patterns, and the increasing role of electronic commerce, markets are becoming increasingly digital.² As markets become increasingly digital in response to modernization, NQI is experiencing pressure to adapt to the new era of digital marketing.³ The adaptation is not in the form of reactive changes to technology but rather a proactive response that its support infrastructure for quality assurance remains congruent with market requirements.⁴

Urbanization brings with it the concentration of consumers and businesses in urban centers that create dense hubs of digital commerce activity and, in itself, call for robust standards and regulatory frameworks to protect the consumer and maintain fair trade.⁵ Similarly, demographic shifts, including changes in age distributions and consumer preferences, imply a need for quality standards and the methods used to enforce them in this respect.⁶ The younger generation, obviously more tech-savvy and more conscious of the need for sustainable products, will look for specific product quality certificates and will continue shopping online.⁷

Besides, general market complexity is rising because of the global pandemic, which increases both market and market reach in general.² Online platforms are no longer just a supplementary channel but have become the main avenue for many businesses regarding public involvement from one country to another.⁸ This has increased the need for a coherent and adaptable NQI that will give efficient solutions to the various quality and safety challenges the digital business is bringing about globally.¹

The challenges in the digital field create a few which are specific in themselves.² The advancement of technologies in commercial applications, such as blockchain and artificial intelligence (AI), and the progressive increase in Internet-connected devices are leading quality assurance into new horizons.⁹ For example, blockchain technology allows a much higher, unprecedented level of traceability and transparency within the supply chain, which considerably enhances the reliability of verification

¹ Chevalier, J. (2022), "Global E-commerce Trends and Their Impact on Quality Assurance", *Journal of International Commerce and Economics*.

² Statista (2022), "E-commerce Market Analysis", Statista Digital Market Outlook.

³ OECD (1997), "The Economic and Social Impact of Electronic Commerce", Organization for Economic Co-operation and Development.

⁴ UNCTAD (2021a), "Digital Economy Report", United Nations Conference on Trade and Development.

⁵ COMCEC (2022), "E-commerce Developments in OIC Member countries", Coordination Office for Economic and Commercial Cooperation.

⁶ Fedorko, R. (2019), "Impact of Digital Transformation on Consumer Behavior", *Digital Consumer Insights Journal*.

⁷ WTO (2017), "E-commerce in Developing Nations: Issues for Small and Medium-Sized Enterprises", World Trade Organization Discussion Paper.

⁸ Statista (2023d), "The Role of Digital Advertising in E-commerce Growth", Statista Research Department.

⁹ EMPIR (2017), "Enhancing Metrology in E-commerce", European Metrology Program for Innovation and Research Report.

regarding both the origin of a product and quality standards.⁵ On the same note, AI can improve accuracy and speed in quality inspections and compliance monitoring processes.⁴

In such a case, NQI must ensure that its strategic directions are kept in line with the state-of-the-art applications but also plan for the future with more flexibility in the frameworks.⁷ In other words, it needs more adaptive regulatory approaches that respond rapidly to emerging market developments and demand by customers.⁶ It also includes the investment in developing NQI professionals who have the capability of managing and exploiting the emerging technologies in their quality assurance function, among others.⁹

As market digital transformation gains momentum, NQI has an increasingly central role to play in giving assurance that products meet pre-set quality and safety levels.¹ NQI can significantly contribute to a more secure and competitive market environment by embracing these changes and repositioning itself towards the challenges of a digital economy.⁸ That benefits directly not only businesses but also consumers.³

This report will, therefore, discuss the main elements of NQI standardization, metrology, accreditation, and conformity assessment in light of international trade. It is now evident that countries can guarantee standards at the national level that are set at an internationally accepted benchmark so as to allow for the removal of entry barriers into world markets for products without a problem, easily building consumer confidence and meeting global quality expectations.³ It is thus critical to be assured that NQI would be compatible with the internationally acceptable standards, which were similarly developed by the European Union and the OIML, the Organization for International Legal Metrology so that it would be competitive at a global level.⁹

The report cites international collaboration in creating and implementing NQI's system. This will, of course, require working closely with the Organization of Islamic Cooperation (OIC) and the Committee for Economic and Commercial Cooperation to harmonize standards across regions, remove technical barriers to trade, and boost economic integration.⁵ Among some case studies in Italy, it was elaborated that institutes like Istituto Nazionale di Ricerca Metrologica (INRIM) and Istituto Italiano del Marchio di Qualità (IMQ) are making fruitful and effective use of NQI for enhanced quality, product quality, and market access.⁴

NQI should thus develop to incorporate newfangled quality and safety concerns in light of the innovations shaping the economy through the development of the Internet of Things (IoT), blockchain, AI, and Machine Learning, among others.⁶ These are issues that call for the adaptation of NQI in line with technological developments so that it remains relevant and possible to support modern trade practices.⁸

Even though advancements are made in developing NQIs, they pose challenges to the uneven development of the infrastructures and the need to build complex capacities to harmonize the standards.⁷ It will benefit from acting upon some strategic recommendations that will address the best-practice learning from leading NQI systems, better international cooperation, investments in technical infrastructure, and in education and training in quality management.⁹

The document mentions international cooperation in developing and implementing NQI's system. Of course, this will require collaboration with organizations like the OIC and the Committee for Economic and Commercial Cooperation (COMCEC) to harmonize standards across regions, mitigate technical barriers to trade, and foster economic integration. Among some of the case studies in Italy, it elaborated that institutions like INRIM and IMQ are making fruitful and effective use of NQI for enhanced quality, product quality, and market access.

As new global technologies reshape the economy through developments in the IoT, blockchain, AI, and Machine Learning (ML), NQI must evolve to incorporate newly emerged quality and safety concerns about these innovations. These are issues that require adaptation of NQI in sync with technological advancements to make it relevant and possible to support modern trade practices. Even as advancements have been made in the development of NQIs, they pose challenges to the uneven development of the infrastructure and the need for building capacities in complex harmonizing standards. It will be beneficial to act on some strategic recommendations that will resolve such issues, involving the best-practice learning from leading NQI systems, better international cooperation, technical infrastructure investments, and education and training in quality management.

Finally, the effective management of NQI is vital to promote international trade, secure the quality of products, and sustainably foster economic development. Through adapting to the digital economy and further integrating with global standards, it will change the competitiveness of nations in a fast-changing global market. The paper is a strategic guide for policymakers, industry stakeholders, and international partners committed to strengthening NQI as the cornerstone of global trade.

Research and Field Visits

In this study, first, existing practices in Kazakhstan, Senegal, the United Arab Emirates (UAE), Italy, and the USA were examined. Then, field visits were made to Kazakhstan, Senegal, and the UAE, and information about NQI was obtained.

Kazakhstan: A detailed analysis of the NQI and metrology systems in Kazakhstan is given in this report. It highlights the country's unique status as a transition state, with tremendous natural resource endowments and a strategic location between Europe and Asia.

Although Kazakhstan's quality infrastructure is robust, the report identifies areas for improvement, particularly in raising public awareness about the importance of QI and metrology. Greater attention should be paid to awareness activities, such as media campaigns, industry conferences, and educational programs, to enhance understanding and adoption of standards. The report also recommends increased investment in budget and personnel resources, along with targeted training and development programs, to boost the effectiveness of Kazakhstan's QI system. The involvement of non-state actors, such as NGOs, firms, and associations, would also be crucial in fostering innovation, improving resource utilization, and scaling up QI initiatives. In conclusion, while Kazakhstan has made significant strides in developing its system, continued efforts to enhance awareness, invest in human resources, and engage non-state actors will be essential to keep pace with global developments and ensure the country's competitiveness in international markets.

Senegal: An elaborate description is made in the report of the Quality Infrastructure and metrology systems in Senegal, while pinpointing the challenges and opportunities associated with the country's current infrastructure. The economy of Senegal is growing, with agriculture, services, and construction being the main contributors to the growth rate. However, significant challenges face the country in its QI, particularly the metrology sector, which positions it at 115 globally. A substantial investment to strengthen Senegal's QI system, though, is needed to enhance human resources, training, and equipment to make it effective and efficient. When corrected, the identified weaknesses in this system will allow better compliance with the national and international standards for better quality of products, consumer confidence, and economic growth. It also targets developing a Senegalese national metrology institute that is internationally acceptable through competence. It would, therefore, improve the accuracy and reliability of measurements made in various sectors and support scientific research and innovation towards improving economic development. Taking on the challenges in its QI system will reinforce Senegal's position on the global economic map, and perhaps other countries would use the case of the UAE as a lesson on how to successfully implement high standards in different sectors.

UAE has made remarkable progress in establishing its NQI, which is crucial for bolstering its diverse economy, enhancing its standing in global trade, and achieving its ambitious goals in innovation and sustainability. By aligning with international standards and focusing on advanced sectors like smart cities, renewable energy, and high-tech manufacturing, the UAE has positioned itself as a leading example of how a robust NQI can improve competitiveness, attract foreign investment, and facilitate global trade. A vital component of this effort is the UAE's legal metrology framework, overseen by Dubai Municipality and the Emirates Metrology Institute (EMI). However, the UAE's legal metrology system is not without its challenges.

The ongoing need to integrate new technologies, improve personnel training, and raise public awareness about the importance of precise measurements is evident. Addressing these issues is vital to maintaining the high standards expected in various sectors. Looking ahead, the establishment of a world-class national metrology institute, along with resolving personnel and budgetary constraints, will further strengthen the UAE's quality infrastructure. The UAE's steady commitment to maintaining high-quality standards, as outlined in its Vision 2030, serves as a guiding model for other nations aiming to enhance their own NQI systems and thrive in the global economy.

Italy: Italy's NQI and metrology systems indicate a framework of solid institutions, an inclusive legal framework, and effective practices. Quality infrastructure, underlined by Italy, permits the production of goods to be at very stringent safety, sustainability, and conformity levels with both European and international regulations. As an EU member, Italy's NQI operates in a multinational regulatory framework and thus represents an exciting example for the study of how NQI systems work in a multinational environment. In any case, the integration of new technologies, along with the costly necessities for research and development, are problematic issues for Italy. The adjustment and investment in this rapid and always-increasing evolution in the markets worldwide and technological innovation are constant. The scientific competences in the field, therefore, become connected to Italy from a proactive involvement in international metrology, which has resulted in upgrading the competitiveness of industrial and manufacturing corporations and laboratories. Looking towards the future, Italy is well set to take steps forward, particularly with nano-metrology and digital metrology, which is bound to redefine high precision in most fields. Since Italy is committed to innovation in this field, it is a measure of the very high stakes in ensuring global metrological standards are both advanced and that its quality infrastructure remains at the highest level and is comparable with the best in scientific and industrial progress.

USA: The USA has the largest and most developed economy worldwide. In addition, it relies on a really strong and influential NQI that has provided enormous value in support of innovation, assurance of consumer safety, and enabling global trade. The U.S. is also the global leader in the metrology domain by being the number one ranked country on the Global Quality Infrastructure Index within the scope of metrology. However strong the U.S. NQI is, there are still some weaknesses. First, the fast pace of technological development, particularly in such new fields as quantum computing and nanotechnology, constantly poses a challenge to the creation of new standards for measurements. Second, the complicated regulation system in the U.S., where federal, state, and local laws and regulations create a convoluted mess, leads to the problem of inconsistency and higher compliance costs for businesses operating across jurisdictions. Further, the United States is criticized for being over-regulatory, with its level of regulations being too high, thus creating a burden on smaller companies and developing countries, which may effectively lock them out of world markets.

There may also be a likelihood of market concentration and reduced competition by having U.S. standards dominate in global trade. In this regard, while the U.S. NQI and metrology practices significantly impact global standards, striking this balance between harmonization, inclusivity, and flexibility will foster an international environment that optimizes innovation, competition, and fair growth.

Surveys This study aimed to formulate policies to advance quality infrastructure (QI) in OIC countries, focusing on metrology and its critical role in supporting trade and industry. The study initially targeted 57 OIC member countries but was narrowed down to a sample of four due to time and resource constraints. The selected countries—one Arab (UAE), two Asian (Kazakhstan and Türkiye), and one African (Senegal)—were chosen to represent a diverse range of quality infrastructure levels, which would allow for the creation of informed policies based on the collected data.

The survey, comprising 19 questions available in multiple languages, reached 53 institutions and organizations, aiming to assess metrological awareness, existing frameworks, and the effectiveness of practices across sectors. Key findings revealed a moderate level of understanding, with notable differences in how countries have developed legal frameworks and implemented metrological standards. The survey was disseminated through OIC contact points, which ensured that it was completed by relevant institutions and experts in quality infrastructure, with responses gathered from 53 institutions and company officials by June 1, 2024. While some countries demonstrate robust metrological systems supported by clear legal frameworks, others struggle with inadequate resources, outdated regulations, and low levels of awareness. Funding and technical expertise emerged as the primary challenges, limiting the effectiveness of metrological services and hindering trade competitiveness. The study emphasizes the need for OIC countries to prioritize regulatory reforms, increase investment in metrology infrastructure, and foster stronger public-private partnerships PPPS to improve the NQI.

Recommendations include enhancing legal and regulatory frameworks, investing in technological advancements, and improving education and training for metrology professionals. Additionally, fostering international collaboration and increasing stakeholder engagement is vital to building a robust metrology system capable of supporting the economic growth and global integration of OIC member countries.

Recommendations The advancement of Quality Infrastructure (QI) in OIC countries is pivotal for boosting competitiveness, ensuring product safety, and opening doors to international markets. By following the policies and strategies outlined here, OIC member countries can make significant strides in both regional and global harmonization of QI.

This harmonization doesn't just enhance the competitiveness of their products on the world stage; it also fosters intra-regional trade, strengthens global standing, and drives economic growth, integrating these nations more deeply into international markets. A robust QI framework is a cornerstone for not only facilitating trade but also fostering economic development, protecting consumers, and promoting sustainable growth.

To elevate QI, it's vital to establish harmonized standards and regulations, crafting a consistent and unified framework across member countries. Such a framework would ease trade and boost competitiveness by ensuring that products, services, and processes align with internationally recognized standards for quality, safety, and environmental protection. Aligning these standards with global benchmarks like ISO, IEC, and Codex Alimentarius can significantly reduce technical trade barriers and improve market access. Enhancing the role of regional standards organizations (RSOs) and forming joint standards committees will be crucial in developing unified standards that reflect both regional needs and international expectations. Regular benchmarking against global standards and addressing any gaps will ensure that these standards are both competitive and globally relevant.

Another key approach is the establishment of Mutual Recognition Agreements (MRAs) among OIC countries, which would unify standards and regulations for QI. MRAs enable the mutual recognition of conformity assessments, certifications, and accreditations across member countries, thereby lowering trade barriers and improving regulatory cooperation. A coordinated strategy, including setting up an MRA Coordination Committee and developing regional MRA frameworks, will ensure these agreements are effectively negotiated and implemented. Establishing clear objectives, creating equivalency agreements, and setting up a transparent dispute resolution framework will further bolster the success of MRAs.

Strengthening QI institutions within OIC countries is crucial for developing a resilient framework. This includes investing in the capacity building of national standards bodies, metrology institutes, accreditation bodies, and conformity assessment organizations. Creating a National Quality Policy (NQP), establishing regional accreditation bodies, and focusing on technical skills development will enhance the operational efficiency of these institutions. Upgrading laboratories and technical facilities, providing specialized training courses and certifications, and promoting regional training initiatives are also vital steps in this enhancement process.

PPPs are instrumental in developing and maintaining QI in OIC countries. Involving the private sector through outreach programs, sector-specific agreements, and regulatory dialogue can harness private sector expertise and resources to bolster the development and sustainability of QI institutions.

Additionally, setting up and strengthening Regional Metrology Networks (RMNs) will enable knowledge sharing, resource pooling, and the dissemination of best practices among member countries, ultimately improving metrology capabilities across the region.

Modernizing metrology infrastructure is another critical aspect of improving QI. Upgrading metrology laboratories and integrating digital tools and platforms will ensure that measurement standards, accreditation, certification, and conformity assessment processes are accurate and reliable. Embracing digital transformation in metrology, incorporating IoT and smart devices, and establishing innovation hubs will further enhance measurement precision, data management, and decision-making.

National accreditation bodies in OIC countries should prioritize achieving compliance with international standards and securing global recognition. Compliance with ISO/IEC 17011 and developing sector-specific accreditation programs are vital to building confidence in the accreditation system. Expanding into new and emerging fields and obtaining ISO 9001 certification will further elevate the credibility and effectiveness of these bodies.

Active participation in international forums and organizations related to standards, metrology, accreditation, certification, and conformity assessment is essential for OIC countries to contribute to global standards development and improve the quality and reliability of their national systems. Developing a comprehensive representation strategy, engaging in technical committees, and forming strategic alliances will enable OIC member countries to influence international policies and ensure that their unique needs and perspectives are acknowledged.

Establishing a Metrology Centre of Excellence within the OIC, particularly focusing on supporting the trade of Halal products, will address specific member country needs and fill a critical gap in international metrological studies. Developing a Halal Metrology Framework, setting Halal standards and certification protocols, and providing comprehensive calibration services will ensure high-quality standards in testing and certification for Halal products.

Supporting SMEs in achieving quality compliance is also vital for enhancing competitiveness and ensuring their products and services meet international standards. Providing technical assistance, training, financial support, and implementing awareness campaigns will help SMEs navigate the complexities of quality standards and achieve internationally recognized certifications.

Promoting a quality culture and increasing consumer awareness are crucial to preparing future professionals to contribute to quality-driven industries and organizations. Incorporating quality management principles into educational curricula, offering on-the-job training, and creating career pathways will instill a culture of quality in students and future professionals.

Strengthening consumer protection laws, promoting certification labels, and launching consumer rights campaigns will further enhance consumer trust in product safety and quality.

Finally, aligning QI initiatives with the United Nations Sustainable Development Goals (SDGs) is crucial for promoting environmental and social standards. Implementing green metrology practices, enhancing ecological control measures, and supporting the adoption of social and environmental certifications will help OIC countries meet global demands for ethically produced goods and contribute to sustainable development.

Ongoing monitoring and evaluation of harmonized standards, MRAs, and related initiatives are essential to ensure they are effective and aligned with their intended goals. Establishing a well-defined division of responsibilities, implementing robust data management systems, and conducting impact assessments will support informed decision-making and continuous improvement in QI processes.

By embracing these comprehensive strategies, OIC member countries can fortify their QI systems, foster regional collaboration, and enhance global competitiveness, ultimately driving sustainable economic growth and development.

1. INTRODUCTION

Effective management of the NQI is a critical component for enhancing trade competitiveness and economic growth in the OIC member countries. NQI encompasses the systems, institutions, and processes that ensure that products and services meet established standards, including metrology, standardization, accreditation, certification, and conformity assessment. As global markets become increasingly interconnected, the ability of OIC countries to align their quality infrastructure (QI) with international best practices is essential to ensure that their goods and services are competitive on the global stage.

In recent years, the importance of a robust NQI has been underscored by the growing emphasis on sustainable development, consumer protection, and the need to meet the stringent requirements of international trade. For OIC member countries, strengthening their NQI systems presents both opportunities and challenges. It offers a way to improve product quality and safety, enhance access to international markets, and promote economic resilience. However, it also requires overcoming significant hurdles, such as harmonizing standards, modernizing metrology infrastructure, and developing technical expertise.

This study explores the strategies and best practices for effective management of NQI in OIC member countries. It examines the current state of QI across the region, identifies key challenges, and provides policy recommendations to improve the efficiency and effectiveness of NQI systems. By addressing these critical areas, OIC member countries can better position themselves to meet the demands of international trade, promote sustainable economic development, and ensure that their citizens benefit from high-quality products and services.

Furthermore, the study aims to provide a detailed, actionable guide to help stakeholders effectively understand and apply the principles of the NQI and metrology. This guidance aims to enhance the international trade capabilities of OIC countries, facilitate market access, and promote sustainable economic practices by ensuring the reliability and quality of goods and services through standardized measurements. In this context, it also includes existing academic research, case studies, and theoretical contributions that explore the multifaceted roles of NQI and metrology in international trade. The components of QI are briefly defined as follows:

Metrology: Metrology, the science of measurement, is critical to ensuring the accuracy and reliability of measurements in commerce, industry, and scientific research. Metrology institutions in OIC Member Countries play a key role in maintaining national measurement standards, which are crucial for quality control, safety, and environmental protection.

Standardization: Standardization involves developing and implementing technical standards that ensure consistency and safety in products and services. Standardization bodies in OIC member countries are responsible for establishing national standards in accordance with international norms, such as those set by the International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC).

Accreditation: Accreditation is the formal recognition that an organization is competent to perform specific tasks such as testing, calibration, or certification. Accreditation bodies in OIC Member countries are responsible for assessing and accrediting conformity assessment bodies and ensuring that they meet international standards of competence.

Certification: Certification involves a third-party organization issuing a certificate confirming that a product, service, or system meets specified standards. In OIC member countries, certification is crucial for access to international markets as it provides assurance to buyers and regulators that products conform to required standards.

Conformity Assessment: Conformity assessment refers to the processes used to demonstrate that products or services meet specified standards. This includes testing, inspection, and certification activities. Conformity assessment bodies in OIC member countries are instrumental in verifying compliance with national and international standards, thus facilitating trade and consumer protection.

The guide provides a holistic structure of proven practices, policy recommendations, and global principles for managing and optimizing NQI systems. In other words, it will provide valuable insights into how different countries and regions implement NQI frameworks to meet domestic and international demands. The guide's practical recommendations, which can directly influence policy formulation and industrial strategies, are a new resource for policymakers and industry leaders.

The study consists of five chapters. Following the introduction, the second chapter explains QI Concepts and the relationships between the concepts in a holistic structure. QI is a comprehensive system covering the institutions, policies, and practices necessary to establish and maintain quality standards in various sectors. QI plays a crucial role in ensuring that products and services meet specific requirements for safety, reliability, and environmental impact. It includes critical components such as standardization, metrology, accreditation, certification, and conformity assessment. These components work together to create a framework that improves product quality, facilitates trade, and protects consumers. In the context of the OIC member countries, it is increasingly recognized that the QI concept is vital for economic development, trade facilitation, and integration into the global economy.

In the third part of the study, QI practices in OIC member countries are included. QI practices in OIC member countries vary considerably, reflecting the region's different economic, social, and regulatory environments. While some member countries have established advanced QI systems, others are in the early stages of developing their QI. These differences present both challenges and opportunities for regional cooperation and harmonization. In order to capitalize on these opportunities, OIC member countries are defined by two different classifications. One of these is the frequently used geographical classification, and the other is the economic classification. Based on these classifications, QI data for OIC countries are examined using descriptive analysis. Correlation analyses are made between foreign trade, per capita income, place in the world QI ranking, participation in QI practices, and economic development and trade development.

Additionally, the third part of the study also analyses the challenges faced by OIC member countries in the QI system and trends in the QI system. One of the most critical challenges faced by many OIC member countries is the lack of resources required to develop and maintain robust QI systems. These constraints include limited financial resources, lack of technical expertise, and inadequate infrastructure for testing, calibration, and certification. In addition, in OIC Member countries, regulatory frameworks supporting QI are often fragmented or poorly coordinated. This fragmentation leads to inconsistencies in the application of standards, duplication of efforts, and inefficiencies that can hinder the overall effectiveness of QI systems. In addition, enterprises, consumers, and policymakers have limited awareness and involvement in the importance of QI. This lack of understanding may lead to low demand for quality standards and certificates and insufficient support for QI initiatives at the national level. Finally, for OIC member countries, ensuring that national QI systems align with international standards and practices requires ongoing efforts in capacity building, harmonization, and international cooperation. In addition to these, the rapid pace of technological innovation and the increasing importance of environmental sustainability are also seen as essential constraints.

The fourth part of the study aims to provide a comprehensive understanding of the current landscape of NQI and metrology systems and offer a predictive perspective on their evolution. By integrating various research techniques, the study provides a robust assessment of the integration and effectiveness of NQI components in improving global trade and regulatory compliance. The countries selected for the case studies in Chapter Four are Kazakhstan, Senegal, UAE, Italy, and the USA. The in-depth case studies of the chosen countries provide detailed insights into the practical implementation and challenges of NQI systems. These case studies focused on countries with different levels of economic development and other approaches to implementing NQI components. This comparative approach will facilitate the understanding of the variability in NQI effectiveness due to regional and economic differences. Two different methods were followed in the case study.

Field visits to Kazakhstan, Senegal, and UAE to observe NQI implementation first-hand, interview local experts, and collect primary data on the effectiveness and challenges of existing metrology systems, and extensive study in Italy and the USA to understand advanced NQI systems, focusing on historical development, current practices, technological integration and impacts on international trade. Finally, large-scale data collection was collected through questionnaires distributed among stakeholders in OIC member countries. These surveys assess the level of awareness of NQI components, regulatory practices, and the impact of their implementation.

In the last part of the study, the internationally recognized NQP principles required for the development or improvement of NQI and the principles expected to contribute to the NQI studies of the OIC member countries, policy recommendations, and the implementation practices necessary to realize these recommendations are included.

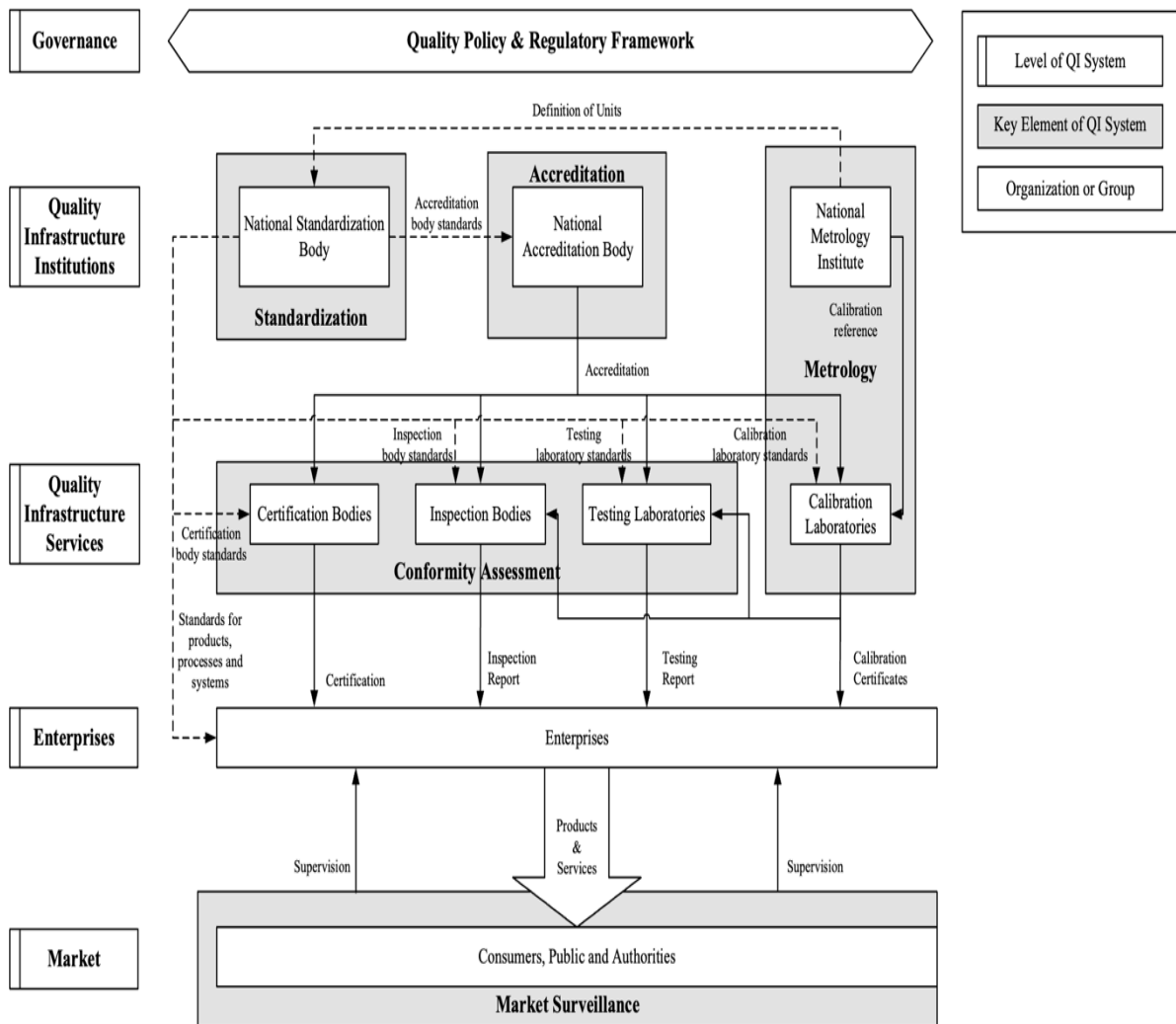
2. FRAMEWORK OF QI SYSTEM

The NQI encompasses the core elements of metrology, standardization, accreditation, and conformity assessment. This collective ecosystem works synergistically to ensure that products and services not only meet predefined quality and safety standards but also remain competitive in the global market and comply with international regulatory requirements. The robustness of NQI is crucial for countries aiming to increase their market access and participate effectively in the worldwide economy. Metrology, the science of measurement, forms the fundamental backbone of these industrial and commercial activities worldwide. It is crucial to ensure measurements' accuracy, reliability, and consistency, which are essential for product development, production, and quality assurance. The importance of metrology goes beyond the technical domain, influencing economic activity by enabling fair trade, ensuring regulatory compliance, and facilitating innovation through precise and reliable data.

In the field of international trade, NQI and metrology are critical as they ensure that products conform to global standards - a prerequisite for entering and succeeding in international markets or export destination countries and regions. By helping to ensure compliance with these standards, NQI and metrology systems help to avoid trade disputes and eliminate technical barriers, thereby promoting smoother and more efficient trade flows. These systems provide the technical basis for trade agreements and help maintain the integrity and quality of goods exchanged globally. The role of metrology extends to the global arena, where it is instrumental in harmonizing standards, facilitating international cooperation, and promoting mutual recognition of measurement standards between countries. This harmonization is essential to ensure that products manufactured in one country can be sold seamlessly in another country without the need for retesting or additional certification, thus improving the efficiency of global supply chains.

A QI system is a combination of initiatives, institutions, organizations, activities, and people. As visualized in Figure 1 below, a key component of a QI system is governance. It is the government that provides the initial impetus for establishing a QI system and is ultimately responsible for ensuring that the QI system fulfills policy objectives and meets the country's needs. To ensure that the QI system is close to international standards and best practices and complies with world trade rules, the government initiates the process by developing a QP and establishing the regulatory framework for the QI system. The QP should clearly define its responsibilities for developing and implementing a technical, regulatory framework and set a time limit for its achievement. Full details on developing the technical regulatory framework should be presented in the implementation plan/strategy. In principle, the envisaged technical regulatory framework should be seamlessly aligned with the regional approach to technical regulation

Figure 1. Quality Infrastructure System



Source: Krob, D., Li, L., Yao, J., Zhang, H., & Zhang, X. (Eds.). (2021)¹⁰

¹⁰ Krob, D., Li, L., Yao, J., Zhang, H., & Zhang, X. (Eds.). (2021). Complex Systems Design & Management. doi:10.1007/978-3-030-73539-5

The key institutional components in the QI system consist of high-level institutions responsible for metrology, standardization, and accreditation. Good international practice has developed regarding QI institutions' configuration (i.e., independence or combination) in a given country. However, many possible combinations exist, depending on local customs, practices, policies, and resource constraints. However, some structures, such as accreditation and conformity assessment services, lead to conflicts of interest and should be avoided. In addition, certain combinations are increasingly seen as unnecessary barriers to trade. When optimizing the QI system, the international organizational structure of QI should be considered. The accreditation, metrology, and standards fields are separated globally. Each of these is further subdivided. However, detailed subdivision is not always advantageous for a country. Instead, it is recommended that a country establish an independent national standards body, an independent metrology institute, and an independent accreditation body. Sometimes, a combination of these may be recommended to reduce costs.

Another link in the QI system chain is the organizations providing conformity assessment and calibration services for QI. A product is tested against specific criteria, such as performance or safety. Testing is the most common form of conformity assessment. Testing is also the basis for other types of conformity assessment, such as inspection and product certification. The second one is inspection agencies; they play an essential role in cross-border trade. They act on behalf of governments and business partners (importers and exporters) by inspecting imported goods and materials. They are responsible for examining a wide range of products, materials, facilities, installations, installations, processes, work procedures, and services in the public as well as the private sector and report on parameters such as quality, fitness for use, and ongoing safety in operation. The objective is to reduce the risk for the inspected product's buyer, owner, user, or consumer. Certification is another, where a certification body provides written assurance that a product, service, process, personnel, organization, or management system meets specific requirements. The last one is calibration services. These services are essential to ensure that measuring equipment used in commerce, health care, environmental control, law enforcement, manufacturing, and other fields remains accurate within specified parameters. Calibration services, whose working standards are traceably calibrated against national (or regional) measurement standards, can be provided by the national metrology institute, the legal metrology department, and independent calibration laboratories in both the public and private sectors. Larger industrial organizations or authorities can even set up their in-house calibration facilities.

The QI system should emphasize markets and consumers. All the components of the QI system interact dynamically with each other. This interaction is particularly evident between businesses and customers/consumers. Businesses offer products and services and receive direct and indirect feedback from consumers in the form of sales and levels of customer satisfaction.

Markets also provide feedback on QI services, institutions, and governance - although not always as quickly. This feedback allows the different components and the entire QI to be reviewed, modified and improved. This emphasizes the dynamism and systemic nature of the QI system. In this context, it is crucial to create a link between the services provided by QI institutions and markets and consumers.¹¹ The roots of metrology go back to ancient civilizations, but it has developed significantly with the advent of industrialization and, more recently, globalization. As economies have grown and interacted more frequently on an international scale, the need for standardization and reliable measurements has become increasingly important. This historical perspective underlines the fact that metrology is constantly adapting to meet the demands of expanding and increasingly sophisticated markets. Current trends in metrology include digitalization, automation, and the integration of new technologies, such as the IoT, which are transforming measurement processes and capabilities. The future of metrology focuses on sustainability, with metrological applications playing an essential role in environmental monitoring and compliance with green standards. Furthermore, as global markets become more integrated and products more complex, demands on metrology systems will increase and require continuous innovation and adaptation¹².

From this perspective, this study will underline the critical importance of NQI and metrology in shaping global trade dynamics, supporting economic development, and facilitating technological innovation in a rapidly evolving world. The overall objective of this study is to enhance the understanding and application of NQI and metrology as crucial elements that support and improve international trade and economic development.

2.1. Metrology

Metrology can be defined as the science of accurate and reliable measurements. Beneath a seemingly simple surface, metrology encompasses a profound body of knowledge with which few people are familiar. Most people use it with the confidence that they share a common perception defined by terms such as meter, kilogram, liter, and watt. Reliability is vital for metrology to connect human activities across geographical and professional boundaries. Metrology is basically the science of measurement covering three main activities: the definition of all internationally recognized units, the realization of measurement units by scientific methods, and the establishment of a traceability chain by determining, documenting, and disseminating the value and accuracy of a measurement. Metrology, one of the critical components of an effective QI, is defined as the science of measurement and its application.

¹¹ https://www.unido.org/sites/default/files/files/2018-06/QP_TECHNICAL_GUIDE_08062018_online.pdf

¹² <https://publicsectorassurance.org/research/the-national-quality-infrastructure-a-tool-for-competitiveness-trade-and-well-being-the-world-bank-march-2013>

Metrology encompasses both the theoretical and practical dimensions of measurement, regardless of the uncertainty involved or the specific field of application. Metrology is also very broad, as it is used in many industries to enforce, validate, and verify pre-defined standards. The broad scope of metrology can be better understood by considering that there are an almost unlimited number of things to measure, numerous ways to perform the measurement, and various methods to express the results.

Metrology is commonly segmented into three subfields, each instrumental in guaranteeing accuracy, reliability, and precision.

Industrial (applied) metrology: Applied metrology ensures that measurement instruments are developed and adapted for industrial or manufacturing environments. This subfield manages these instruments' calibration and quality control to improve their operational performance.

Legal metrology: Legal metrology mainly focuses on the regulation requirements of measurement and measuring instruments to create an environment where consumers are protected and fair trade is achieved. One of the primary roles of government is to provide laws and regulations and safeguard firms and companies from negative consequences and false measurements. Therefore, this study will give special attention to the different approaches and various ways to improve QI backed by adequate legal metrology.

Scientific metrology: Scientific metrology concentrates on innovating new measurement techniques and setting measurement standards. Thus, it serves as the foundation for all subfields dedicated to advancing and upholding scientific measurement methodologies.

Metrology thus plays a fundamental role in a better-performing economy and the country's development in many aspects, such as adopting scientific and technological advances, facilitating the design and efficient production of market-oriented products, and identifying non-conformities. It provides essential support for health and safety assessments, environmental monitoring, and food processing. It also provides the basis for fair trade within national economies and across international markets. Metrology also plays an essential role in protecting both buyers and sellers in commercial transactions involving goods or services, as well as in situations where measurements are used to enforce regulations.

The history of metrology can be traced back to ancient civilizations, where standard measures were an integral part of trade and construction. In ancient Egypt, for example, cubits were a standard measurement used to build structures such as pyramids. The Renaissance brought significant advances in metrology by developing more accurate measuring instruments.

This era saw the introduction of standardized tools for length, weight, and volume, which were vital for the expanding trade networks of the time the 19th century marked a turning point with the establishment of national metrology institutes, such as the BIPM(BIPM) in 1875, which was instrumental in the development of the metric system. The 20th century saw further progress with the standardization of measurements at an international level, facilitated by the formation of global bodies such as the International Organization of Legal Metrology (OIML).

2.2. Standardization

A standard can be defined as a “Document approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory. It may also include or deal exclusively with terminology, symbols, packaging, marking or labeling requirements as they apply to a product, process or production method”.¹³ Standards provide guidance to improve quality, optimize processes, and ensure customer satisfaction, but the decision to comply with them is entirely up to the relevant parties. For instance, ISO 9001 is a standard used by many companies worldwide to improve their quality management processes. It defines how an organization should establish a quality management system to enhance customer satisfaction and ensure continuous improvement. However, compliance with ISO 9001 is not mandatory. Nevertheless, some standards are required, such as vehicle safety standards in the automotive industry. UN ECE Regulation 13 is a compulsory vehicle braking system standard established by the United Nations Economic Commission for Europe (UNECE). It sets out the requirements for braking performance, including how braking systems must function under various conditions, such as emergency braking or braking at high speeds. Vehicle manufacturers must comply with UN ECE Regulation 13 to legally sell vehicles in many regions, including the European Union. Compliance with this regulation is not optional; it is required by law to ensure that vehicles meet minimum safety standards for braking systems.

Standardization is a crucial aspect of the modern world and plays a vital role in ensuring consistency, compatibility, and reliability across various industries and sectors. Standardization promotes a unified approach to product and service development, manufacturing, and delivery by establishing standard guidelines, specifications, and requirements. This not only enhances the quality and safety of products but also facilitates interoperability and reduces technical trade barriers. Standardization enables companies to streamline their processes, reduce costs, and improve efficiency, ultimately benefiting both businesses and consumers while promoting trade, both at national and international levels.

¹³ Standards, Metrology, & Conformity Assessment: Technical Barriers to Trade <https://standardsalliance.ansi.org/>

Swann (2009) investigates how standardization reduces trade barriers and facilitates smoother international commerce. The study presents data and analysis showing that standards help companies gain enhanced market access and improve competitiveness on a global scale, particularly by aligning products with international expectations and requirements¹⁴. Blind (2016) outlines the economic benefits of standardization, emphasizing its crucial role in fostering innovation and boosting productivity. The paper argues that standards create a foundation that supports technological advancements and innovation, contributing significantly to overall economic growth¹⁵. The literature provides a comprehensive overview of the pivotal roles that NQI and metrology play in facilitating international trade and promoting industrial competitiveness. It also sets the stage for addressing the identified research gaps, proposing that future work could explore innovative ways to support SMEs and enhance the global applicability of NQI systems.

To add more, standardization is essential for driving innovation and fostering economic growth. By providing a framework for developing new technologies and solutions, standards help create a level playing field for businesses, encouraging healthy competition and collaboration. They also enable the dissemination of knowledge and best practices, promoting the adoption of the newest technologies and facilitating the transfer of expertise. In an increasingly globalized world, standardization can be treated as a critical enabler of international trade, helping to eliminate technical barriers and promote the free flow of goods and services. As such, it is an indispensable tool for countries seeking to enhance their competitiveness and achieve sustainable economic development.

The development of international standards began to accelerate in the 20th century, particularly after the creation of the ISO in 1947. This body helped unify standards across nations, making it easier for companies to operate in an increasingly globalized economy.

- ✓ Four basic categories of standards functions can be distinguished¹⁶;

Information and reference standards, also called measurement standards, establish a common technical language in which physical properties can be compared and descriptive technical information conveyed. They include unit standards, such as the number system, which were probably the first technical standards.

¹⁴ Swann G.M.P. (2009) "International Standards and Trade: A Review of the Empirical Literature", Paper prepared for the OECD Workshop and Policy Dialogue on Technical Barriers to Trade, 5-6 October 2009, <http://www.oecd.org/dataoecd/13/24/43685142.pdf>

¹⁵ Knut Blind, 2016. "[The impact of standardisation and standards on innovation](#)," [Chapters](#), in: Jakob Edler & Paul Cunningham & Abdullah Gök & Philip Shapira (ed.), [Handbook of Innovation Policy Impact](#), chapter 14, pages 423-449, Edward Elgar Publishing.

¹⁶ DTI (Department of Trade and Industry). 2005. "The Empirical Economics of Standards." DTI Economics Paper 12, UK Department of Trade and Industry, London.; Swann, G. M. P. 2000. "The Economics of Standardization." Final Report for Standards and Technical Regulations Directorate, UK Department of Trade and Industry. Manchester Business School, Manchester, UK.; Blind, K. 2004. *The Economics of Standards: Theory, Evidence, Policy*. Northampton, MA: Edward Elgar.

Weights and measures were first codified in 3500 BC, primarily to facilitate the fair and reliable collection of taxes. Centuries later, in 1799, different unit and reference standards in different kingdoms merged into the metric system¹⁷. These standards also include information standards, which provide rules for communicating product characteristics. For example, bolt standards explain how to specify bolt dimensions. A bolt manufacturer need only specify "M10 x 1.5-6g-S" to be fully understood by its customers; it does not need to describe a particular bolt as "metric fastener thread profile M, fastener nominal size (nominal major diameter) 10 mm, thread pitch 1.5 mm, external thread tolerance class 6g, and thread engagement length group S (short)".

Variety-reducing (or interchangeability) standards define the common characteristics of two or more units. In this way, they provide interchangeability and create economies of scale and learning in production. Most standards fall into this category. Variety-reducing standards grew out of the Industrial Revolution when the efficiency of mechanized manufacturing depended on codifying the characteristics of products and processes. A well-known standard of this type is the international paper standard, ISO 216, which defines the A4 format used in most of the world except North America. The widespread use of A4 paper has many benefits beyond economies of scale in paper production itself. It avoids the need to rework documents to fit different formats, and it allows consumers to choose between competing paper brands, to calculate shipping weights based on the number of pages (most A4 sheets are the same weight), and to fit paper from different sources into the same envelopes and folders, among many other benefits.

Compatibility and interface standards define physical or virtual relationships between independent entities for the purpose of interoperability or communication. Most of a country's infrastructure uses compatibility standards to link several private and public entities. Consider the case of electricity distribution standards in the UK, which is an early adopter of compatibility standards. All sockets accept a single type of plug, type G, and supply 230V at 50Hz. In contrast, in Cuba, there is a single 60Hz frequency standard, but the voltage supplied is either 110V or 220V, and sockets can be of one of five types - A, B, C, F, or L. As a result, Cuban consumers may need to fit electrical appliances with cumbersome adapters and converters before they can use them at home.

Minimum quality and safety standards allow consumers to assess the quality or safety of a product before they buy it. The best-known quality standards, the ISO 9000 standards of the ISO, are perhaps the most misunderstood. ISO 9000 standards do not specify a product's quality but a management system. They are process standards that describe the organizational procedures an organization must follow to ensure the consistent quality of its products and services.

¹⁷ Krechmer, K. 2000. "The Fundamental Nature of Standards: Economic Perspective." Paper presented at the International J. A. Schumpeter Society Economics Conference, Manchester, UK, June 28–July 1.

Suppliers who adhere to these standards signal buyers that they can produce goods and services of consistent quality. These standards play a particularly important role in today's global economy and will be discussed many times throughout this book. Like quality standards, safety standards are widely used for consumer goods such as toys, food, medicines and electrical appliances. They may specify requirements relating to product design, product performance, or manufacturing processes.

From this perspective, establishing standardization among OIC members can improve not only trade but also collaboration and knowledge-sharing in the long run, promoting increased welfare throughout the process. Establishing standards among member countries can provide a vital boost to trade and welfare.

2.3. Accreditation

Accreditation is another vital component of the NQI, serving as a vital tool for ensuring the competence, impartiality, and integrity of conformity assessment bodies.

Accreditation enhances the credibility and reliability of conformity assessment results by assessing the technical proficiency and adherence to international standards of testing laboratories, inspection bodies, and certification organizations. This, in turn, promotes trust and confidence among consumers, businesses, and regulatory authorities, both within a specific country and across borders. Accreditation acts as a stamp of approval, demonstrating that conformity assessment bodies have the necessary expertise and resources to perform their tasks effectively and efficiently.

The concept of accreditation originated in the early 20th century as industries and technologies became more complex and the need for standardized and reliable quality assurance methods grew. The establishment of national and international accreditation bodies aimed to unify standards and ensure the competency of organizations in conducting certification and testing according to these standards.

Accreditation acts as a supra layer that guarantees impartiality, confidence in results, and competence of the assessors. Accreditation is regulated and is defined as an attestation by a national accreditation body that a conformity assessment body meets the requirements set by harmonized standards and, where applicable, any additional requirements, including those set out in relevant sectoral schemes, to carry out specific conformity assessment activity. Accreditation is a service of public interest, and national accreditation bodies act as public authorities and, as such, are objective and impartial. This should provide confidence in the results.

Development of National Systems: In several countries, national accreditation bodies began to form to oversee and ensure the competency of institutions involved in conformity assessment. These bodies were crucial in establishing a trustworthy infrastructure for quality assurance.

International Coordination: The latter half of the 20th century saw the creation of international networks and agreements such as the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF), which play a crucial role in ensuring the mutual recognition of accreditation among countries. This international framework helps reduce duplication in testing and certification, significantly easing the process of entering new markets.

Modern Developments: In recent years, accreditation has evolved to encompass a broader range of services and sectors, including healthcare, education, and information technology. This reflects the growing importance of accreditation in various aspects of global commerce and public welfare.

In addition to its role in ensuring the reliability of conformity assessment, accreditation also plays a crucial role in facilitating international trade and market access. By promoting the mutual recognition of conformity assessment results among countries, accreditation helps to reduce technical trade barriers and enhance the free flow of goods and services across borders. This is particularly important in our globalized economy, where businesses often need to demonstrate compliance with a wide range of international standards and regulations to compete with others. By providing a framework for harmonizing conformity assessment practices and the mutual recognition of results, accreditation helps create fair competition for businesses, thus enabling companies to access new markets and opportunities. In this perspective, it serves as an essential tool for countries seeking to enhance their trade competitiveness and achieve sustainable economic growth.

2.4. Conformity Assessment

Metrology provides the measurement accuracy and standards that are essential for the integrity of conformity assessment processes. Conformity assessment, in turn, relies on metrology to ensure that products, services, and systems meet the required standards, ensuring quality, safety, and compliance across various sectors.

Conformity assessment is a critical part of the NQI, working in tandem with standardization, metrology, and accreditation to ensure the quality, safety, and reliability of products and services. By evaluating the conformity of products, services, and processes against specified requirements, i.e., standards and regulations, conformity assessment provides a means of demonstrating compliance and building trust in the marketplace. This can be achieved through various methods, including testing, inspection, and certification, which are carried out by competent and impartial conformity assessment bodies. By ensuring that products and services meet the necessary standards and requirements, conformity assessment helps to protect consumers and promote public health and safety while supporting the smooth functioning of markets.

Conformity assessment also plays a crucial role in facilitating international trade and market access. By providing a means of demonstrating compliance with international standards and regulations, conformity assessment helps remove technical barriers to trade and promote the free flow of goods and services across borders¹⁸. This is again crucial in an increasingly globalized economy, where businesses must navigate a complex web of standards and regulations to access new markets and opportunities. By working in conjunction with accreditation, which ensures the competence and impartiality of conformity assessment bodies, conformity assessment helps businesses, promoting fair competition and enabling them to demonstrate the quality and reliability of their products and services to customers around the world. Parallel to standardization and accreditation, conformity assessment is an essential tool for countries seeking to enhance their trade competitiveness and achieve sustainable economic growth and OIC countries are no exception.

Conformity assessment refers to the processes used to demonstrate that a product, service, or system meets the requirements of a particular standard or regulatory framework. The three primary tools of conformity assessment are testing, certification, and inspection:

Testing involves evaluating a product or system's characteristics to determine whether it meets specified requirements. This process is often carried out in laboratories or specialized facilities equipped to measure performance, safety, durability, and other critical attributes.

Certification is the formal recognition that a product, service, or system complies with specific standards. An independent body usually grants certification after a thorough evaluation of the product or system in question. This process often includes testing, as well as reviews of production processes and quality management systems.

Inspection involves examining products, services, or systems to ensure they conform to specified requirements. This can include on-site evaluations, audits of production processes, and assessments of compliance with regulatory standards. Inspections are often carried out by qualified professionals who assess whether the operational and environmental conditions meet established criteria.

Conformity assessment tools, which include testing, inspection and certification, are crucial for the effective functioning of NQI. They help ensure that products, services, and processes meet specified standards, thereby fostering trust in national and international markets. However, many OIC member countries face significant challenges in effectively implementing these systems. Common challenges include:

¹⁸ Kellermann M. (2019), Ensuring Quality to Gain Access to Global Markets: A Reform Toolkit, World Bank, <https://thedocs.worldbank.org/en/doc/249621553265195570-0090022019/original/FullQIToolkitReport.pdf>

Lack of Awareness Among Businesses: Many businesses, especially small and medium-sized enterprises (SMEs), are unaware of the importance of conformity assessment and how it can enhance their competitiveness in both local and international markets.

Limited Government Engagement: In some countries, government agencies may not fully understand the significance of conformity assessment or may not prioritize its development, leading to inadequate policy support.

Weak Regulatory Frameworks: Some OIC member countries lack the necessary legal and regulatory frameworks to enforce conformity assessment effectively. This can lead to inconsistencies in the implementation and enforcement of standards.

Fragmentation of Standards: In some cases, the coexistence of multiple, overlapping, or conflicting standards can create confusion and inefficiencies, complicating the conformity assessment process.

Slow and Inefficient Processes: In some OIC member countries, the conformity assessment processes are bogged down by bureaucracy, leading to delays and inefficiencies.

2.5. Calibration and Verification

Calibration and verification tools are central to an effective NQI, which ensure the accuracy and reliability of measurements used in manufacturing, trade, and regulatory processes. These tools are essential across various sectors, including manufacturing, healthcare, food production, and environmental monitoring. Calibration ensures that measurement instruments are accurate and aligned with standards, while verification ensures that these instruments continue to perform correctly over time. Both processes are vital to maintaining the integrity of measurements in metrology. Metrology provides the foundational science and standards for measurements, ensuring that there is a consistent and universally recognized basis for all measurements. Calibration is directly linked to metrology, as it involves comparing an instrument's measurements against the metrological standards to ensure accuracy. Without metrology, there would be no reference point for calibration. Verification builds on both metrology and calibration by ensuring that instruments or processes conform to the required standards and continue to perform accurately over time. It is an ongoing process that often requires recalibration and revalidation to maintain compliance and quality. In OIC member countries, calibration and verification underpin critical industries and ensure that products and services meet both national and international standards.

Calibration is the process of comparing a measurement instrument or system against a standard of known accuracy. This process ensures that the instrument provides accurate and traceable measurements, which are crucial for maintaining consistency in product quality, safety, and

compliance with international standards. Calibration is typically performed in specialized laboratories with highly precise reference standards.

Verification involves confirming that an instrument or system meets the specified requirements for accuracy and performance. Verification is often performed after calibration to ensure that the instrument continues to function correctly over time, especially in critical applications where measurement accuracy directly impacts safety, performance, or regulatory compliance.

While calibration and verification tools are critical to NQI, many OIC member countries face challenges in implementing these systems effectively. Common challenges include:

Lack of Calibration Laboratories: Many OIC member countries lack the necessary infrastructure, such as calibration laboratories, to support accurate measurement systems. These countries may need to rely on foreign laboratories, which can be costly and time-consuming.

Limited Technical Expertise: A shortage of skilled personnel trained in calibration and verification processes can hinder the development of effective NQI systems in OIC countries. Building local expertise is essential for the long-term success of these initiatives.

Inconsistent Standards: The lack of harmonized standards across OIC member countries can create barriers to trade and reduce the effectiveness of calibration and verification tools. Harmonization of standards and metrology practices is necessary to facilitate trade and ensure the mutual recognition of measurement results.

3. NQI for OIC Member Countries

NQI is a cornerstone of sustainable development, economic growth, and international trade for OIC member countries. By ensuring that products and services meet high standards of quality, safety, and environmental sustainability, NQI enhances the competitiveness of businesses, protects consumers, promotes innovation, and supports regulatory compliance. For OIC member countries, investing in and strengthening NQI systems is essential to unlocking new opportunities in the global economy, achieving SDGs, and fostering long-term prosperity for their populations.

3.1. Importance of NQI

NQI is vital for OIC member countries seeking to participate more fully in the global economy. When products are certified to meet international standards, they can access new markets and trade opportunities. A robust NQI system is critical for improving the competitiveness of industries in OIC member countries. By adhering to internationally recognized standards, businesses can enhance the quality and performance of their products and services. This not only allows them to compete more effectively in the global marketplace but also promotes innovation and operational efficiency. Higher quality standards drive industries to optimize their processes, reduce waste, and improve productivity, all of which contribute to long-term economic growth.

NQI plays a key role in protecting consumers by ensuring that the products they purchase meet established safety and quality standards. Through the implementation of standards and conformity assessments, NQI systems prevent the circulation of substandard or unsafe products, thus safeguarding public health and safety. This is particularly important in sectors such as food, pharmaceuticals, and medical devices, where the quality of products has a direct impact on human health. Many OIC member countries face pressing environmental challenges, such as resource depletion, climate change, and pollution. NQI systems that integrate sustainability standards help these countries address these issues by promoting responsible production and consumption practices. NQI drives innovation by establishing frameworks that encourage the development and adoption of new technologies.

A strong NQI system helps OIC member countries improve regulatory compliance across various sectors. Governments use NQI to enforce health, safety, environmental, and other regulations that protect the public and ensure fair competition. By aligning with internationally accepted practices, NQI helps governments implement effective regulatory frameworks that are transparent, predictable, and consistent with global norms. This, in turn, enhances governance and builds trust among businesses, consumers, and international partners.

There are many examples of an inadequate NQI system causing significant losses to exporting countries in the absence of a reliable and robust NQI system or when faced with new regulations. Some of these cases can be shown as follows:

CASE 1. Vietnamese Seafood Industry¹⁹

In 2016, the United States tightened its regulations on catfish imports, requiring compliance with the USDA's food safety standards. Many Vietnamese exporters struggled to meet these requirements due to inadequate quality infrastructure, including poor testing facilities and lack of certification processes. As a result, several shipments of Vietnamese catfish were rejected at U.S. ports, leading to a sharp decline in exports to one of Vietnam's largest markets. This rejection caused significant financial losses for Vietnamese exporters and damaged the reputation of the country's seafood industry on the global stage.

The 2016 tightening of U.S. regulations on catfish imports had a profound impact on Vietnam's seafood industry. The shift from FDA oversight to USDA's stricter food safety standards created a significant hurdle for Vietnamese exporters who were unprepared for the enhanced regulatory environment. The lack of adequate quality infrastructure in Vietnam, such as insufficient testing facilities and certification processes, meant that many exporters struggled to comply with the new requirements. As a result, the rejection of Vietnamese catfish at U.S. ports not only led to immediate financial losses but also tarnished the reputation of Vietnam's seafood industry. The decline in exports to the U.S., one of Vietnam's largest markets, highlighted the vulnerabilities within the country's export system and underscored the importance of investing in better quality control and certification mechanisms. This situation also served as a cautionary tale for other countries relying heavily on exports to markets with stringent regulatory frameworks, emphasizing the need for robust domestic infrastructure to support compliance with international standards. Moreover, the financial repercussions extended beyond the immediate losses, affecting the livelihoods of many workers in the Vietnamese seafood industry and disrupting trade relationships. It illustrated how regulatory changes in a major importing country could have far-reaching consequences for exporting nations, particularly those with emerging economies that may not have the resources to quickly adapt to new standards.

¹⁹

https://www.efaidnbmnnnibpcajpcgclefindmkaj/https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Food%20and%20Agricultural%20Import%20Regulations%20and%20Standards%20-%20Narrative_Hanoi_Vietnam_12-28-2017.pdf

CASE 2. Indian Pharmaceutical Exports²⁰

In 2013, the U.S. Food and Drug Administration (FDA) banned the import of drugs from certain Indian pharmaceutical companies due to non-compliance with Good Manufacturing Practices (GMP). These issues were linked to weak quality control and regulatory oversight within India's NQI.

The ban led to significant financial losses for the affected companies, tarnished the reputation of India's pharmaceutical industry, and resulted in increased regulatory scrutiny of Indian drug exports. This prompted the Indian government to take steps to strengthen its NQI and improve compliance with international standards.

The 2013 FDA ban on drugs from certain Indian pharmaceutical companies was a pivotal moment for India's pharmaceutical industry, exposing critical weaknesses in quality control and regulatory oversight. The non-compliance with Good Manufacturing Practices (GMP) highlighted the gaps in India's NQI, particularly in ensuring that pharmaceutical production met international standards. This situation served as a stark reminder of the importance of maintaining stringent quality controls, especially in an industry as vital as pharmaceuticals, where lapses can have severe public health implications.

The financial losses incurred by the affected companies were substantial, underscoring the economic risks associated with non-compliance. Beyond the immediate financial impact, the ban damaged the global reputation of India's pharmaceutical industry, which is known as the "pharmacy of the world" due to its large volume of generic drug exports. The increased regulatory scrutiny that followed the ban added further challenges, as Indian exporters faced more rigorous inspections and a loss of trust in key markets.

In response to this crisis, the Indian government recognized the need to bolster its quality infrastructure and align more closely with international standards. This led to efforts to enhance regulatory oversight, improve the capabilities of testing laboratories, and ensure that manufacturing practices across the industry adhered to global benchmarks. The situation also highlighted the broader necessity for countries with significant export-oriented industries to maintain robust regulatory frameworks that can prevent such incidents and protect their industries' international standing.

²⁰ <https://qualitymatters.usp.org/indian-pharma-s-role-global-drug-supply>

CASE 3. Kenyan Horticulture Exports²¹

In 2013, the European Union rejected several shipments of Kenyan fresh produce, including beans and peas, due to non-compliance with pesticide residue limits. The rejections were attributed to inadequate testing and certification processes within Kenya's NQI.

The rejections led to financial losses for Kenyan exporters, strained trade relations with the EU, and threatened the livelihoods of many farmers dependent on these exports. This situation underscored the need for Kenya to enhance its quality infrastructure, particularly in the areas of testing and certification, to meet international standards.

The 2013 rejection of Kenyan fresh produce shipments by the European Union due to non-compliance with pesticide residue limits was a critical event that highlighted significant deficiencies in Kenya's NQI. The inability to meet the EU's stringent standards revealed gaps in Kenya's testing and certification processes, which are essential for ensuring that agricultural products are safe and compliant with international regulations. This situation served as a stark reminder of the importance of robust quality controls in global trade, particularly for countries whose economies are heavily reliant on agricultural exports.

The financial losses incurred by Kenyan exporters were substantial, as the rejection of shipments not only meant immediate economic setbacks but also threatened long-term trade relationships with one of Kenya's key markets. The impact extended beyond exporters to the many farmers who depend on these exports for their livelihoods, underscoring the broader socioeconomic consequences of such trade disruptions. The incident strained trade relations with the EU and highlighted the vulnerability of Kenya's agricultural sector to shifts in regulatory requirements in key export markets.

In response to these challenges, it became evident that Kenya needed to invest in strengthening its quality infrastructure. Enhancing the accuracy and reliability of testing facilities, improving certification processes, and ensuring compliance with international standards were crucial steps for regaining market access and rebuilding confidence among international buyers. This incident not only underscored the necessity of quality infrastructure for sustaining export markets but also highlighted the interconnectedness of global trade, where lapses in one area can have widespread and lasting effects on a nation's economy and reputation.

²¹ https://fpeak.org/wp-content/uploads/2023/05/Good_Practice_Guide-Beans-and-Peas-Final-Version.pdf

CASE 4. Brazilian Beef Exports²²

In 2017, several countries, including the European Union, temporarily suspended imports of Brazilian beef following a scandal where it was revealed that some meat processing companies had been involved in bribing inspectors to certify tainted meat as safe. This indicated weaknesses in Brazil's quality infrastructure, particularly in regulatory enforcement and corruption control.

The suspension led to significant financial losses for the Brazilian beef industry, damaged its reputation as a reliable meat supplier, and prompted the Brazilian government to implement stricter controls and reforms in its quality infrastructure to regain international trust.

The 2017 suspension of Brazilian beef imports by several countries, including the European Union, was a significant blow to Brazil's meat industry and a stark revelation of systemic issues within the country's quality infrastructure. The scandal, which involved bribery of inspectors to certify tainted meat as safe, highlighted critical weaknesses in regulatory enforcement and corruption control within Brazil. This event underscored how lapses in governance and oversight can have far-reaching consequences, not just in terms of public health but also in international trade and economic stability.

Brazil's beef industry suffered considerable immediate financial losses as it temporarily lost access to some of its most lucrative markets. The reputational damage was equally severe, shaking global confidence in Brazil as a reliable meat supplier. This incident served as a wake-up call, showing that trust in food safety is fundamental to maintaining trade relationships and that any breach of this trust can lead to swift and severe repercussions.

In response, the Brazilian government was compelled to take decisive action to restore confidence in its meat industry. This included implementing stricter controls, enhancing regulatory enforcement, and taking steps to combat corruption within the inspection process. The scandal also emphasized the broader importance of maintaining robust quality infrastructure, not just in Brazil but globally, as a means of ensuring the safety and integrity of food supply chains. For Brazil, these reforms were crucial in rebuilding its reputation and regaining the trust of international markets.

²² <https://www.aljazeera.com/economy/2017/3/20/brazils-rotten-meat-scandal-prompts-major-import-bans>

3.2. Benefits of NQI

A robust NQI is essential for building a resilient, competitive, and sustainable economy. It not only opens doors to international trade but also ensures that quality and safety benefits permeate all levels of society, from consumers to producers, contributing to overall national development.

A well-developed NQI enables countries to meet the stringent standards of international markets, facilitating smoother entry into global trade. This is particularly crucial for export-oriented industries, as compliance with international standards helps avoid costly rejections and trade barriers, thus expanding market opportunities. A strong NQI contributes to the overall competitiveness of a country's industries by ensuring that products meet quality standards. This enhances export revenues and attracts foreign investment, driving economic growth and job creation.

A well-established NQI encourages innovation by setting benchmarks that industries strive to meet or exceed. It also facilitates the adoption of new technologies and practices, leading to improved productivity and the development of higher-value products.

A robust NQI helps identify and mitigate risks associated with product safety, environmental impact, and public health. This proactive approach reduces the likelihood of costly recalls, legal liabilities, and damage to a country's reputation.

A strong NQI helps improve the quality of domestic goods and services by applying consistent quality standards across all sectors. This leads to healthier competition within the local market, driving improvements in quality and efficiency, which benefit consumers and businesses alike. Consumers, both domestic and international, are more likely to trust and purchase products that are certified to meet recognized standards. A robust NQI ensures that products are safe, reliable, and high-quality, thereby boosting consumer confidence and demand.

Countries with a robust NQI are better positioned to participate in international standard-setting bodies and collaborate on global initiatives. This enhances their influence in shaping global standards and fosters international partnerships that can lead to knowledge exchange and shared best practices.

Many OIC member countries rely heavily on natural resources such as oil and gas. NQI enables these countries to diversify their economies by developing new industries, particularly in sectors such as manufacturing, agriculture, and services. By fostering higher-quality production, NQI helps countries build resilience against economic shocks and reduces their dependence on commodity exports. For many OIC member countries, halal trade is a significant economic sector. NQI systems that include halal standards, certification, and metrology ensure that products meet the strict requirements of halal markets. This not only enhances consumer confidence but also opens up opportunities for OIC countries to become global leaders in halal food, cosmetics, pharmaceuticals, and other products. A

reliable NQI system improves the investment climate by providing assurance that the quality of products and services meets international standards. This attracts foreign direct investment (FDI) as investors seek markets with predictable regulatory environments and high-quality infrastructure. FDI, in turn, supports job creation, knowledge transfer, and economic development in OIC member countries. NQI is not limited to private sector benefits; it also enhances public sector services. For example, healthcare services in OIC countries can be significantly improved by adopting standards for medical devices, laboratory testing, and healthcare facilities. Implementing NQI in public services raises the overall quality of life and improves access to essential services.

Many academic studies show that the components of QI contribute significantly to innovation, trade, the welfare of individuals, and the development of countries.

King et al. (2006) tested whether good measurements would support innovation because the incentives to innovate depend on the capacity of the firm and consumer to measure and verify whether the product has specific unique characteristics. He collected data from the Community Innovation Survey regarding using the National Measurement System (NMS) by different industrial sectors. The findings were different for product innovations and process innovations. While the impacts of good measurements were significant and positive for the former, the effects on the latter were not substantial. It was also shown that the direction and magnitude of the impacts also depend on other factors that range from sound testing systems to the level of competition in goods and services markets²³.

NIST (2006) conducted a survey that enquired about measurement requirements in different sectors, asking how innovation was refrained by the lack of suitable measurements. Two of the most notable outcomes of this study were: lacking accuracy of measurement tools is the most common problem to innovation, namely in those sectors whose dynamics lead to more technological changes (e.g., IT, telecommunications, health care, nanotechnology); the inexistence of standards, metrics and so on, that enable the assessment of new technologies hinders significant innovation²⁴.

Birch (2003) assessed the impacts of their measurement activities on trade. In this study, it was argued that for each dollar spent by this organization on periodic inspections to evaluate the quality of measurement tools, it would save, on average, \$11.40 in measurement errors. This value would vary from sector to sector. In sectors where measurement accuracy was more relevant, this value would go up to \$28.7²⁵.

²³ King, M., R. Lambert, P. Temple and R. Witt (2006), "The Impact of the Measurement Infrastructure on Innovation in the UK", Unpublished Paper, Department of Economics of the University of Surrey

²⁴ NIST (2006), "An Assessment of the United States Measurement System: Addressing Measurement Barriers to Accelerate Innovation," Special Publication No.1048, NIST, available online at: http://usms.nist.gov/usms07/usms_assessment_report_2006.pdf.

²⁵ Birch, J. (2003), "Benefit of Legal Metrology for the Economy and Society", Report for International Committee of Legal Metrology

NMS of the UK (1999) includes several case studies made by the Department of Trade and Industry of the UK (DTI). Among others, the case of Warm Petrol is a good illustration of the importance of legal metrology. This case refers to the losses associated with the temperature of oil, higher than the ambient, incurred by retailers because suppliers were ignoring that petrol contracts when it cools to the ambient temperature and that there are vapor losses associated with the temperature at which it is delivered. The dispute between retailers and suppliers went on for over a decade, and the losses, allied with the high competition in the retail market, started putting many firms out of business. This issue caught the attention of DTI who made an assessment of the benefits if legislation would be made by the NMS in order to force oil suppliers to keep the temperature of the oil below the ambient temperature. In order to do so, the costs that producers would have to incur to comply with the new legislation were calculated and amounted to £15 million, and the costs associated with implementing this legislation were £75 million. On the other hand, externalities are expected from this legislation: retailers would face lower losses, and fewer retailers would go out of business, increasing competition. For retailers, losses would be reduced by £80 million. Regarding the retailers that would not go out of business, the reduced employment that is avoided amounts to a benefit of £13 million. As mentioned in the paper, most of the benefits would be reaped every year while the costs would mostly be only incurred once²⁶

Lima et al. (2008) conducted an impact assessment study to measure the consequences of socio-environmental certification on community forest management in the State of Acre for wood production. This study shows that the impacts of this certification were relatively small because several public institutions are already involved with Community Forest Management. Still, some changes were noted, namely regarding the disposal of residues, awareness about the use of fire, measures to protect wildlife, and degree of involvement in environmental complaints. In order to sanction the impacts of this certification, it was selected a group of community producers with similar economic and geographic characteristics to those of the certified community producers and against whom a group of accredited producers were compared regarding: environmental preservation, quality of the administration of the association, use of Personal Protection Equipment (PPE), and income from wood sales²⁷.

Imhof and Lee (2007) aimed at assessing the impacts of certified fair-trade plantations in Bolivia. Some of the significant findings were that fair trade has an effect on poverty reduction and, therefore, contributes to the decrease in politically related conflicts; it increased the competition among

²⁶ NMS (1999), "Review of the Rationale for and Economic Benefit of the UK National Measurement System", NMS, available online at: <http://www.bis.gov.uk/files/file32855.pdf>.

²⁷ Lima, A., A. Keppe, M. Alves, R. Maule, G. Spavorek (2008), "Impact of FSC forest certification on agroextractive communities of the state of acre, Brazil", IMAFLORA.

intermediaries as a result of the emergence of fair trade cooperatives, which led to an increase of the price paid to the producers; it enabled capacity building because certified fair-trade implies constant training on organic production, management issues and so on. In order to conduct this study, 160 interviews were made using a semi-directly administered questionnaire, which permitted the gathering of data regarding prices, yields, processing stages, and average costs²⁸.

Martin et al. (2000) prepared an impact assessment study on NIST's certified reference material for the sulfur content in fossil fuels on a range of economic and environmental issues, namely, on the increase of production efficiency, changes of transaction costs, reduction of sulfur entering the environment, reduction of penalties imposed by regulatory agencies. In order to do so, it was evaluated how the reference material led to a change in the accuracy of the measurement of sulfur in fossil fuels and in the cost of these tests, how these changes affected the behavior of stakeholders and the quantification of the economic benefits or losses associated with these changes. In order to compare the situation before and after the creation of standard reference materials (SRMs), it was assumed that the level of uncertainty associated with the measurement of sulfur in fossil fuels would be today similar to what it was before the introduction of the reference material in the middle 1980s. The estimated present value of benefits was US\$409 million against costs of US\$3 million²⁹.

Although the academic literature emphasizes that the QI system makes significant contributions to countries' economic development and trade potential, the lack of academic studies on the effects that may arise with NQI in OIC member countries is also seen as an important deficiency. The next section presents the situation of OIC member countries in terms of the QI system more clearly.

²⁸ Imhof, S. and A. Lee (2007), 'Assessing the Potential of Fair Trade for Poverty Reduction and Conflict Prevention: A Case Study of Bolivian Coffee Producers', Europainstitut of the University of Basel, available at: www.swisspeace.ch/typo3/fileadmin/user_upload/pdf/Assessing_the_Potential_of_Fair_Trade_for_Poverty_Reduction_and_Conflict_Prevention.pdf.

²⁹ Martin, S., M. Gallaher, A. O'Connor (2000), "Economic impact of standard reference materials for sulfur in fossil fuels", NIST.

Benefits of NQI	
Enhanced International Trade	A well-developed NQI helps countries meet international standards, facilitating smoother entry into global markets and expanding export opportunities.
Increased Competitiveness and Investment	A strong NQI enhances industry competitiveness, attracts foreign investment, and drives economic growth and job creation by ensuring products meet quality standards,
Innovation and Technology Adoption	A robust NQI fosters innovation by setting benchmarks, promoting the adoption of new technologies, and improving productivity and product value.
Risk Mitigation	Effective NQI systems identify and mitigate risks related to product safety, environmental impact, and public health, reducing the likelihood of costly recalls and legal issues.
Consumer Confidence and Market Diversification	NQI improves product quality, boosts consumer confidence and demand, and supports economic diversification by developing new industries beyond natural resources.
Public Sector Improvement	NQI enhances the quality of public services, such as healthcare, by implementing medical device and facility standards, thereby improving overall quality of life.

3.3. Private-Public Partnerships (PPPs)

PPPs can play a crucial role in strengthening NQI, which is the foundation for ensuring the quality, safety, and efficiency of products, services, and processes within a country. Enhancing NQI through PPPs brings together the expertise, resources, and innovation of the private sector with the government's regulatory authority and public interest mandate.

The partnerships involve collaboration between private sector businesses and government bodies. Businesses often have advanced technical knowledge, innovative capabilities, and resources that can be harnessed to enhance NQI. Companies can work with public agencies to develop industry-specific standards. They bring practical insights, ensuring that standards are relevant and applicable to real-world scenarios. Private companies can invest in or co-develop metrology laboratories and testing centers, which are critical for conformity assessment. Such investments can reduce the burden on government budgets, accelerate the establishment of these facilities, and contribute to training and capacity building in NQI institutions, ensuring that staff are up-to-date with the latest technologies and methodologies.

PPPs generally refer to more formalized and long-term collaborations between governments and private entities. These partnerships are often structured through contracts where private partners deliver public services or infrastructure. PPPs can be used to develop and operate national laboratories, testing facilities, or certification bodies. The government may provide regulatory oversight, while the private partner manages day-to-day operations, ensuring efficiency and

innovation. Governments can collaborate with private organizations to establish or enhance national accreditation bodies. Private entities may contribute through technical expertise, while the government ensures alignment with international standards.

Private sector involvement brings specialized knowledge and cutting-edge technology to the table. By collaborating with businesses, public agencies can ensure that NQI development keeps pace with global advancements. PPP models allow for shared financial and operational responsibilities, which can be especially beneficial in resource-constrained environments. By pooling resources, both sectors can achieve more significant results than they could independently. Private entities often have more flexibility and speed in executing projects compared to government agencies. This can lead to faster implementation of NQI improvements, helping industries comply with international standards and access global markets more quickly. Partnerships allow risks associated with NQI projects to be shared between the public and private sectors. For example, the financial burden does not fall solely on the government if a project faces delays or cost overruns.

One of the critical challenges is ensuring that the objectives of private businesses align with public policy goals. While enterprises are profit-driven, public entities focus on social welfare, consumer protection, and international competitiveness. Aligning these goals requires careful negotiation and clear contractual terms. Maintaining rigorous regulatory oversight is crucial to ensure that NQI improvements meet national and international standards. The public sector must ensure that private partners adhere to established guidelines and that quality is not compromised for profit. PPP projects, particularly those involving critical infrastructure, require long-term commitment and sustainability. It's essential to design partnerships that can adapt to changing technologies, market conditions, and regulatory environments. For these partnerships to succeed, both sides must have a high level of trust and capacity. Governments must ensure that private partners have the technical and financial capabilities to deliver on their commitments, while private partners need confidence in the government's stability and regulatory framework.

There are some QI systems in OIC member countries where private-public cooperation is realized. Some of them can be summarized as follows:

The Dubai Accreditation Department³⁰ works with private testing and calibration laboratories to ensure that they meet international standards. This partnership allows private entities to gain accreditation recognized globally, which is crucial for international trade and market access. This has led to enhanced trust in products and services coming from the UAE, boosting the country's trade and economic growth. In Indonesia, BSN³¹ has partnered with SMEs to help them understand and

³⁰ <https://www.dm.gov.ae/municipality-business/accreditation-and-conformity/>

³¹ <https://www.trade.gov/country-commercial-guides/indonesia-standards-trade>

implement national and international standards. This partnership involves training, certification process support, and quality management assistance. This initiative has enabled many SMEs to improve their product quality, leading to better market access and increased export opportunities. Malaysia has a strong focus on Halal certification as part of its NQI. The Department of Islamic Development Malaysia (JAKIM)³² works with private certification bodies and the food industry to ensure products meet Halal standards recognized worldwide. Malaysia's Halal certification is widely accepted globally, positioning the country as a leader in the Halal industry. SASO³³ has established partnerships with private manufacturing companies to ensure that products meet both national and international standards. Through these collaborations, SASO provides guidance and support for companies to achieve compliance. This has enhanced the overall quality of products manufactured in Saudi Arabia, helping them gain broader acceptance in international markets. The TSE³⁴ has worked closely with various private sector organizations to develop and update standards that align with international norms. For example, in the automotive sector, TSE collaborates with industry stakeholders to develop standards that ensure the safety and quality of vehicles, facilitating better market access for Turkish products globally. This partnership has helped in the international recognition of Turkish products, improving export competitiveness.

3.4 Efforts of OIC in Enhancing NQIs

SMIIC

The journey towards establishing a unified mechanism for the harmonization of standards among Islamic states began with the 1st Meeting of the Economic and Commercial Cooperation Standing Committee (COMCEC) of the Organization of Islamic Cooperation (OIC) in 1984. Recognizing the need for a collaborative approach to standardization, COMCEC played a pivotal role in the formation of the Standardization Experts Group for Islamic States (SEG) in 1985. The SEG's efforts culminated in the approval of the Statute of the Standards and Metrology Institute for Islamic Countries (SMIIC) at the 14th COMCEC Meeting in 1998. This milestone marked the beginning of a coordinated effort to develop and implement standards especially for Halal issues across OIC member states. COMCEC's unwavering support has been instrumental in SMIIC's mission to harmonize standards, thereby facilitating trade, ensuring product safety, and enhancing the economic integration of the Islamic world.

The Standards and Metrology Institute for Islamic Countries (SMIIC) plays a pivotal role in this regard. Established in 2011 to promote harmonization in the fields of standardization, metrology, and accreditation among OIC member states, the SMIIC aims to facilitate trade, enhance the quality and

³² <https://www.islam.gov.my/en/>

³³ <https://www.smiic.org/en/member/17>

³⁴ <https://www.tse.org.tr/>

safety of products and services, and promote scientific and technological cooperation. By providing a unified framework for the standards as per the needs of its members and especially for halal standards, the SMIIC seeks to address the challenges posed by varying interpretations of what constitutes halal, lack of coordination, and differing levels of technical infrastructure and expertise among member countries.

Standardization Process of SMIIC:

The consensus among stakeholders is the foundation of the SMIIC's standardization process. The SMIIC plays a vital role in developing standards that meet the needs of its member states and its standardization process is a comprehensive and systematic approach involving several key components and stages. The Standardization Management Council (SMC) is one of the central bodies within the SMIIC, responsible for overseeing the development and implementation of standards. The SMC coordinates and monitors the performance of the technical committees, ensuring that they operate efficiently and effectively. The Council evaluates the performance of each technical committee, assigns chairs, and allocates secretariats. This oversight ensures that the committees are aligned with SMIIC's objectives and are working towards producing high-quality standards.

Technical committees (TCs) are the primary bodies driving standardization activities within SMIIC. Each technical committee focuses on a specific area of expertise, such as halal food, cosmetics, pharmaceuticals, tourism, or petroleum. These committees are responsible for developing standards relevant to their specific field, ensuring that the standards are technically sound and meet industry needs.

SMIIC currently has several technical committees, each focusing on specific areas of interest and expertise. The committees including the Committee for Conformity Assessment (SMIIC/CCA) have published 57 standards in total and 20 of them are on halal issues.

While halal is a particular special focus within SMIIC due to its importance to member states, the organization encompasses a broad spectrum of technical activities, addressing the diverse interests and needs of its members.

Role of the SMIIC in Standardization, Metrology and Quality Infrastructure

Quality infrastructure is a foundational element in the modern global economy, playing a pivotal role in facilitating international trade, ensuring safety, and promoting innovation. At its core, standardization provides a set of consensus-based criteria for all the pillars of quality infrastructure, ensuring that products and services meet specific requirements.

On the other hand, halal standardization is a specialized area that focuses on ensuring that products and services comply with technical requirements and Islamic law. As the demand for halal products grows globally, it becomes increasingly important to align halal standards with the broader quality infrastructure to ensure their credibility, reliability, and acceptance. In this context, it is of utmost importance to embrace international practices in the halal industry and benefit from all the elements of international quality infrastructure, particularly standardization, metrology, and accreditation.

The significance of a cohesive halal standardization and accreditation system is profound. A harmonized framework can simplify trade processes, build consumer confidence, and ensure that halal products adhere to consistent quality and safety standards. However, the OIC region faces multiple challenges in achieving such cohesion, including diverse interpretations of halal standards, insufficient collaboration among member states, and variations in technical capabilities. All these challenges will be addressed through the implementation of the **OIC Global Halal Quality Infrastructure (OHAQ)**, which includes designated bodies for each element of conformity assessment.

Metrology is one of the key parts of the OHAQ that supports the global trade of halal products and services. Metrology infrastructure, harmonization, and implementation of measurement standards among the OIC Member States play a critical role in improving halal product quality and reliability and eliminating technical trade barriers thus developing trade among themselves and other countries. SMIIC is responsible for defining the metrology policies and strategies within the OIC. The SMIIC Metrology Council (MC) serves as the operational body of SMIIC, facilitating cooperation among national metrology authorities from Islamic countries. The SMIIC MC Working Plan focuses on various training and capacity-building activities. These include Scientific, Legal, and Industrial Metrology, Trainings Related to Halal Activities and Calibration, Proficiency Testing as well as Joint Work, Consultancy, Research and Development workshops. These training programs and collaborative activities are designed to enhance expertise and promote best practices within the OIC region in the specific field of metrology. As an example; the SMIIC MC Interlaboratory Comparisons (ILCs) which aim to foster and enhance measurement accuracy across participating laboratories have been commenced in November 2023 for Mass, Temperature, and Pressure with the National Metrology Institutes (NMI) of Azerbaijan, Burkina Faso, Jordan, Malaysia, Qatar, Uganda, and Uzbekistan. Similarly, the SMIIC MC conducts Research and Development (R&D) projects aimed at capacity building, which are essential for advancing metrology practices and promoting innovation. Through these R&Ds, the SMIIC MC, in collaboration with the SMIIC General Secretariat, intends to provide annual support for specific projects in the Member States that will contribute directly to the development of OHAQ.

SMIIC MC also supports the development of OIC/SMIIC standards and guidelines specifying certain materials or ingredients to be produced as Reference Materials (RMs) and Certified Reference Materials (CRMs) to ensure the metrological traceability and accuracy of the testing results in halal industry for both OIC and non-OIC countries. In this regard, the SMIIC MC is already working on a Medical Metrology Standard/Guide for Legal Metrology Purposes draft to be used by the OIC Member States. Metrology activities in OIC Global Halal Quality Infrastructure will provide the technical basis for the halal certification programs throughout the OIC Member States that aim at qualifying the halal products of OIC Member States within and for access to new markets.

SMIIC plays a critical role as an organ of the Organization of Islamic Cooperation (OIC) in promoting and developing halal standardization among member states and serves as a crucial part of OHAQ. Its mission is to enhance the trade and economic integration of OIC member countries through the development of uniform standards and quality infrastructure. With its 17 Technical Committees, OIC/SMIIC standards are meticulously crafted, adhering to the highest professional and best practice guidelines. The collective action of 350-400 experts within these technical committees is instrumental in fortifying the quality infrastructure of SMIIC Member States. Training and capacity-building programs organized by SMIIC for its members and stakeholders involved in the halal industry are essential to implementing halal standards effectively.

SMIIC engages in research and development activities to continuously improve halal standards and address emerging issues. This includes collaborating with academic institutions, industry stakeholders, and other standardization bodies to ensure that halal standards remain relevant and up-to-date. Aligning halal standards with the broader quality infrastructure ensures credibility, facilitates international trade, and promotes consumer trust. As an OIC organ, SMIIC plays a pivotal role in developing, harmonizing, and promoting halal standards, ultimately contributing to the economic integration and growth of OIC member countries.

3.5. Current Overview of NQI

In order to provide a comprehensive NQI system due diligence for OIC member countries, this part of the study analyses 52 OIC countries (due to data limitation in some OIC countries) on the basis of two different groups: regional and economic. The findings obtained in the analysis made by using the Global QI Index (GQII) data set for OIC countries and the determinations regarding the effects of the NQI system and geographical classification are:

Sub-Saharan Africa (SSA):

Nigeria, Mozambique, Uganda, Senegal, Benin, Mali, Cameroon, Burkina Faso, Sudan, Togo, Gabon, Niger, Sierra Leone, Guinea-Bissau, Gambia, Chad, Guinea and Côte d'Ivoire

Europe and Central Asia (ECA):

Türkiye, Kazakhstan, Uzbekistan, Albania, Azerbaijan, Kyrgyzstan and Tajikistan

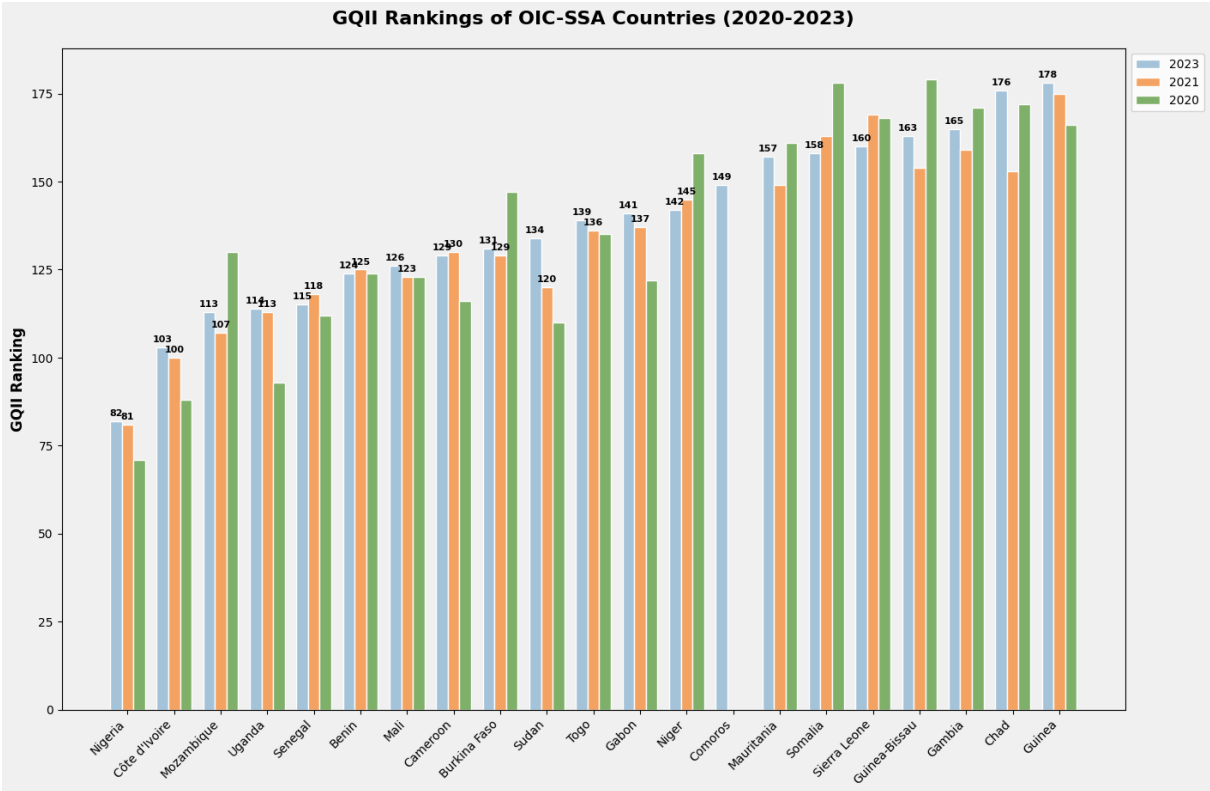
Middle East and North Africa (MENA):

Egypt, Saudi Arabia, UAE, Iran, Tunisia, Qatar, Oman, Morocco, Kuwait, Jordan, Iraq, Algeria, Bahrain, Lebanon, Yemen, Libya and Djibouti

East and South Asia and Latin America (ESALA):

Indonesia, Malaysia, Pakistan, Bangladesh, Guyana, Brunei Darussalam, Afghanistan, Suriname and Maldives

Figure 2. Global QI Ranking for OIC Member Countries in SSA



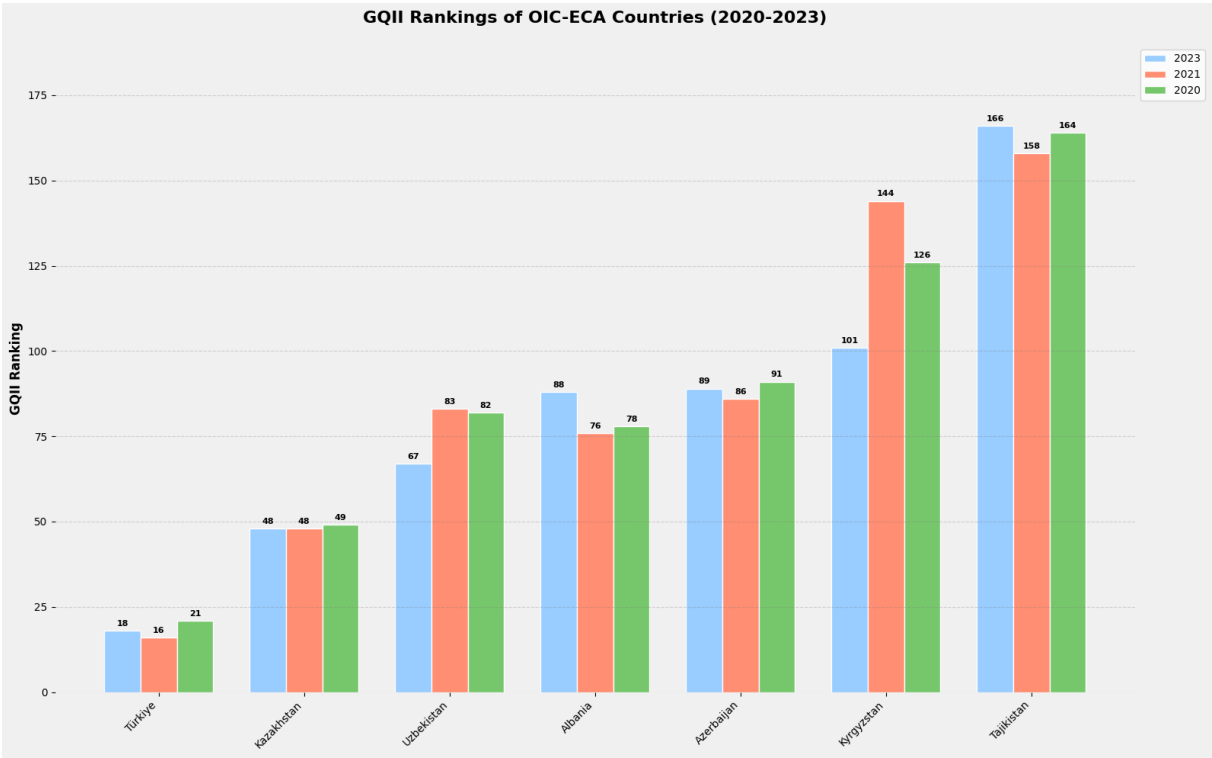
Source: Compiled by the Authors from GQII database.

The GQII database provides a ranking for the years 2020, 2021 and 2023. As seen in Figure 2, only Nigeria, one of the OIC member countries in the SSA region, has a ranking of 83 in 2023. The ranking of all other countries in the region is above 100.

Considering that the GQII ranking is made for 183 countries, the importance of improvement areas and NQI studies for the region in question are felt more. Here, the fact that the 2023 rankings of Nigeria, Côte d'Ivoire, Uganda, Senegal, Mali, Sudan, Togo, Gabon, Chad, and Guinea are further behind compared to 2020 once again reveals the importance of NQI work. The countries that have made progress in 2023 compared to the 2020 ranking in terms of the region are: Mozambique, Burkina Faso, Mauritania, Somalia, Sierra Leone, Guinea Bissau, and Gambia.

Figure 3 indicates that most of the countries in the OIC-ECA group have shown stability or slight improvement in their rankings over the period of 2020-2023. The overall trend can be considered positive or stable in the performance of these countries, except Tajikistan and Albania. Türkiye has shown significant improvements in their rankings.

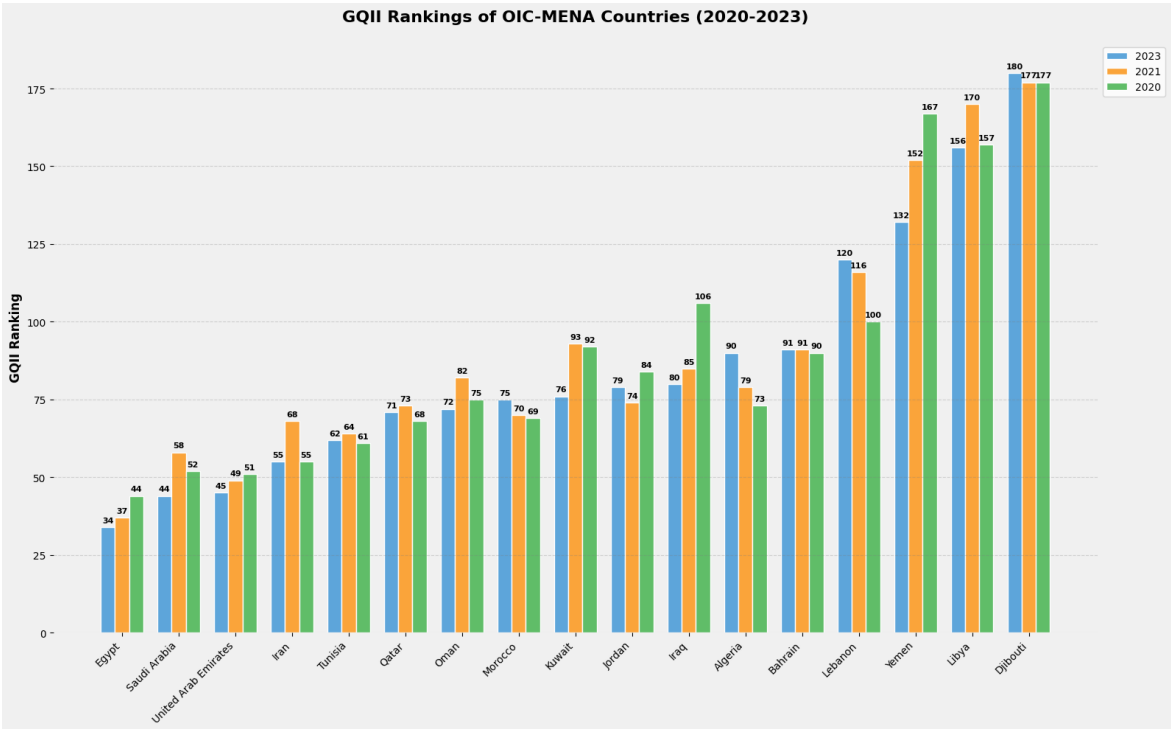
Figure 3. Global QI Ranking for OIC Member Countries in ECA



Source: Compiled by the Authors from GQII database.

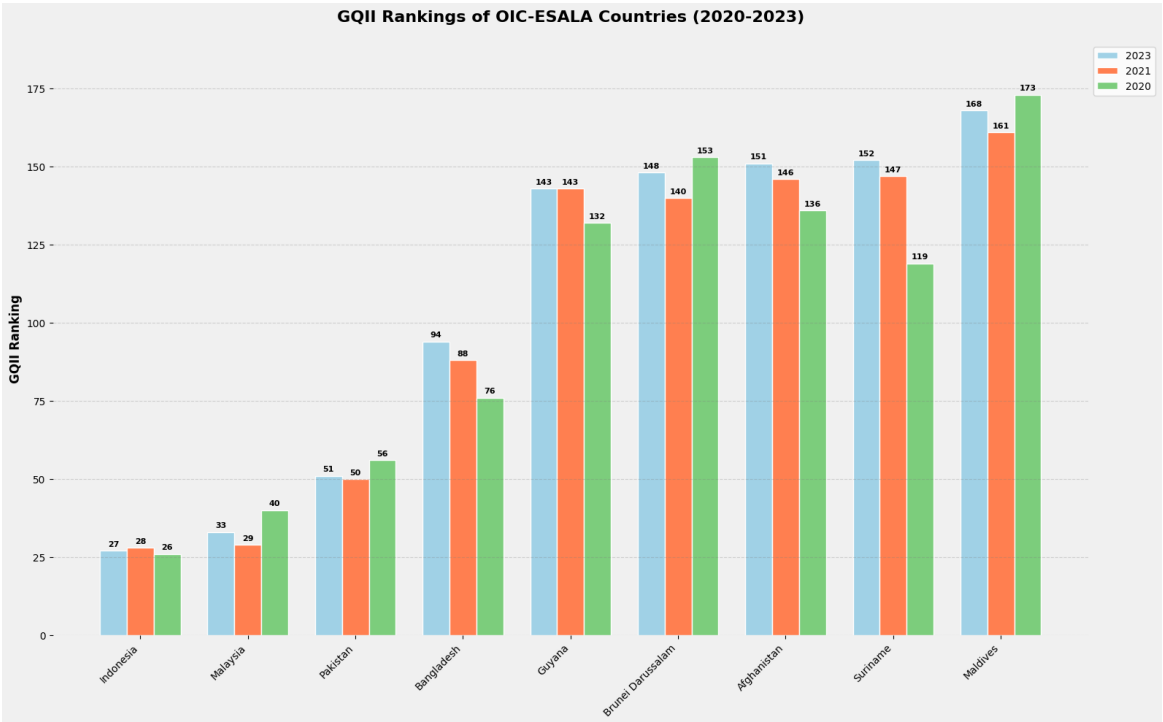
Figure 4 shows the NQI performance of OIC member countries in the MENA region. According to the findings obtained, Morocco, Jordan, Algeria, Lebanon and Djibouti faced a decline in the ranking in 2023 compared to previous years. While the OIC member countries in the MENA region are generally distributed with a ranking below 100, the ranking and performance of Lebanon, Yemen, Libya and Djibouti seem to be behind. Egypt has the best performance in the MENA region, followed by Saudi Arabia, the UAE and Iran.

Figure 4. Global QI Ranking for OIC Member Countries in MENA



Source: Compiled by the Authors from GQII database.

Figure 5. Global QI Ranking for OIC Member Countries in ESALA

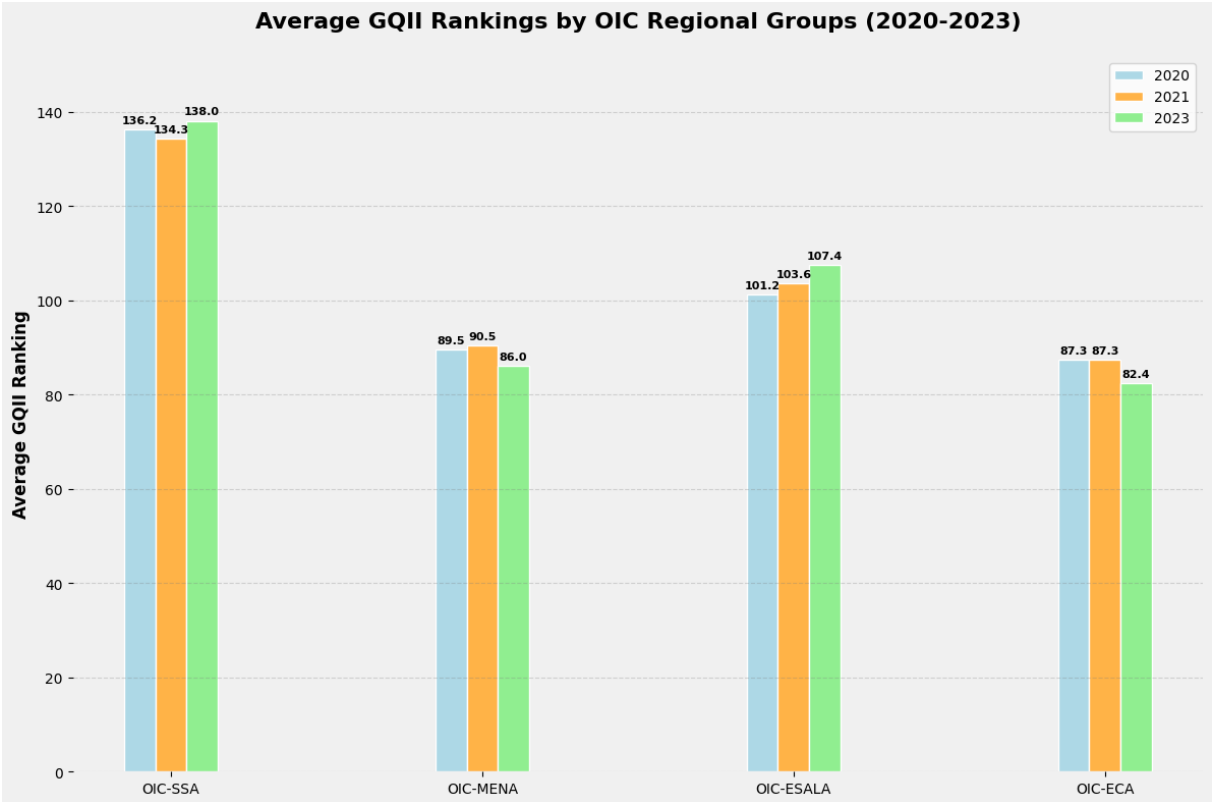


Source: Compiled by the Authors from GQII database.

Figure 5 shows the NQI performance of OIC member countries in the ESALA region. According to the findings, while Indonesia has the best ranking in the region, it is seen that all OIC member countries in the region have declined in the ranking in 2023. There appears to be room for improvement for some countries in this group. A separation can be observed between the top performers (Malaysia, Indonesia, Pakistan) and the rest of the countries, which indicate a need for tailored policymaking.

The data discussed reveal significant disparities both within and between regions, with OIC-ECA countries generally having a higher quality of infrastructure than their counterparts, particularly those in the OIC-SSA region. Notable exemplars of high-quality infrastructure include Türkiye in the OIC-ECA region, consistently ranking below 20, and the UAE and Egypt in the OIC-MENA (Middle East and North Africa) region.

Figure 6. Global QI Ranking for OIC Regional Groups



Source: Compiled by the Authors from GQII database.

The temporal analysis from 2020 to 2023 indicates a general trend of improvement across many OIC countries, suggesting ongoing efforts to enhance infrastructure quality. This positive trajectory is particularly evident in the OIC-MENA region and the OIC-ESALA region.

However, the persistence of wide ranking ranges within regions, especially in OIC-ESALA (ranging from about 30 to 170), underscores the heterogeneous nature of infrastructure development among OIC member countries. Despite these improvements, the data highlight persistent challenges, particularly in the OIC-SSA region, where many countries rank between 100 and 180, indicating significant room for infrastructure improvement. This stark contrast with better-performing regions underscores the need for targeted development strategies and potentially increased investment in infrastructure projects in these lower-ranked countries.

In conclusion, the GQII rankings provide valuable insights into the state of infrastructure quality in OIC countries, highlighting both progress and persistent disparities. This information can serve as an important tool for policymakers and researchers in identifying areas for targeted improvement and formulating strategies to address infrastructure gaps within the OIC community.

In summary, a number of trends can be identified across the different geographic regions;

- OIC-SSA: Higher GQII rankings, indicating lower QI.
- OIC-MENA: Moderate GQII rankings, with some countries showing significant improvement.
- OIC-ESALA: Lower GQII rankings with a tendency for general improvement.
- OIC-ECA: Lowest GQII rankings, indicating the best QI, with minor changes over the years.

Additionally, the GQII rankings for 54 OIC member countries also offer a comprehensive analysis of infrastructure quality across different income levels from 2020 to 2023. The data is categorized into four distinct income groups: Low income, lower middle income, upper middle income, and high income, providing insights into the relationship between economic status and infrastructure quality among OIC nations.

Low-Income Countries:

Afghanistan, Mozambique, Uganda, Burkina Faso, Yemen, Sudan, Togo, Niger, Somalia, Sierra Leone, Guinea-Bissau, Gambia, Chad, Guinea and Mali

Lower – Middle Income Countries:

Indonesia, Egypt, Pakistan, Iran, Tunisia, Uzbekistan, Morocco, Nigeria, Algeria, Bangladesh, Senegal, Benin, Cameroon, Sudan, Tajikistan, Côte d'Ivoire, Kyrgyzstan and Djibouti

Upper-Middle Income Countries:

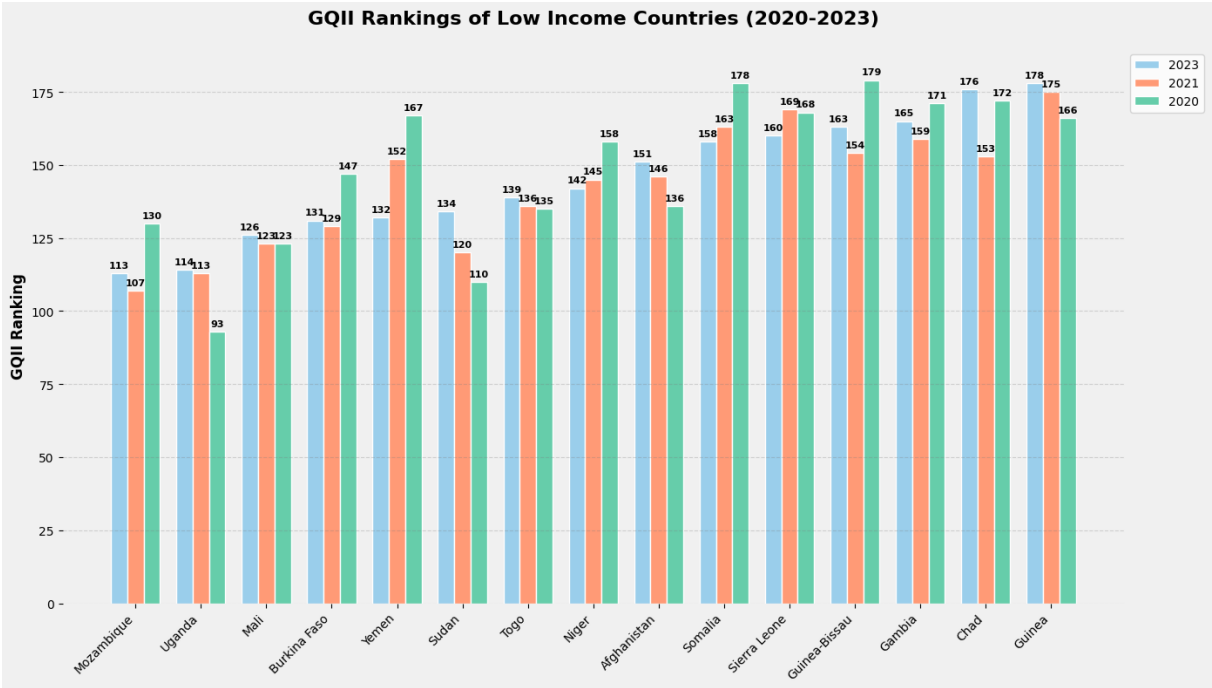
Türkiye, Malaysia, Kazakhstan, Jordan, Iraq, Albania, Azerbaijan, Lebanon, Gabon, Guyana, Suriname, Libya and Maldives

High Income Countries:

Saudi Arabia, UAE, Qatar, Oman, Kuwait, Bahrain and Brunei Darussalam

It can be observed on Figure 7 that The group exhibits the poorest infrastructure quality, with most countries ranking between 100 and 180. This disparity underscores the significant impact of economic resources on a nation's ability to develop and maintain high-QI

Figure 7. Global QI Ranking for OIC Member Countries in Low-Income Group



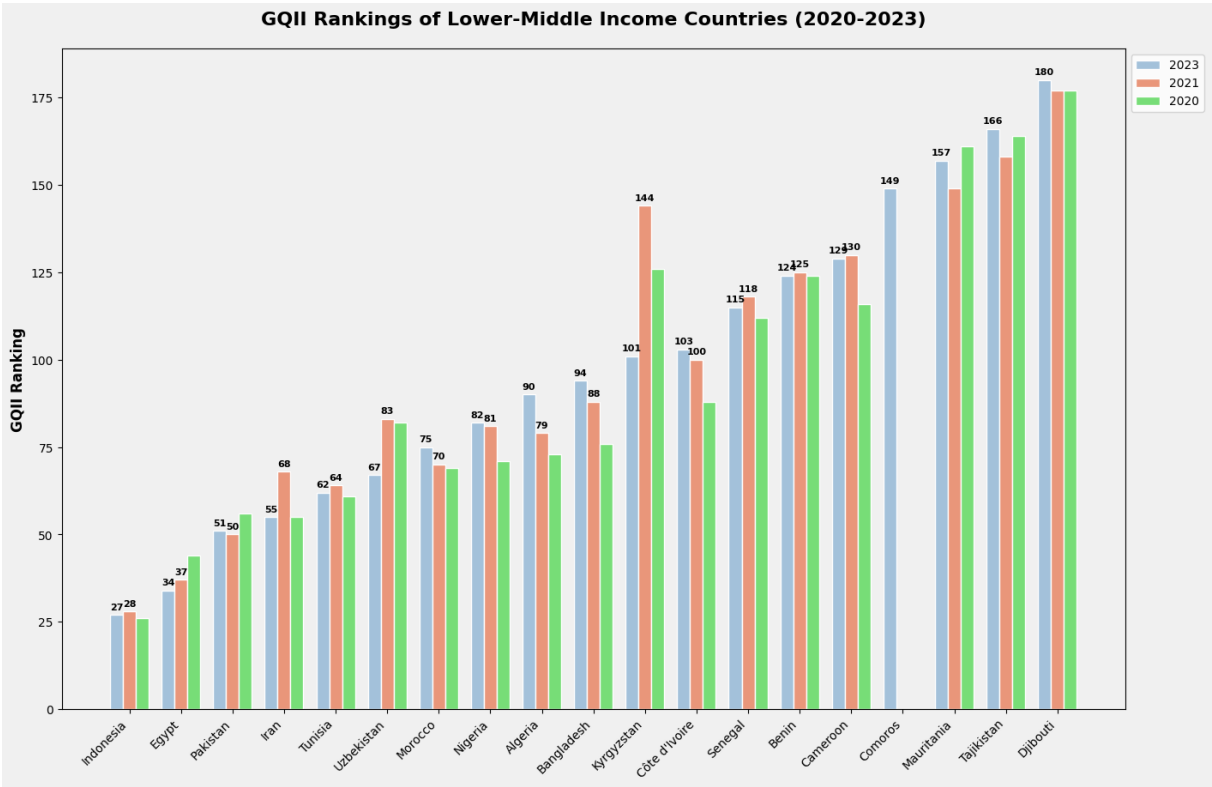
Source: Compiled by the Authors from the GQII database.

Low-income OIC member countries, many of which are located in Africa and Asia, often struggle with poverty, underdeveloped industries, weak institutional frameworks, and limited access to global markets. However, a well-established NQI system can help these countries address these issues by promoting higher standards in production, encouraging industrial growth, and facilitating access to international trade.

For low-income countries, participation in global trade is essential for economic growth. However, without adequate NQI systems, their products often fail to meet the stringent quality, safety, and environmental standards required by international markets. This leads to limited market access and missed opportunities. Strengthening NQI ensures that these countries can meet international standards and gain access to export markets, reducing technical barriers to trade and enhancing their integration into the global economy. An effective NQI system can improve industrial performance by providing the necessary frameworks for quality assurance, standardization, and measurement accuracy.

This enables industries to produce goods that meet international benchmarks, increasing their competitiveness and fostering industrial development. Weak NQI systems can lead to substandard products entering the market, potentially endangering public health and safety. This is particularly critical in sectors such as food, pharmaceuticals, and healthcare. NQI helps ensure that products meet safety and quality standards, protecting consumers and enhancing public health outcomes in low-income countries. Foreign investors seek markets with reliable regulatory frameworks, transparency, and adherence to international standards. By establishing a robust NQI system, low-income countries can create a favorable business environment that attracts FDI. This investment brings capital, technology transfer, and job creation, further stimulating economic growth.

Figure 8. Global QI Ranking for OIC Member Countries in Lower-Middle Income Group



Source: Compiled by the Authors from GQII database.

It can be observed that as income levels rise, rankings improve. Indonesia and Egypt can be regarded as examples in this group. The wide spread of rankings (from around 30 to 180) indicates that even within the lower-middle income category, there are significant differences in infrastructure quality, although many countries show improvement in their rankings.

Indonesia has been investing in its NQI over the past few decades, with institutions such as the National Standardization Agency of Indonesia (BSN) and the National Accreditation Committee (KAN) playing key roles. However, the country faces challenges related to the fragmentation of its QI and limited coordination between agencies. Indonesia's large geographical size and diverse economy present both opportunities and obstacles in standardizing quality practices across different regions and industries. Efforts to harmonize national standards with international norms have been ongoing, particularly in the Halal certification sector, where Indonesia aims to position itself as a global leader. Despite progress, Indonesia's global QI ranking reflects the need for further investment in metrology, testing, and certification facilities. Strengthening regional cooperation within Southeast Asia is also needed to facilitate MRAs and enhance market access.

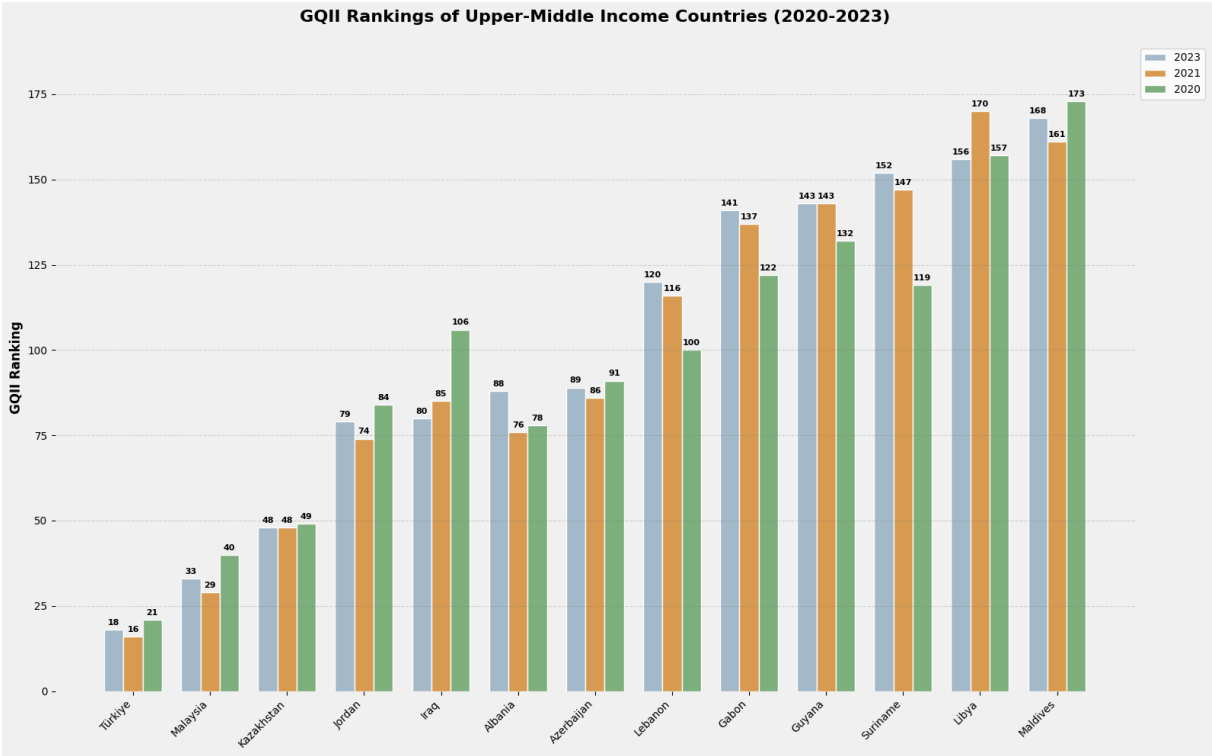
Egypt has also made strides in improving its NQI, with institutions such as the Egyptian Organization for Standardization and Quality (EOS) and the Egyptian Accreditation Council (EGAC) driving quality initiatives. Egypt's strategic location as a gateway between Africa, the Middle East, and Europe gives it significant trade advantages, but it also requires robust QI systems to capitalize on these opportunities. The Egyptian government has been focused on enhancing its industrial base and attracting foreign investment, particularly in the manufacturing and textiles sectors. However, challenges remain in upgrading metrology and testing infrastructure, improving conformity assessment processes, and ensuring alignment with international standards. Egypt's global QI ranking indicates that, while the country has established a solid foundation, there is a need for further reforms and investments to strengthen its QI. This includes enhancing the capacity of laboratories, improving certification processes, and fostering greater collaboration with international QI bodies.

It is seen in Figure 9 that the increased trend in ranking with an increased level of income can also be observed again. Türkiye and Malaysia can be treated as outliers in this group with exceptionally good performance. Upper-middle-income OIC member countries, including Malaysia, Türkiye, Kazakhstan, and others, are increasingly recognized for their efforts to develop robust NQI systems. These countries have significantly improved their global QI rankings thanks to investments in metrology, standardization, and accreditation institutions. However, there are still areas for improvement in achieving global recognition and enhancing economic performance further.

Türkiye has made significant strides in strengthening its NQI, particularly in sectors such as automotive, electronics, and textiles. The Turkish Standards Institution (TSE) and the Turkish Accreditation Agency (TURKAK) have played pivotal roles in raising the country's quality standards. Türkiye's strategic location between Europe and Asia has also facilitated its integration into global supply chains, enhancing its QI performance.

Malaysia has consistently ranked highly among OIC countries in global QI assessments. The government has established world-class standardization, metrology, and accreditation institutions, such as the Department of Standards Malaysia (DSM) and the National Metrology Institute of Malaysia (NMIM). Malaysia’s focus on enhancing its Halal certification system has also positioned it as a global leader in the Halal industry, further boosting its QI ranking. Kazakhstan has prioritized the development of its NQI as part of its broader economic modernization efforts. The country’s metrology and conformity assessment infrastructure investment has helped it improve its QI ranking. Kazakhstan’s focus on harmonizing its standards with international norms has also enabled it to increase its trade with neighboring countries and access global markets.

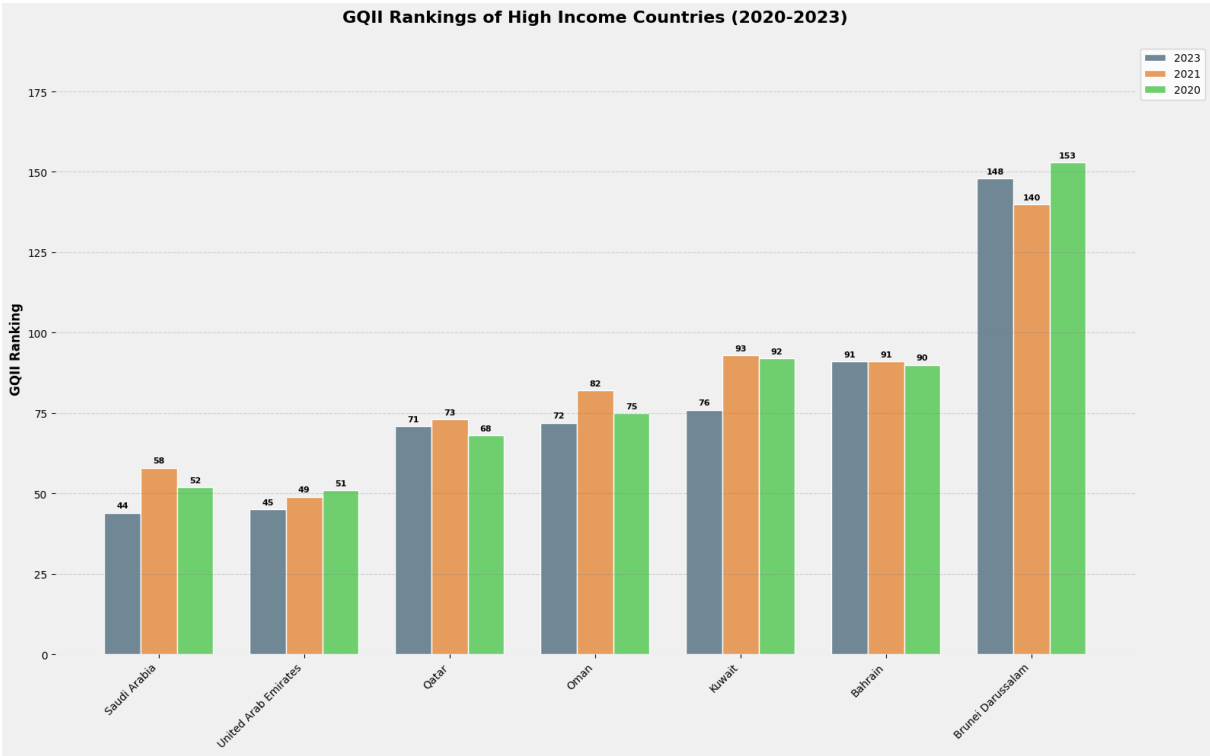
Figure 9. Global QI Ranking for OIC Member Countries in Upper-Middle Income Group



Source: Compiled by the Authors from GQII database.

It can be said that a clear correlation emerges between income levels and GQII rankings, with higher-income countries generally demonstrating superior infrastructure quality in Figure 10. The High-Income group, led by the Saudi Arabia and the UAE with rankings consistently below or around 50, showcases the best overall performance. Saudi Arabia and the UAE have emerged as regional leaders in the development and implementation of NQI. Their strong performance in global QI rankings reflects their commitment to building robust institutions that align with international standards.

Figure 10. Global QI Ranking for OIC Member Countries in High Income Group



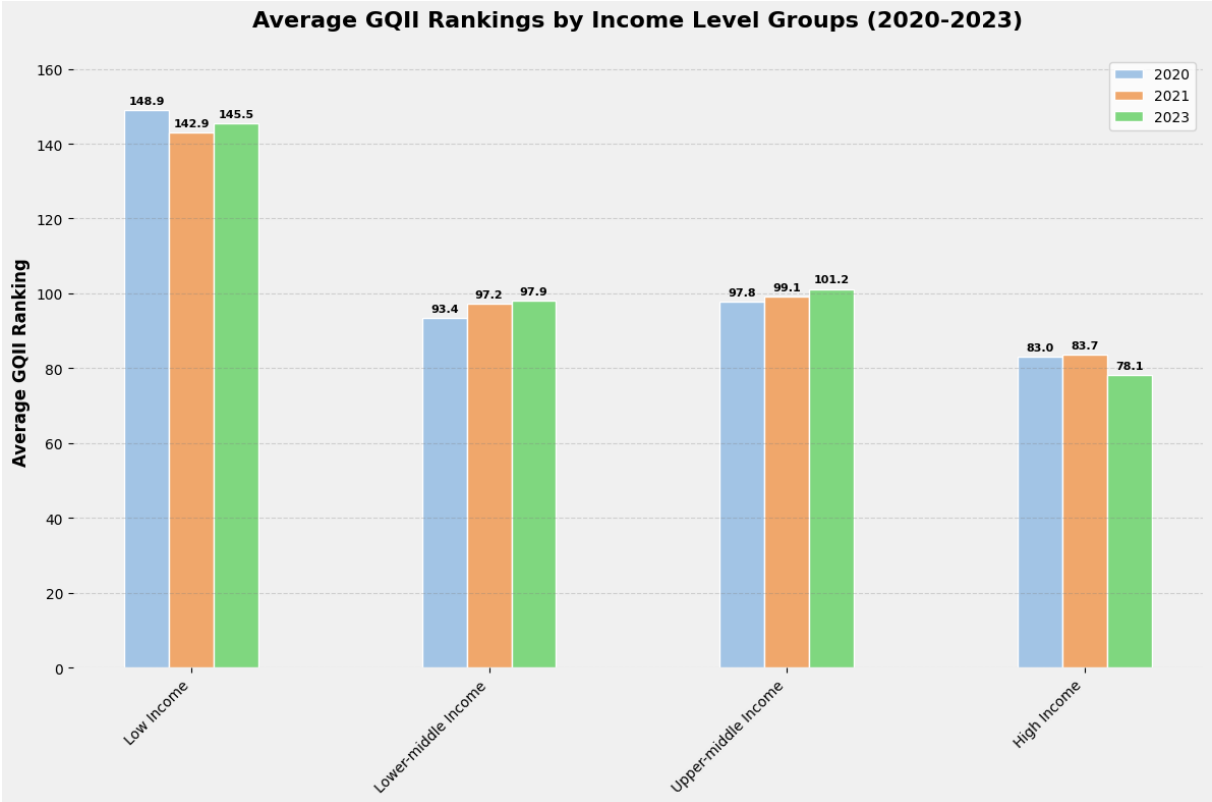
Source: Compiled by the Authors from the GQII database.

Saudi Arabia has made significant strides in improving its national QI, driven by the ambitious Vision 2030 plan, which aims to diversify the economy and reduce dependence on oil. The Saudi Standards, Metrology, and Quality Organization (SASO) plays a central role in these efforts by overseeing the development of national standards, accreditation, and certification processes. Saudi Arabia’s global QI ranking reflects its investments in upgrading its standards and metrology institutions. The country has focused on aligning its standards with international norms, particularly in critical sectors such as energy, manufacturing, and construction. SASO’s involvement in international organizations, such as the ISO and the International Electro Technical Commission (IEC), has bolstered Saudi Arabia’s reputation as a leader in QI. In addition to these efforts, Saudi Arabia has pioneered in developing standards for Halal certification, positioning itself as a global hub for Halal products. This leadership in Halal standards is a critical component of Saudi Arabia’s strategy to increase its share of the global Halal market, which is estimated to be worth trillions of dollars.

The UAE has positioned itself as a global leader in QI, strongly focusing on innovation, sustainability, and international cooperation. The Emirates Authority for Standardization and Metrology (ESMA) is at the forefront of the UAE’s efforts to enhance its QI.

It plays a critical role in setting national standards, accrediting conformity assessment bodies, and ensuring compliance with international best practices. The UAE’s high global QI ranking is a testament to its commitment to quality and innovation. The country has developed world-class infrastructure, including state-of-the-art laboratories and testing facilities, which support its diverse economy. The UAE has aligned its standards with international norms in sectors such as aerospace, renewable energy, and advanced manufacturing, making it a preferred destination for global trade and investment. The UAE has also pioneered the promotion of sustainable development through its QI system. The country has adopted green building standards, energy efficiency certifications, and environmental quality standards, all supporting its broader sustainability goals. As part of its Vision 2021 and beyond, the UAE aims to lead the region in promoting sustainable and innovation-driven economic growth.

Figure 11. The Comparison of Global QI Ranking for OIC Member Countries Based on Income Groups



Source: Compiled by the Authors from the GQII database.

Despite the overall positive trajectory, significant variations persist within each income group, highlighting the complex interplay of factors beyond mere economic classification that influence infrastructure quality.

This analysis provides valuable insights for policymakers and researchers, emphasizing the need for targeted strategies to address infrastructure gaps and promote more equitable development across the OIC community, particularly for lower-income nations struggling to improve their infrastructure quality.

In summary, there are several observable trends across different income levels;

- Low Income: Higher GQII rankings, indicating poorer QI overall.
- Lower-middle Income: Moderate GQII rankings, with some countries showing significant improvements.
- Upper-middle Income: Lower GQII rankings with a general trend of improvement.
- High Income: Lowest GQII rankings, indicating the best QI, with minimal changes over the years.

Although many of the individual variables do not significantly correlate with GQII rankings, a few topics are worth underlining for policymakers.

3.6. Analysis of NQI

The concept of NQI serves as a critical backbone for countries' economic, social, and environmental development. NQI encompasses standards, metrology, accreditation, certification, and conformity assessment tools that ensure the quality and safety of products and services. The interaction between NQI and key economic indicators such as Gross Domestic Product (GDP), foreign trade, income levels, and SDGs is becoming increasingly evident as governments and businesses realize the importance of QI in fostering sustainable development and global competitiveness.

Quality infrastructure is foundational to economic development because it provides the necessary standards and certifications that enable countries to participate in global trade, enhance domestic productivity, and ensure consumer protection. The interrelation between QI and GDP directly reflects how well a country's products and services meet international quality standards, which in turn affects their global competitiveness.

Countries with robust NQI systems generally have higher GDPs because they are able to produce high-quality goods and services that meet international standards, reducing barriers to global trade. High-quality production processes foster innovation, increase efficiency, and reduce waste, all of which contribute to economic growth. Furthermore, NQI enhances industrial performance by ensuring that domestic companies comply with global standards, driving the productivity and value-added sectors of the economy.

There is a strong correlation between NQI and foreign trade. Countries with effective QI are better equipped to meet the stringent requirements of international markets, resulting in increased exports. For instance, conformity assessment bodies, including testing, certification, and inspection services, ensure that goods meet importing countries' safety and quality requirements. As a result, countries with developed QI systems experience fewer trade disputes and non-tariff barriers, which promotes smoother access to global markets and increases foreign trade volumes.

The relationship between QI and income levels can be observed in both high-income and low-income countries. In high-income countries, NQI is often highly advanced, supporting industries such as manufacturing, technology, and pharmaceuticals, which generate high income and contribute to a higher standard of living. In contrast, low-income countries often have weaker QI systems, limiting their ability to compete in global markets and resulting in lower income levels. Improving NQI in low-income countries can boost economic growth by enabling businesses to access international markets, diversify exports, and improve product quality, all of which can lead to higher income levels and poverty reduction.

Quality infrastructure plays a crucial role in supporting the SDGs. The alignment of NQI with SDGs promotes responsible production and consumption, encourages innovation and infrastructure development, and supports environmental sustainability. The correlation between QI, GDP, foreign trade, and SDGs creates a positive feedback loop. A robust QI system enhances GDP by enabling industries to produce higher-quality goods and services, which can be exported to international markets. Increased foreign trade, in turn, generates higher income levels, driving further investments in QI. The impact of QI on GDP, foreign trade, and SDGs can be seen in various OIC member countries. For example, Türkiye, Malaysia, and the UAE have invested significantly in developing their NQI systems, resulting in increased export capabilities, economic diversification, and improved performance in achieving SDGs.

In this part of the study, a more in-depth analysis is provided and the correlation relationship between NQI and economic indicators for OIC countries is obtained. Although there are deficiencies in the data set, establishing a relationship between NQI and some indicators by using the data of OIC countries through GQII data contributes to the creation of evidence-based information to support policy recommendation.

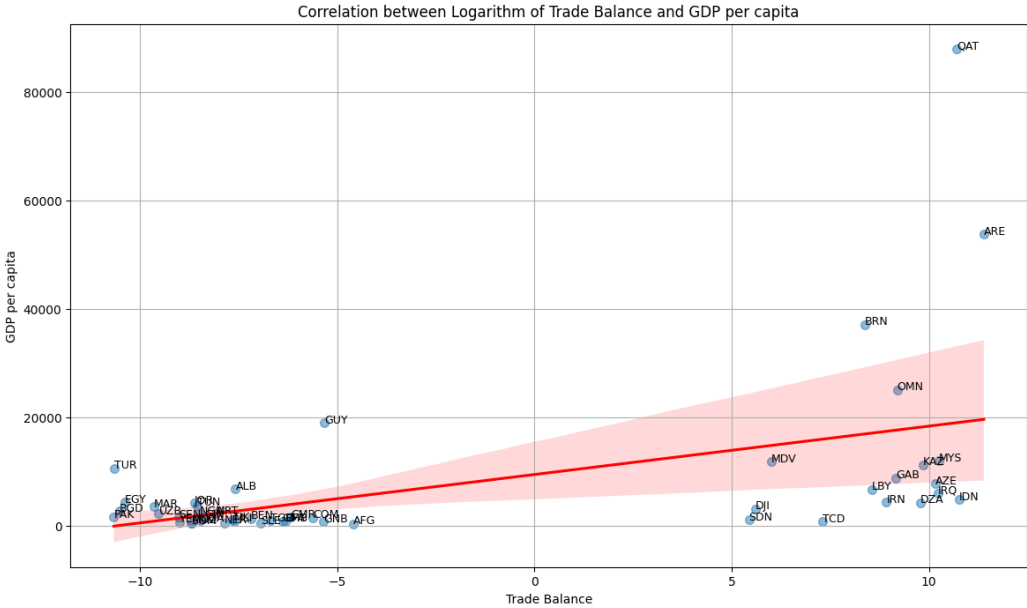
Table 1. OIC Member Countries Codes³⁵ Used Analysis' Findings

Country Code	Country	Country Code	Country
AFG	Afghanistan	LBN	Lebanon
ALB	Albania	LBY	Libya
DZA	Algeria	MYS	Malaysia
AZE	Azerbaijan	MDV	Maldives
BHR	Bahrain	MLI	Mali
BGD	Bangladesh	MRT	Mauritania
BEN	Benin	MAR	Morocco
BRN	Brunei Darussalam	MOZ	Mozambique
BFA	Burkina Faso	NER	Niger
CMR	Cameroon	NGA	Nigeria
TCD	Chad	OMN	Oman
COM	Comoros	PAK	Pakistan
CIV	Côte d'Ivoire	QAT	Qatar
DJI	Djibouti	SAU	Saudi Arabia
EGY	Egypt	SEN	Senegal
GAB	Gabon	SLE	Sierra Leone
GMB	Gambia	SOM	Somalia
GIN	Guinea	SDN	Sudan
GNB	Guinea-Bissau	SUR	Suriname
GUY	Guyana	TJK	Tajikistan
IDN	Indonesia	TGO	Togo
IRN	Iran	TUN	Tunisia
IRQ	Iraq	TUR	Türkiye
ITA	Italy	UGA	Uganda
JOR	Jordan	ARE	UAE
KAZ	Kazakhstan	USA	United States of America
KWT	Kuwait	UZB	Uzbekistan
KGZ	Kyrgyzstan	YEM	Yemen

³⁵ Analysis included Italy and USA as examples of best practices for the part of the case study

When analyzing the logarithm of trade balance and GDP per capita, economists apply logarithmic transformations to stabilize variances, linearize exponential relationships, and capture relative rather than absolute changes in economic variables. This approach helps reveal deeper correlation patterns, particularly when examining economic data over time or across countries with differing scales of economic activity. A positive correlation between the logarithm of trade balance and GDP per capita suggests that improvements in trade performance are associated with higher standards of living and economic prosperity in OIC countries.

Figure 12. Correlation Between GDP per capita and Trade Balance in OIC Member Countries



Source: Authors’ calculation

Figure 12 shows a positive correlation between the logarithm of trade balance and GDP per capita, indicating that countries with higher trade balances also tend to have higher GDP per capita. Countries with high GDP per capita and high trade balances, such as Qatar and the UAE, indicate economic solid performance, which can be considered outliers. Conversely, countries with low GDP per capita and low trade balances, such as Sudan and Chad, indicate weaker economic performance. The positive correlation suggests that countries with strong trade performance tend to have higher economic output and wealth, highlighting the importance of trade and export-oriented policies in achieving sustainable economic growth. OIC countries aiming to improve their GDP per capita may focus on policies that enhance their trade balance, such as boosting exports or reducing imports. There's a noticeable cluster of data points at the lower end of both scales, suggesting many countries have lower trade balances and lower GDP per capita, which policymakers can improve.

While the positive correlation between trade balance and GDP per capita holds for many OIC countries, low-income OIC member countries face challenges in achieving this dynamic. Countries with persistent trade deficits often struggle to improve GDP per capita due to their reliance on imports and limited export capacity. Factors such as political instability, lack of industrialization, and inadequate infrastructure hinder their ability to generate a positive trade balance and realize higher standards of living. Countries such as Niger, Chad, and Yemen have faced difficulties in diversifying their economies and reducing trade deficits. As a result, their GDP per capita remains low compared to more developed OIC nations. Addressing these challenges through trade policy reforms, investments in infrastructure, and capacity-building in export-oriented industries is crucial for fostering economic growth in these countries. The development and success of a robust NQI are crucial for economic growth and international trade competitiveness. In OIC member countries, there is a growing recognition of the importance of certification and active participation in technical committees as essential components of NQI activities. Certification refers to the process by which products, services, or processes are evaluated against specific standards and confirmed to meet those criteria. In the context of NQI, certification is a critical tool for ensuring that businesses comply with international standards in areas such as quality, safety, environmental sustainability, and social responsibility. Certificates such as ISO 9001 (quality management), ISO 14001 (environmental management), and ISO 22000 (food safety management) are widely recognized worldwide and provide credibility to businesses seeking to engage in global trade. For instance, countries like Türkiye, Malaysia, and the UAE, which have high numbers of certified businesses and active participation in international technical committees, have seen significant growth in their export sectors. Their involvement in shaping global standards ensures that their products are competitive in international markets, contributing to their economic development. Technical committees are specialized groups of experts who contribute to the development, revision, and maintenance of standards. These committees play a pivotal role in shaping the standards landscape by ensuring that standards are up-to-date, relevant, and reflective of current industry practices. Participation in technical committees enables countries and industries to have a voice in the international standard-setting process, ensuring that their specific needs and perspectives are taken into account. Participation in technical committees further reinforces this correlation by allowing OIC countries to gain insights into the latest technological advancements, industry best practices, and regulatory trends. This knowledge is then integrated into national standards and certification schemes, resulting in continuous improvements in product quality and safety. Similarly, participation in technical committees provides opportunities for experts from OIC countries to collaborate with international counterparts, share best practices, and gain access to cutting-edge research. This collaborative approach fosters innovation and capacity building, which are essential for sustaining growth in key sectors such as manufacturing, agriculture, and services.

The more certificates issued and the greater the participation in technical committees, the more aligned a country becomes with global standards. This alignment is crucial for OIC countries seeking to integrate into global value chains and participate in international trade agreements. Certification ensures that products and services meet the requirements of foreign markets, while participation in technical committees helps shape those standards to reflect local needs and realities. By aligning their QI with international norms, OIC countries improve their competitiveness on the global stage. Countries like Saudi Arabia, Egypt, and Indonesia have benefited from this alignment, as their economies are increasingly integrated into global supply chains due to their commitment to certification and standards development. There is a strong correlation between the number of certifications and active participation in technical committees and the overall strength of a country's NQI. A vibrant NQI requires a well-established framework for testing, certification, accreditation, and standardization, all of which are bolstered by an increase in certifications and engagement in standards development. Countries with strong NQIs are better equipped to support innovation, industrial development, and trade, which in turn drives economic growth. They also become more resilient to global challenges such as supply chain disruptions, regulatory changes, and technological shifts. The total number of certificates (9001, 22000, 14001, 27001, 50001, 13485, 45001) held by OIC member countries also provides a perspective on the overall state of QI efforts and how these efforts.

Table 2. Total Number of Certificates and Participation in Technical Committees by Country

Country	Sum of Total Certificates	Participation in Technical Committees	2023 GQII Ranking
Afghanistan	26	10	151
Albania	951	6	88
Algeria	671	144	90
Azerbaijan	557	64	89
Bahrain	1049	88	91
Bangladesh	1222	98	94
Benin	52	12	124
Brunei Darussalam	130	10	148
Burkina Faso	33	14	131
Cameroon	275	84	129
Chad	7	14	176
Comoros	7	14	149
Côte d'Ivoire	7	14	103
Djibouti	13	0	180
Egypt	6547	730	34
Gabon	47	46	141
Gambia	3	8	165
Guinea	21	0	178

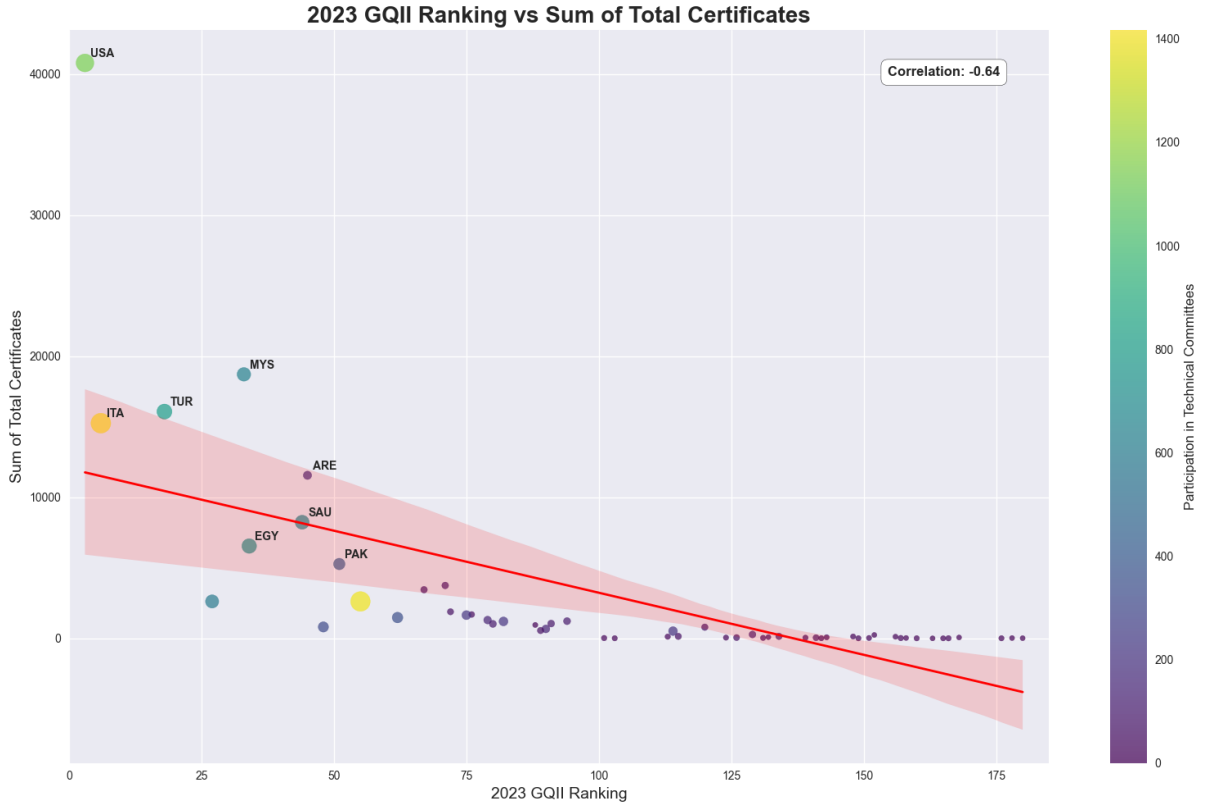
Guinea-Bissau	1	0	163
Guyana	77	10	143
Indonesia	2617	580	27
Iran	2617	1386	55
Iraq	1025	98	80
Italy	15255	1418	6
Jordan	1298	136	79
Kazakhstan	810	314	48
Kuwait	1693	36	76
Kyrgyzstan	21	20	101
Lebanon	792	68	120
Libya	116	6	156
Malaysia	18719	620	33
Maldives	63	0	168
Mali	56	48	126
Mauritania	21	22	157
Morocco	1647	218	75
Mozambique	120	18	113
Niger	10	10	142
Nigeria	1201	212	82
Oman	1886	56	72
Pakistan	5272	416	51
Qatar	3750	78	71
Saudi Arabia	8232	664	44
Senegal	142	60	115
Sierra Leone	6	14	160
Somalia	27	0	158
Sudan	143	66	134
Suriname	241	0	152
Tajikistan	7	20	166
Togo	42	16	139
Tunisia	1476	342	62
Türkiye	16077	782	18
Uganda	515	206	114
UAE	11560	170	45
United States of America	40796	1130	3
Uzbekistan	3449	72	67
Yemen	88	-	132

Source: Compiled by the Authors from GQII database.

When the number of certificates is analyzed in detail, Malaysia leads with 18,719 certificates, indicating a robust QI and a high level of regulatory compliance. Indonesia follows closely with 16,843 certificates, also reflecting a strong commitment to quality standards. Türkiye also has a high number with 16,077 certificates, highlighting its strong QI. The UAE has 11,560 certificates, indicating a well-developed system for certification and quality compliance. Saudi Arabia, with 8,232 certificates, shows substantial regulatory compliance and QI.

On the other hand, countries like Guinea-Bissau (1), Gambia (3), Chad (7), Sierra Leone (6), and Niger (10) have very low counts, which can be a sign of limited engagement with quality standards and possibly underdeveloped QI whereas countries like Benin (52), Burkina Faso (33), and Guinea (21) also show low engagement with quality standards, suggesting a room for improvement. Overall, data from SSA reveals low levels of engagement.

Figure 13. Correlation Between Sum of Total Certificates, Participation in Technical Committees, and GQII Rankings for OIC Member Countries

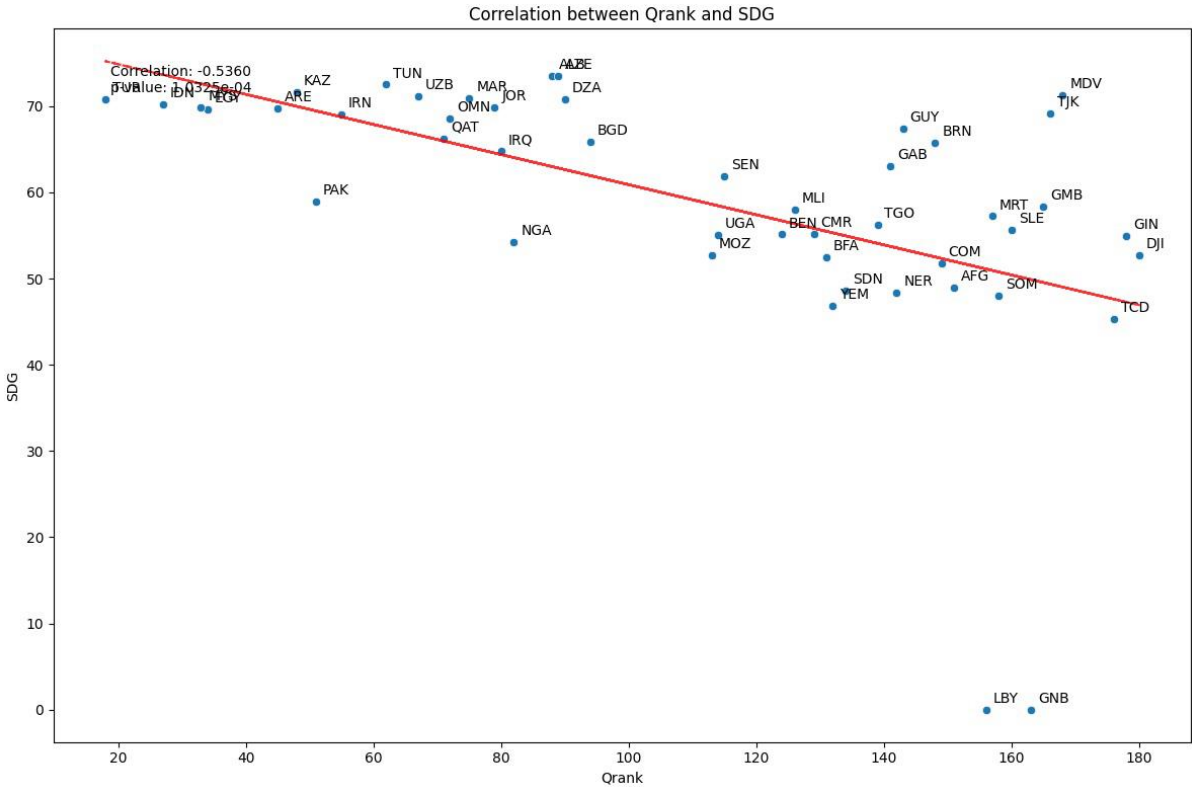


Source: Authors’ calculation

Using the available data to analyze the relationship between GQII rankings and the total number of certificates, the extremely low p-value obtained indicates that the observed correlation is highly unlikely to have occurred by chance. Therefore, it can be confidently stated that there is a significant relationship between GQII Ranking and total number of certificates.

From this perspective, Figure 13 provides insight into outliers such as Türkiye, Malaysia, and the UAE, whose total number of certificates is significantly higher than other member countries and whose efforts are also reflected in their GQII rankings. Countries like the USA, ITA, and TUR also have more extensive, brighter dots, indicating high participation in technical committees along with their high certificate counts and good rankings. There's also a cluster of countries with good rankings (below 50) and relatively high certificate counts, including EGY (Egypt), SAU (Saudi Arabia), and ARE (United Arab Emirates). The general trend shows that improving a country's quality infrastructure (lowering its GQII ranking) is associated with an increase in the total number of certificates. This trend underscores the importance of QI in supporting certification activities, which can be critical for trade, industry standards, and overall economic development. This relationship is statistically significant, suggesting that improvements in QI can lead to higher numbers of certifications. Countries that invest more in these areas tend to have better GQII rankings. The majority of OIC countries are clustered at the lower right of the graph, indicating lower total certificates and higher GQII rankings (lower overall performance), and thus a need for policymakers to incentivize participation in QI initiatives.

Figure 14. Correlation Between GQII Rankings and SDGs for OIC Member Countries



Source: Authors' calculation

The correlation indicates a moderate negative correlation between GQII and SDG scores, which is also statistically significant. This means that as a country falls behind in ranking, the SDG score tends to decrease.

In Figure 14, the red line represents the trend, which slopes downward from left to right. This means that as GQII ranking increases (indicating lower quality infrastructure), SDG scores tend to decrease. Countries with better (lower) GQII rankings tend to have higher SDG scores. This suggests that countries with more developed QI also tend to perform better in SDGs. There's considerable scatter around the trend line, indicating that while there's a correlation, many countries deviate from the trend. Additionally, some countries appear as outliers, such as Libya and Guinea-Bissau at the bottom correct, with shallow SDG scores despite high GQII rankings (indicating poor quality infrastructure). There's also a cluster of countries with lower GQII rankings (20-60) and higher SDG scores (65-75), primarily representing more developed nations. Another cluster exists with higher GQII rankings (120-180) and lower SDG scores (45-60), likely representing countries that have room for improvement. The wide scatter of data points and the presence of outliers indicate that the relationship discussed is not absolute, suggesting that other factors beyond overall ranking can significantly influence a country's progress in sustainable development. However, achieving a standard level of QI plays an essential role in achieving SDG goals.

3.7. Challenges on NQI

NQI is a vital framework that underpins the quality, safety, and efficiency of products and services within a country. For countries, especially those in the OIC, developing and maintaining a robust NQI is crucial for economic growth, international trade, consumer protection, and achieving SDGs. However, despite its importance, the development and implementation of NQI face several significant challenges.

Limited Financial Resources: One of the primary challenges in developing a robust NQI is the limited financial resources available, particularly in low-income and lower-middle-income OIC countries. Establishing and maintaining institutions for metrology, standardization, accreditation, and certification requires significant investment. This includes the costs of building infrastructure, acquiring advanced technologies, training personnel, and conducting research and development. In many cases, governments may prioritize other immediate needs, such as healthcare, education, and infrastructure, leaving limited budgets for NQI-related activities. As a result, many countries struggle to develop and sustain a comprehensive QI, which hinders their ability to compete in international markets and ensure consumer safety.

Developing a robust NQI requires substantial investment in physical infrastructure, such as metrology laboratories, testing and certification facilities, and quality control mechanisms. However, many OIC countries, especially those in the low-income category, face significant financial constraints that limit their ability to build and maintain this infrastructure. The high cost of advanced technology, laboratory equipment, and facilities often makes it difficult for these countries to keep pace with international standards. Without state-of-the-art infrastructure, it is challenging to conduct accurate testing, calibration, and certification processes, which are essential for ensuring product quality and safety. For instance, in some countries, existing facilities may be outdated or operating below capacity due to a lack of maintenance, upgrades, or expansion funds. This inadequacy in infrastructure reduces the country's ability to meet international trade requirements, thereby limiting its export potential and reducing economic growth opportunities.

A well-functioning NQI system relies not only on infrastructure but also on highly skilled personnel who can develop standards, perform calibrations, carry out inspections, and oversee certification processes. Building such technical expertise requires continuous training, education, and capacity-building programs, which are often resource-intensive. Limited financial resources in OIC member countries mean that governments and institutions struggle to invest in the training and professional development of NQI personnel. As a result, these countries may face a shortage of qualified professionals in critical areas, such as metrology, quality assurance, and accreditation. This shortage hampers the ability of national QI bodies to perform their functions effectively, leading to delays in certification, inconsistencies in standards enforcement, and a lack of participation in international standard-setting bodies. The lack of funding also restricts opportunities for international exchange programs, workshops, and collaborative initiatives that are essential for knowledge sharing and capacity building. Consequently, OIC countries may be left behind in the adoption of best practices and the development of innovative approaches to QI.

Investment in research and development is crucial for advancing the technical capabilities of NQI institutions and adapting to emerging global trends. However, financial constraints severely limit the scope of R&D activities in many OIC countries. Without adequate funding, it is difficult for these countries to invest in developing new measurement techniques, testing methodologies, and certification processes that align with international standards. The lack of R&D capacity also restricts innovation in QI, which is necessary to meet the demands of rapidly evolving industries, such as information technology, pharmaceuticals, and renewable energy. This innovation gap further exacerbates the challenges that OIC countries face in participating in global value chains and hinders their ability to compete in high-tech markets.

Moreover, the absence of a strong R&D culture limits the ability of OIC member countries to contribute to the global standardization process, which is increasingly driven by cutting-edge research in areas such as digital technology, AI, and intelligent manufacturing.

Due to limited domestic financial resources, many OIC member countries heavily depend on external funding sources, such as international aid, loans from multilateral organizations, and grants from development partners to support their NQI initiatives. While these external funding sources can provide much-needed financial relief, they are often accompanied by challenges of their own. For example, external funding is typically project-based and time-limited, meaning that long-term sustainability is not guaranteed. Once the funding ends, countries may struggle to maintain or expand their NQI activities, leading to a stagnation or decline in the QI that had been developed. Furthermore, external donors may have their own priorities and conditions attached to funding, which may not always align with the recipient country's specific needs or strategic goals. This can result in misaligned investments that fail to address the most pressing challenges in building a strong NQI.

Limited financial resources for NQI development directly impact a country's ability to participate effectively in international trade. Global markets demand that products meet stringent quality, safety, and environmental standards, which are verified through testing, certification, and accreditation. Countries with weak or underdeveloped NQI systems are at a disadvantage in meeting these requirements, leading to trade barriers that restrict their access to global markets. For OIC member countries with limited financial resources, this means missed opportunities to diversify exports, attract FDI, and integrate into global supply chains. It also affects the competitiveness of local industries, which may struggle to meet the quality standards required by international buyers. This lack of competitiveness not only stifles economic growth, but also limits job creation and poverty reduction efforts in these countries.

The financial disparity between OIC member countries further complicates efforts to develop a cohesive regional approach to NQI. High-income OIC countries such as Saudi Arabia and the UAE have the financial capacity to develop advanced QI systems that are on par with international standards. In contrast, low-income OIC countries such as Somalia, Niger, and Afghanistan lack the resources to build even the basic elements of NQI. This disparity creates an uneven playing field within the OIC, where some countries can participate in international trade and global standardization efforts, while others remain marginalized. It also hinders regional integration and cooperation, as countries with more advanced NQI systems may be reluctant to engage in trade or MRAs with countries that have less developed QI.

Addressing the challenge of limited financial resources requires strategic planning and policy interventions. However, many OIC countries face difficulties in prioritizing NQI development within their national economic policies. Competing demands for scarce resources—such as health, education, infrastructure, and security—often take precedence, leaving NQI as a lower priority. Moreover, the absence of comprehensive national quality policies and strategies in many countries makes it difficult to attract both domestic and international investment in NQI. Policymakers need to recognize the long-term benefits of investing in NQI, not only for economic growth and trade but also for consumer protection, environmental sustainability, and social development.

Lack of Technical Expertise and Capacity: Another critical challenge is the shortage of technical expertise and capacity within NQI institutions. Metrology, standardization, accreditation, and certification require specialized knowledge and skills, which are often in short supply in many OIC member countries. This lack of expertise can result in delays in developing and implementing standards, inefficiencies in testing and certification processes, and difficulties in maintaining accreditation. The lack of skilled personnel also affects the ability of countries to participate effectively in international technical committees, which is crucial for influencing global standards and ensuring that local needs are addressed. Without adequate capacity, countries may find it challenging to meet the requirements of international trade agreements and ensure that their products meet global standards.

Lack of expertise is particularly evident in low-income OIC countries, where educational and training institutions may not offer specialized programs in metrology, quality management, and standardization. The absence of such programs limits the availability of trained personnel to operate and maintain NQI systems. In countries where training programs do exist, they may be outdated or insufficiently aligned with international best practices, further compounding the expertise gap. In addition to the shortage of trained personnel, OIC countries face challenges in providing ongoing professional development and training for their NQI workforce. NQI systems need to adapt to emerging global trends, new technologies, and changing international standards, requiring continuous education and capacity building for staff. However, limited financial resources and institutional capacities often mean that opportunities for professional development are scarce. Many OIC countries lack access to advanced training programs, international workshops, and certification courses that are necessary to keep professionals up to date with the latest developments in their fields. This lack of access to professional development limits the ability of NQI bodies to improve their processes, adopt new technologies, and ensure that their systems remain competitive on the global stage.

Moreover, the absence of regional training initiatives or exchange programs within the OIC further exacerbates the situation. Without collaborative efforts to share knowledge and best practices, OIC member countries are left to rely on fragmented and often outdated sources of information, which impedes their ability to build a well-functioning NQI system.

Participation in international standardization bodies such as the ISO, the IEC, and the ILAC is crucial for staying informed about global standards, influencing the development of new standards, and ensuring alignment with international practices. However, many OIC countries face challenges in actively participating in these forums due to a lack of technical expertise and capacity. Without adequate representation in these bodies, OIC countries miss out on opportunities to contribute to the development of international standards that affect their industries and trade interests. Furthermore, limited participation hinders their ability to understand and implement new standards and best practices, which are essential for maintaining a competitive edge in global markets. The lack of engagement in international standard-setting processes also creates a disconnect between global standards and national practices. This can lead to misalignment between domestic NQI systems and international expectations, making it difficult for OIC countries to achieve international recognition for their certification, accreditation, and conformity assessment efforts.

The process of developing national standards that are aligned with international norms is a key function of NQI. However, the lack of technical expertise in many OIC countries hampers their ability to develop and implement such standards effectively. Standardization requires a deep understanding of industry-specific requirements, measurement techniques, and quality assurance principles, which may not be readily available in these countries. In some OIC member countries, the process of standard development is often slow and disjointed, leading to delays in the implementation of critical standards needed for trade, industry, and consumer protection. The absence of technically skilled personnel in standards bodies can result in poorly designed or incomplete standards that fail to meet international benchmarks. This deficiency creates obstacles for businesses seeking to export products to global markets, as they may be unable to demonstrate compliance with international standards. Moreover, the lack of capacity to update and revise standards regularly can lead to outdated regulations that do not reflect current industry practices, technological advancements, or evolving consumer needs. This further undermines the competitiveness of OIC countries in international trade.

Metrology, the science of measurement, is a fundamental component of NQI, as accurate and reliable measurements are essential for quality control, safety, and compliance with standards. However, many OIC countries struggle with weak metrology and calibration systems due to a lack of technical expertise in this field.

Effective metrology requires highly specialized knowledge of measurement techniques, calibration processes, and international measurement standards. In countries where this expertise is lacking, NQI bodies may be unable to provide accurate and reliable measurement services, which are critical for industries such as manufacturing, pharmaceuticals, food safety, and environmental monitoring. The absence of well-trained metrologists also impacts the ability of these countries to establish national measurement standards that are traceable to international benchmarks. This lack of traceability can lead to discrepancies in measurement results, undermining the credibility of NQI systems and reducing the confidence of international partners in the quality of products and services originating from these countries.

The lack of technical expertise and capacity in NQI has far-reaching implications for trade and economic growth in OIC countries. Inadequate NQI systems hinder the ability of these countries to meet the quality, safety, and environmental standards required by international markets, resulting in trade barriers that limit their export potential. For businesses in OIC countries, the absence of reliable NQI systems means higher costs for compliance with international standards, as they may need to seek certification, testing, and accreditation services from foreign providers. This not only increases operational costs but also reduces the competitiveness of OIC products in global markets. Furthermore, the lack of expertise in QI impedes FDI in OIC countries. International investors often require assurances that local products and services meet global quality standards. Without a well-functioning NQI system, OIC countries may struggle to attract investment, particularly in high-value sectors such as manufacturing, technology, and pharmaceuticals.

The combined effect of reduced trade opportunities, higher compliance costs, and lower investment levels ultimately stifles economic growth and development in OIC member countries.

Inadequate Institutional Coordination: Effective NQI requires strong coordination among various institutions, including national standards bodies, metrology institutes, accreditation bodies, and conformity assessment organizations. In many OIC countries, however, there is often a lack of coordination and communication between these entities. This can lead to overlapping responsibilities, inefficiencies, and inconsistencies in the implementation of standards and quality assurance processes. Inadequate coordination can also result in a fragmented QI, where different sectors operate in silos without a unified approach to quality management. This fragmentation hinders the development of a cohesive national strategy for QI, making it difficult to address emerging challenges and capitalize on new opportunities.

One of the primary challenges arising from inadequate institutional coordination is the fragmentation of responsibilities among different agencies and organizations involved in NQI.

In many OIC countries, multiple entities are responsible for standards development, metrology, accreditation, and certification. However, without clear delineation of roles and effective coordination, there is often a duplication of efforts and inefficiencies in resource utilization. This fragmentation can lead to inconsistencies in standards and regulations, as different agencies may develop conflicting requirements or fail to harmonize their approaches. Additionally, overlapping responsibilities can result in redundant processes and increased administrative burdens for businesses, ultimately affecting the overall efficiency and reliability of the NQI system.

Inadequate institutional coordination often stems from the absence of a unified national strategy for NQI development. Without a cohesive strategy, efforts to establish and maintain QI are disjointed and lack direction. This can hinder progress in aligning national standards with international benchmarks and achieving effective integration of various NQI components. A well-defined national strategy should outline clear objectives, roles, and responsibilities for each institution involved in NQI. It should also address priorities for capacity building, resource allocation, and stakeholder engagement. Without such a strategy, OIC countries may struggle to develop a comprehensive and integrated NQI system that supports trade, industry, and consumer protection.

Effective communication and collaboration among institutions are crucial for the successful implementation and management of NQI systems. However, inadequate coordination often results in poor communication between different agencies and stakeholders involved in NQI. This can lead to misunderstandings, delays, and inefficiencies in implementing standards, regulations, and quality assurance processes. For instance, if metrology institutes and certification bodies do not coordinate effectively, discrepancies in measurement standards and certification practices may arise. Such misalignments can undermine the credibility of the NQI system and create barriers for businesses seeking to comply with national and international quality standards.

Inadequate institutional coordination can also impact the formulation and implementation of quality policies and regulations. When institutions do not work together effectively, it becomes challenging to develop coherent policies that address the needs of different sectors and align with international standards. This lack of coordination can result in fragmented policy frameworks and inconsistent enforcement of quality regulations. Moreover, policy formulation may be influenced by competing interests and priorities of different agencies, leading to conflicts and delays in decision-making. This can hinder the ability of OIC countries to adopt and implement effective quality policies that support economic growth, consumer protection, and international trade.

Institutional coordination is critical for effective capacity building and resource allocation within NQI systems. Inadequate coordination can lead to uneven distribution of resources and training opportunities among different institutions and regions. This can create disparities in the development and implementation of QI, affecting the overall effectiveness of the NQI system. For example, if metrology and accreditation bodies do not coordinate their capacity-building efforts, there may be gaps in technical expertise and infrastructure development. This can hinder the ability of these institutions to provide reliable and accurate quality assurance services, ultimately impacting the competitiveness of businesses and the credibility of the NQI system.

Aligning national quality standards with international benchmarks is essential for ensuring that products and services from OIC countries can compete effectively in global markets. Inadequate institutional coordination can impede efforts to harmonize national standards with international norms, resulting in misalignment and trade barriers. For example, if standards development organizations and accreditation bodies do not work together effectively, it may be challenging to adopt and implement international standards and practices. This misalignment can limit the ability of OIC countries to gain international recognition for their certification and conformity assessment processes, affecting their access to global markets.

Effective stakeholder engagement is essential for the successful implementation of NQI systems. However, inadequate institutional coordination can result in a limited engagement with critical stakeholders, including industry representatives, consumer groups, and academic institutions. This lack of engagement can hinder the development of relevant and effective quality standards and regulations. Involving stakeholders in developing and reviewing quality policies and standards helps ensure that they meet industry needs and address consumer concerns. Without proper coordination, OIC countries may struggle to engage stakeholders effectively, leading to standards and regulations that are disconnected from market realities and consumer expectations.

Insufficient Awareness and Engagement: Awareness and engagement among businesses, government agencies, and the public are essential for the successful implementation of NQI. However, in many OIC member countries, there is often a lack of understanding of the importance of QI and its role in economic development. This lack of awareness can result in a low demand for certification and accreditation services, limited participation in standardization activities, and inadequate support for NQI initiatives from both the public and private sectors. Additionally, without strong engagement from key stakeholders, it is challenging to develop standards that are relevant and widely adopted. The lack of awareness also limits the ability of consumers to make informed decisions based on quality and safety standards, which undermines efforts to protect public health and safety.

A major challenge faced by OIC countries is the limited awareness among the general public and businesses about the importance of NQI. Many individuals and organizations are not fully informed about the role and benefits of standards, certification, accreditation, and metrology. This lack of awareness can lead to insufficient demand for quality-assured products and services and a lack of understanding of the benefits of adhering to international standards. Businesses, particularly SMEs, may not recognize the value of investing in QI or obtaining certifications. This can result in lower compliance with standards, which affects the competitiveness of products in global markets and undermines consumer trust.

Insufficient engagement with NQI institutions is another significant challenge. Effective NQI systems require active participation from various stakeholders, including industry players, government agencies, and civil society organizations. However, in many OIC countries, there is a lack of proactive engagement with these institutions. For example, businesses may not actively participate in the development of standards or provide feedback on existing regulations. Similarly, government agencies may not fully engage with industry representatives or consumer groups in the formulation of quality policies. This limited engagement can lead to a disconnect between the needs of various sectors and the quality standards implemented by NQI institutions.

Insufficient awareness and engagement also result in weak integration of NQI into national policy frameworks. In many OIC countries, QI is not always given adequate priority in policy-making processes. This lack of integration can lead to inadequate support for NQI initiatives, limited resources for development, and insufficient alignment with international standards. When NQI is not a priority in national policies, it becomes challenging to build and sustain effective QI. This can result in fragmented efforts and missed opportunities to enhance trade competitiveness, protect consumers, and support economic growth.

Promoting a quality culture within businesses and industries is essential for the successful implementation of NQI systems. However, in many OIC countries, there is a lack of emphasis on cultivating a culture of quality and continuous improvement. This can result in a focus on short-term gains rather than long-term quality assurance. Without a strong quality culture, businesses may be less likely to invest in quality management practices, seek certification, or adhere to standards. This can undermine the effectiveness of NQI systems and limit the ability of OIC countries to compete effectively in global markets.

Awareness and engagement with NQI are also impacted by inadequate training and capacity building. Many OIC countries face challenges in providing sufficient training and development opportunities for individuals and organizations involved in NQI. This lack of training can result in a limited understanding of quality standards, certification processes, and best practices.

Without proper training, stakeholders may struggle to effectively implement and manage QI. This can lead to gaps in technical expertise, reduced effectiveness of NQI systems, and challenges in maintaining compliance with international standards.

Effective NQI systems require strong collaboration between the public and private sectors. However, in many OIC countries, there is limited collaboration between government agencies, industry players, and other stakeholders. This lack of cooperation can hinder the development and implementation of quality policies, standards, and regulations. Public-private collaboration is essential for ensuring that NQI systems are responsive to industry needs, consumer expectations, and global trends. Without effective collaboration, there may be gaps in the development of standards, inconsistencies in enforcement, and limited opportunities for sharing best practices.

Barriers to International Trade: For many OIC countries, the lack of a strong NQI presents significant barriers to international trade. Global markets require products to meet specific standards and undergo rigorous conformity assessment procedures. Without recognized certification and accreditation, products from countries with weak NQI systems may face difficulties in accessing international markets. This can lead to lost export opportunities, reduced foreign exchange earnings, and limited economic growth. Furthermore, the inability to meet international standards can also affect the competitiveness of local industries. Businesses may struggle to innovate and improve product quality, which can limit their ability to compete with foreign firms in both domestic and international markets.

One of the primary barriers to international trade for OIC countries is the incompatibility of national standards with international benchmarks. Many OIC countries have established their own quality standards and regulations that may not align with globally accepted standards set by organizations such as the ISO, the IEC, and Codex Alimentarius. This misalignment can create obstacles for businesses seeking to export products to global markets. Products that do not meet international standards may face regulatory barriers, such as additional testing or certification requirements, which can increase costs and delay market entry. The lack of harmonization between national and international standards undermines the ability of OIC countries to compete effectively in global trade.

Many OIC countries struggle with complex and fragmented regulatory frameworks related to QI. Multiple agencies may be involved in setting standards, conducting inspections, and issuing certifications, leading to overlapping responsibilities and inconsistent enforcement. The complexity of regulatory requirements can create barriers for businesses attempting to navigate the export process. Inconsistent regulations and certification procedures can lead to confusion, delays, and increased costs for exporters. Additionally, fragmented regulatory frameworks can result in varying levels of compliance and quality assurance, affecting the credibility of NQI systems.

MRAs facilitate international trade by allowing countries to recognize each other's conformity assessments, certifications, and accreditations. However, many OIC countries face challenges in establishing and implementing MRAs with key trading partners. Limited recognition of MRAs can hinder the ability of OIC countries to access global markets. Without MRAs, businesses may need to undergo redundant testing and certification processes in different countries, increasing costs and time-to-market. The lack of mutual recognition can also affect the credibility of NQI systems, as exporters may face difficulties in proving the quality and safety of their products in international markets.

The effectiveness of NQI systems is closely tied to the availability and quality of infrastructure for quality assurance. In many OIC countries, there are challenges related to the adequacy and modernization of testing laboratories, calibration facilities, and certification bodies. Inadequate infrastructure can limit the capacity of OIC countries to meet international quality standards and conduct reliable assessments. This can affect the ability of businesses to obtain necessary certifications and approvals for export. Additionally, outdated or insufficient infrastructure can lead to delays in testing and certification processes, impacting trade efficiency and competitiveness.

Accessing international markets often requires compliance with stringent quality and regulatory requirements. OIC countries may face barriers related to market access, including non-tariff barriers such as technical regulations, standards, and certification requirements imposed by importing countries. These barriers can create challenges for OIC businesses seeking to enter global markets. Companies may need to invest significant resources in meeting the regulatory requirements of different countries, which can be particularly challenging for SMEs with limited financial and technical resources. Addressing these barriers requires effective coordination between NQI institutions and a focus on aligning national standards with international requirements.

Emerging Technological Challenges: The rapid pace of technological advancement presents both opportunities and challenges for NQI development. As new technologies, such as digital manufacturing, AI, and the IoT become more prevalent, NQI systems must adapt to address the quality and safety concerns associated with these innovations. However, many OIC countries lack the resources and expertise to keep up with these technological changes, leading to gaps in their QI. Emerging technologies also require the development of new standards and testing procedures, which can be time-consuming and resource-intensive. Without the ability to adapt quickly to technological changes, countries risk falling behind in global markets and missing out on the benefits of technological innovation.

The integration of advanced technologies, such as AI, big data analytics, and blockchain into QI poses a significant challenge. These technologies have the potential to enhance NQI systems by improving data management, process efficiency, and transparency. However, many OIC countries face difficulties in adopting and integrating these technologies due to limited technical expertise, financial constraints, and outdated infrastructure. For instance, AI can revolutionize quality control processes through predictive analytics and automated inspections. Blockchain technology can enhance traceability and transparency in supply chains. However, without proper infrastructure and expertise, OIC countries may struggle to leverage these technologies effectively, leading to gaps in quality assurance and increased vulnerability to technological disruptions.

As NQI systems increasingly rely on digital tools and platforms, cybersecurity risks become a critical concern. The implementation of digital solutions for quality control, certification, and compliance introduces potential vulnerabilities to cyber-attacks, data breaches, and system failures. Many OIC countries may lack robust cybersecurity frameworks and protocols to protect sensitive data and maintain the integrity of NQI systems. Cybersecurity risks can undermine the effectiveness of NQI by compromising the confidentiality and accuracy of quality data. This can lead to a loss of trust in quality assurance processes and impact the credibility of certification and accreditation systems. OIC countries must invest in strengthening their cybersecurity measures to protect their NQI systems from emerging threats.

The fast-paced evolution of technology presents a challenge for maintaining up-to-date NQI systems. New technologies emerge rapidly, and keeping up with these changes requires continuous adaptation and upgrading of QI. OIC countries may struggle to keep pace with technological advancements due to resource constraints and limited technical capacity. Failure to adapt to new technologies can result in outdated quality assurance practices, reduced competitiveness in global markets, and missed opportunities for innovation. OIC countries need to develop strategies for continuous monitoring and integration of technological advancements to ensure that their NQI systems remain relevant and effective.

The digital divide, or the gap between those with access to digital technologies and those without, is a significant challenge for OIC countries. In many member countries, there is a disparity in access to digital tools and resources between urban and rural areas, as well as between large enterprises and SMEs. This divide can impact the equitable implementation of NQI systems. For example, SMEs in rural areas may lack access to advanced quality control technologies and digital platforms, leading to inconsistencies in quality assurance. Addressing the digital divide requires targeted efforts to enhance digital infrastructure, provide training, and support the adoption of technologies across all sectors and regions.

The rapid advancement of technology also presents challenges for regulatory and standards development. As new technologies emerge, there is a need to update and develop new regulations and standards to ensure their safe and effective use. However, the pace of technological change can outstrip the ability of regulatory bodies to develop and implement appropriate standards. OIC countries may face difficulties in keeping regulatory frameworks and standards up-to-date with technological advancements. This can result in regulatory gaps, inconsistent implementation, and challenges in ensuring compliance with emerging technologies. Collaborative efforts between governments, industry stakeholders, and international organizations are necessary to address this challenge and develop relevant regulations and standards.

Regional and International Alignment: Achieving alignment with regional and international standards is crucial for enhancing trade and economic integration. However, many OIC countries face challenges in harmonizing their standards with those of neighboring countries and international bodies. Differences in regulatory frameworks, technical requirements, and conformity assessment procedures can create barriers to trade and limit the effectiveness of regional QI initiatives. In some cases, political and economic considerations may also hinder efforts to achieve regional and international alignment. For example, countries may be reluctant to adopt international standards if they perceive them as being unfavorable to local industries or if they lack the capacity to implement them effectively.

Regional cooperation is essential for harmonizing standards and regulations within a specific geographic area. However, OIC countries often face challenges related to fragmented regional cooperation efforts. Different regional bodies and organizations may have overlapping or conflicting objectives, leading to inconsistencies in standards and regulatory practices. Fragmented regional cooperation can hinder the development of a cohesive regional QI and create obstacles for businesses operating across multiple countries. Effective regional alignment requires coordinated efforts among member countries, regional organizations, and stakeholders to establish common goals, frameworks, and practices.

The effectiveness of NQI alignment depends on the ability to update and harmonize regulatory and policy frameworks. Many OIC countries face challenges in developing and implementing regulatory frameworks that are consistent with international standards. Outdated or fragmented regulatory frameworks can create inconsistencies and barriers to alignment. Additionally, policy changes and updates may require significant time and effort and may face resistance from various stakeholders. Ensuring that regulatory and policy frameworks support alignment with international standards is a critical aspect of strengthening NQI systems.

Sustainability and Environmental Concerns: As the world increasingly focuses on sustainable development and environmental protection, NQI systems must also address these concerns. However, integrating sustainability into NQI practices can be challenging, particularly for countries that are still developing their basic QI. There is a need to develop standards and certification schemes that promote environmentally sustainable practices, such as energy efficiency, waste reduction, and the use of renewable resources. Additionally, NQI systems must also address social sustainability, including fair labor practices, social responsibility, and consumer protection. Achieving these goals requires a comprehensive approach that considers the economic, social, and environmental dimensions of sustainability.

Challenges on NQI	
Limited Financial Resources	Limited financial resources delay the development of strong NQI systems in many low-income countries, impacting infrastructure, training, R&D, and global competitiveness, while also increasing reliance on external funding.
Lack of Technical Expertise and Capacity	The shortage of technical expertise in NQI institutions leads to inefficiencies in standardization, testing, and accreditation, limiting international participation, trade, and economic growth.
Inadequate Institutional Coordination	Inadequate institutional coordination in NQI systems often leads to fragmented responsibilities, inefficiencies, and inconsistent implementation of standards, hindering the development of a cohesive quality management strategy and impacting global competitiveness.
Insufficient Awareness and Engagement	Insufficient awareness and engagement among businesses, government agencies, and the public lead to low demand for QI services, limited participation in standardization, and inadequate support for NQI initiatives, affecting the overall effectiveness and integration of quality management systems.
Barriers to International Trade	Barriers to international trade stem from inadequate NQI systems, which lead to difficulties meeting international standards, fragmented regulatory frameworks, limited MRAs, and insufficient quality assurance infrastructure. These factors impact export opportunities, increase costs, and hinder economic growth.
Emerging Technological Challenges	Emerging technological challenges include adapting NQI systems to rapid advancements like AI, IoT, and digital manufacturing, addressing gaps in expertise and infrastructure, managing cybersecurity risks, and keeping regulatory frameworks and standards up-to-date, all while bridging the digital divide and integrating sustainability into quality practices.

Regional and International Alignment	Achieving alignment with regional and international standards is challenging due to fragmented cooperation, varying regulatory frameworks, and resistance to policy updates, which impedes trade and economic integration.
Sustainability and Environmental Concerns	Integrating sustainability into NQI systems is challenging, particularly for developing countries, due to the need for comprehensive standards and certification schemes that address environmental and social sustainability alongside economic considerations.

3.8. Trends in NQI

As the global landscape evolves, several emerging trends are shaping the future of NQI. These trends reflect technological advancements, shifts in market demands, and changing regulatory requirements.

Digital Transformation: The integration of digital technologies into NQI systems is revolutionizing quality management processes. Digital transformation encompasses the adoption of tools such as AI, big data analytics, and the IoT to enhance the efficiency and accuracy of quality control and assurance. AI-driven analytics can predict and identify potential quality issues before they arise, while IoT sensors enable real-time monitoring of products and processes. These technologies facilitate more proactive and data-driven approaches to quality management.

AI and machine learning are revolutionizing NQI by automating complex processes and providing data-driven insights. These technologies enable predictive analytics, where AI algorithms analyze historical data to forecast potential quality issues before they occur. This proactive approach helps in identifying trends, optimizing processes, and improving overall quality management. The IoT connects devices and sensors across production lines and supply chains, allowing real-time monitoring and control of quality parameters. IoT-enabled sensors collect data on various aspects of production and product performance, providing valuable insights for quality assurance and enabling quick responses to potential issues.

Digital transformation has led to the development of online databases that house a vast array of standards and regulations. These databases provide easy access to up-to-date information on quality standards, facilitating compliance and harmonization efforts. Businesses and regulatory bodies can quickly reference and implement the latest standards, ensuring that their quality management practices are current and relevant. Conformity assessment tools are increasingly becoming digital, streamlining the processes of testing, certification, and inspection.

Digital tools for conformity assessment allow for more efficient data collection, analysis, and reporting. These tools help manage large volumes of data, improve accuracy, and reduce the time required for assessments.

The shift to digital accreditation platforms simplifies the accreditation process for organizations seeking certification. These platforms provide online submission, review, and management of accreditation applications, making it easier for organizations to achieve and maintain certification. Digital platforms also enhance transparency and reduce administrative burdens. Cloud computing facilitates the storage, management, and sharing of quality-related data across organizations and geographical locations. Cloud-based solutions enable seamless collaboration among stakeholders, including regulatory bodies, businesses, and certification agencies. This enhances the efficiency of quality management processes and promotes consistency in standards and practices. Digital transformation has led to creating collaborative platforms where stakeholders can engage in real-time discussions, share best practices, and collaborate on quality management initiatives. These platforms foster innovation and knowledge exchange, driving improvements in QI and facilitating alignment with international standards.

Using big data analytics in NQI allows for the analysis of large and complex datasets to uncover patterns, trends, and insights related to quality. By leveraging big data, organizations can make informed decisions, optimize processes, and enhance overall quality management. This data-driven approach supports continuous improvement and helps in addressing quality challenges effectively. Automated reporting systems streamline the generation and distribution of quality reports, reducing manual effort and minimizing errors. These systems enable real-time reporting, allowing organizations to monitor quality metrics and performance indicators more effectively. Automated reporting also supports compliance with regulatory requirements and facilitates transparency. Automation in measurement systems enhances the accuracy and reliability of calibration processes. Automated systems reduce human error, increase precision, and improve efficiency in measurement and calibration activities. This is crucial for maintaining high standards of quality and ensuring the accuracy of measurement instruments.

Digital platforms are transforming the way training and certification programs are delivered. Online courses, webinars, and virtual workshops make quality management training more accessible to a broader audience. These digital resources support the development of skills and knowledge necessary for effective quality management. Digital transformation supports e-governance initiatives by providing online access to regulatory information, compliance requirements, and submission processes. This enhances accessibility for businesses and organizations, making navigating regulatory frameworks easier and achieving compliance with quality standards.

Blockchain Technology: Blockchain technology is gaining traction in NQI for its ability to provide transparency and traceability in supply chains. By creating immutable records of transactions, blockchain enhances the ability to track and verify the authenticity and quality of products. This is particularly valuable in sectors like pharmaceuticals, food safety, and luxury goods.

One of the fundamental features of blockchain technology is its ability to create immutable records. Each transaction or data entry on a blockchain is cryptographically secured and linked to previous records, creating a tamper-proof ledger. In the context of NQI, this feature ensures that data related to product quality, certification, and compliance is securely recorded and cannot be altered retroactively. This enhances transparency and trust in the quality management process. Blockchain provides end-to-end traceability of products and materials throughout the supply chain. By recording each step of a product's journey on a blockchain, stakeholders can track its origin, production process, and distribution. This level of traceability is particularly valuable in sectors like pharmaceuticals, food safety, and luxury goods, where verifying authenticity and adherence to quality standards is critical.

Blockchain technology enables the verification of product authenticity by creating a digital record that can be easily accessed and verified by all parties involved. For example, in the food industry, blockchain can track the journey of food products from farm to table, ensuring that they meet safety and quality standards. This helps prevent fraud and counterfeiting, which are significant challenges in global supply chains. Blockchain can streamline certification processes by providing a secure and transparent platform for managing and verifying certifications. Certification bodies can record and update certifications on a blockchain, allowing stakeholders to access real-time information on the status and validity of certifications. This reduces the risk of fraudulent certifications and simplifies the verification process for businesses and regulatory authorities.

The cryptographic nature of blockchain technology ensures the security and integrity of data. Quality-related data, such as test results, inspection reports, and compliance records, are stored in a decentralized and secure manner. This protects against data breaches and unauthorized access, ensuring that quality information remains accurate and reliable. Blockchain's immutability prevents data tampering and unauthorized modifications. Once data is recorded on the blockchain, it becomes part of a permanent and verifiable record. This is crucial for maintaining the integrity of quality data, as any attempts to alter or falsify information can be easily detected and traced back to the source.

Blockchain technology enables real-time access to data across the supply chain. Stakeholders can monitor the status and quality of products at any point in the supply chain, providing immediate insights into potential issues or deviations from quality standards. This real-time monitoring facilitates prompt decision-making and helps prevent quality problems before they escalate.

Blockchain technology supports decentralized collaboration among stakeholders by providing a shared and transparent platform for data exchange. This collaborative approach allows businesses, regulatory bodies, and certification agencies to collaborate more effectively, improving coordination and alignment in quality management efforts. Smart contracts are self-executing contracts with the terms of the agreement directly written into code. In the context of NQI, intelligent contracts can automate quality assurance processes, such as triggering inspections or releasing payments upon compliance verification. This automation reduces administrative overhead and enhances the efficiency of quality management.

Green Certifications: As sustainability becomes a global priority, there is a growing emphasis on green certifications and standards that address environmental impact. NQI systems increasingly incorporate certifications such as ISO 14001 (Environmental Management) and eco-labels to promote environmentally friendly practices. Businesses are being encouraged to adopt sustainable practices and obtain certifications that demonstrate their commitment to reducing their carbon footprint and minimizing environmental impact.

Consumers increasingly seek products and services that align with their values, including environmental responsibility. Green Certifications help businesses meet this demand by providing verified proof of their commitment to sustainable practices. This certification not only enhances brand reputation but also opens up new market opportunities. ISO 14001 is a widely recognized standard for environmental management systems (EMS). It provides a framework for organizations to manage their environmental responsibilities systematically and integrate sustainable practices into their operations. Achieving ISO 14001 certification demonstrates an organization's commitment to reducing its environmental impact and improving its environmental performance. LEED certification is a prominent standard for green building and sustainable design. It assesses the environmental performance of buildings and communities and provides third-party verification of their sustainability. LEED certification covers various aspects of green building, including energy efficiency, water usage, indoor environmental quality, and sustainable site development. ENERGY STAR is a certification program that identifies and promotes energy-efficient products and practices. It is widely recognized for its role in helping organizations and consumers reduce energy consumption and greenhouse gas emissions. ENERGY STAR certifications are available for a range of products, including appliances, electronics, and buildings.

Green Certifications drive improvements in environmental performance by encouraging organizations to adopt sustainable practices and reduce their environmental impact. Certified organizations often implement measures to conserve resources, reduce waste, and minimize emissions, contributing to overall environmental sustainability.

Achieving Green Certifications provides a competitive advantage by differentiating organizations in the marketplace. Certified organizations can leverage their green credentials to attract environmentally conscious customers, gain access to new markets, and enhance their brand reputation. Implementing green practices often leads to cost savings through improved resource efficiency and reduced operational costs. For example, energy-efficient technologies and waste reduction strategies can lower energy bills and operational expenses, providing financial benefits in addition to environmental gains.

Circular Economy: The concept of a circular economy, which focuses on reducing waste and maximizing resource use, influences NQI trends. Standards and certifications related to circular economy principles are emerging, guiding businesses in designing products that are recyclable, reusable, and sustainable. NQI ensures that recycled and reused materials meet the same quality and safety standards as virgin materials. This promotes trust in circular products and ensures they perform at the required level. NQI helps organizations adhere to national and international environmental standards related to resource efficiency, waste reduction, and sustainable production practices. Compliance with these standards is essential for promoting circular practices within industries. Certification bodies within NQI validate and certify circular practices, such as product recycling, remanufacturing, and sustainable supply chain management. These certifications are vital for businesses to demonstrate their commitment to the circular economy and for consumers to identify environmentally responsible products.

One of the key emerging trends in NQI is the development of standards that are specifically tailored to circular economy principles. These standards set guidelines for the design of products with end-of-life in mind, encourage the use of recycled materials, and promote closed-loop manufacturing processes. Examples of such standards include ISO 14040 and ISO 14044 for life cycle assessments (LCA), which help organizations assess the environmental impact of their products and processes throughout their entire lifecycle. With growing consumer demand for sustainable products, certification schemes that verify circularity in products and processes are becoming increasingly popular. Certifications such as Cradle to Cradle (C2C) and other eco-labels assess products based on their sustainability, recyclability, and safe material use. These certifications provide businesses with a competitive edge and enable consumers to make informed choices about the products they purchase.

Metrology, as a part of NQI, is increasingly focusing on resource efficiency metrics that are aligned with circular economy goals. Measurement standards for energy consumption, material usage, and waste generation are being developed to help industries optimize their resource inputs and minimize waste outputs. Precise measurement of recycled material content, energy efficiency, and emissions reductions is essential for ensuring that circular practices meet environmental targets.

Innovation in product design is a significant driver of the circular economy, and NQI is responding by supporting standards and certifications that encourage circular design practices. This includes designing products for durability, reparability, and upgradability, as well as using modular components that can be easily replaced or repurposed. NQI frameworks help validate these design innovations, ensuring they comply with quality and safety standards while promoting longer product lifecycles. Digital technologies, such as blockchain and the IoT, are increasingly being integrated into NQI to support traceability and transparency in circular supply chains. These platforms enable businesses to track the flow of materials throughout the product lifecycle, ensuring that recycled or repurposed materials meet quality standards. That circular processes are transparent and verifiable. Digital platforms also facilitate the certification of circular products by providing real-time data on material use and environmental impact.

Consumer-Centric Standards: There is a growing emphasis on developing standards and regulations prioritizing consumer protection and safety. NQI systems are evolving to include consumer-centric standards that address emerging concerns, such as data privacy, product safety, and ethical sourcing. For instance, standards related to data protection, such as ISO/IEC 27001, are becoming increasingly important as businesses handle vast amounts of sensitive information. Ensuring that products meet safety standards and ethical requirements is crucial for building consumer trust and confidence.

In response to growing consumer concerns about product safety, especially in sectors such as food, pharmaceuticals, and electronics, there is an increasing emphasis on stringent health and safety standards. NQI systems are enhancing certification and testing procedures to ensure that products comply with these regulations and meet consumer expectations for safety. For example, food safety standards such as ISO 22000, which outlines food safety management systems, are increasingly being adopted globally. These standards help businesses ensure that their food products are safe for consumption and comply with international food safety regulations. Additionally, testing and certification of pharmaceuticals and medical devices are becoming more rigorous to ensure that they are safe for consumers.

Consumers increasingly prioritize sustainability in their purchasing decisions, and NQI frameworks are evolving to reflect this trend. Standards for eco-friendly products, such as certifications for organic food, biodegradable packaging, and low-carbon manufacturing processes, are being developed and implemented. In addition to sustainability, ethical sourcing, and fair trade are becoming critical components of consumer-centric standards. Certifications such as Fair Trade and Rainforest Alliance ensure that products are sourced ethically, with fair wages, safe working conditions, and sustainable farming practices.

NQI systems are adapting to incorporate these certifications as part of their standardization efforts, ensuring that products meet not only safety and quality requirements but also ethical standards. This trend reflects the growing consumer demand for transparency and social responsibility in the supply chain.

With the rise of digital technologies and e-commerce, consumers are increasingly concerned about data privacy and security. NQI systems are developing standards to protect consumer data and ensure that businesses comply with data protection regulations, such as the General Data Protection Regulation (GDPR) in the European Union. These digital standards include guidelines for cybersecurity, encryption, and secure data handling processes. Certification of businesses that meet these standards helps build consumer trust in online platforms and digital services, ensuring that personal data is handled responsibly and securely.

Increased Transparency: Transparency in quality assurance processes is becoming a key focus. Consumers and stakeholders demand greater visibility into product quality and safety. NQI systems are incorporating measures to enhance transparency, such as public reporting of compliance data and certification status.

One of the most significant trends in NQI transparency is the increasing focus on supply chain traceability. Consumers, regulators, and businesses demand more detailed information about the origin of products, the processes involved in their production, and the ethical standards they meet. Technologies such as blockchain play a crucial role in enhancing supply chain transparency by providing a secure and immutable record of transactions at every stage of the supply chain. This allows consumers and regulators to trace products from their source to the final point of sale, ensuring compliance with quality and sustainability standards. For example, in the food industry, traceability systems allow for the tracking of food products from farm to table, ensuring that they meet safety and quality standards. This is particularly important in cases of food recalls, where traceability can help identify the source of contamination and prevent further harm to consumers.

Another emerging trend is the move towards open access to standards, certification criteria, and conformity assessment results. Many NQI systems are making this information publicly available through online platforms, allowing stakeholders to easily access and verify the certification status of products and services. This trend not only enhances transparency but also levels the playing field for businesses, particularly SMEs, by making information about standards and certification processes more accessible. It also empowers consumers to verify the claims made by companies and ensures that certifications are credible and meaningful.

For instance, some countries are creating online databases where consumers and businesses can search for products that have been certified to meet specific standards, such as organic certification or fair trade labeling. This promotes greater consumer awareness and encourages companies to adhere to higher quality and sustainability standards.

Alignment with International Standards: The push for global harmonization of standards and regulations is gaining momentum. NQI systems align more closely with international standards set by organizations such as ISO, IEC, and Codex Alimentarius to facilitate cross-border trade and ensure consistency.

One of the emerging trends is the harmonization of regional standards with international ones. This involves aligning standards within regional trade blocs, such as the OIC, the African Union, or ASEAN (Association of Southeast Asian Nations), with global standards. Harmonized regional standards help create a unified market, allowing for a smoother flow of goods and services between neighboring countries and beyond. For OIC member countries, regional harmonization efforts are crucial in reducing trade barriers within the organization and promoting greater economic cooperation. These efforts can also help countries align with international standards, providing a stepping stone to broader global integration.

Another trend is the increasing involvement of countries in international standards-setting bodies such as ISO, IEC, and the International Telecommunication Union (ITU). By participating in the development of international standards, countries can ensure that their national interests and priorities are reflected in global regulations. Active participation also allows countries to stay informed about the latest developments and best practices in various sectors. For OIC member countries, increasing participation in international standards-setting processes is a way to ensure that their unique needs, such as Halal certification standards, are recognized and incorporated into global frameworks. While alignment with overarching international standards is essential, there is also an increasing focus on sector-specific standards. Specific international standards play a critical role in ensuring the quality and safety of products and services for industries such as healthcare, energy, food safety, and information technology. For example, ISO 13485 sets the standard for medical devices, while ISO 22000 focuses on food safety management systems. OIC member countries increasingly recognize the importance of aligning their national regulations with these sector-specific standards to boost their industries' credibility and global competitiveness.

Adoption of Industry 4.0: The fourth industrial revolution, or Industry 4.0, drives innovation in QI. NQI systems are embracing intelligent manufacturing technologies, such as robotics, automation, and advanced analytics, to improve quality control and enhance efficiency.

Industry 4.0 represents the fourth industrial revolution, where smart factories leverage cutting-edge technology to create more efficient, flexible, and data-driven production processes. These technologies include cyber-physical systems (CPS), cloud computing, and digital twins, all of which rely on accurate measurement, testing, certification, and quality assurance—the core functions of NQI. The convergence of these domains demands that NQI systems evolve to support the growing complexity of modern industry. Automation and robotics are central to Industry 4.0. These technologies enhance production efficiency, but they also introduce new challenges in measurement, calibration, and certification. To ensure the accuracy and precision of automated systems, NQI institutions must adopt standards that address the calibration and validation of robotic equipment, sensors, and control systems. For OIC member countries, embracing Industry 4.0 technologies requires NQI institutions to adopt new standards, ensure the reliability of high-tech equipment, and implement advanced conformity assessment processes. QI must adapt to meet the quality and safety requirements of increasingly automated and data-driven industries.

Investment in Infrastructure: Modernizing and expanding QI is essential for keeping pace with emerging trends. This includes upgrading laboratories, enhancing testing capabilities, and adopting advanced technologies to support quality assurance processes.

Adequate NQI infrastructure underpins economic growth and competitiveness by providing businesses with the tools and resources needed to comply with quality standards and regulations. Investment in QI fosters innovation, supports export opportunities, and enhances the overall business environment. Investment in state-of-the-art testing and calibration laboratories is essential for maintaining accurate and reliable measurement standards. Upgrading equipment, adopting new technologies, and ensuring adherence to international calibration standards enhance laboratories' capability to perform high-quality tests and provide accurate results.

Collaborative approaches and PPPs are emerging as effective strategies for infrastructure investment. By leveraging resources and expertise from both the public and private sectors, NQI systems can benefit from shared investments, improved facilities, and innovative solutions. PPPs facilitate the development of infrastructure projects and ensure that they meet the needs of diverse stakeholders.

Collaborative Policy Development: Collaborative efforts among governments, industry stakeholders, and international organizations are essential for developing effective policies and regulations. Joint initiatives and partnerships are being established to address common challenges and promote best practices in quality management.

Trends in NQI	
Digital Transformation	The integration of digital technologies like AI, IoT, and big data is revolutionizing NQI(NQI) systems by enhancing efficiency, accuracy, and collaboration in quality management, conformity assessments, accreditation, and regulatory compliance processes.
Blockchain Technology	Blockchain technology is revolutionizing NQI by enhancing transparency, traceability, and security in supply chains, ensuring product authenticity, streamlining certifications, and enabling real-time quality monitoring.
Green Certifications	Green certifications, such as ISO 14001, LEED, and ENERGY STAR, promote sustainable practices by helping businesses reduce their environmental impact, conserve resources, and enhance market competitiveness.
Circular Economy	NQI supports the circular economy by creating standards and certifications for recyclable, reusable, and sustainable products, ensuring quality, safety, resource efficiency, waste reduction, and transparent circular supply chains.
Consumer-Centric Standards	NQI systems are increasingly focusing on consumer-centric standards, including data privacy, product safety, and ethical sourcing certifications like ISO/IEC 27001 and Fair Trade.
Increased Transparency	NQI systems are improving transparency by implementing public reporting of compliance data, supply chain traceability via blockchain, and open access to certification status.
Alignment with International Standards	Aligning with international standards, especially through regional harmonization and sector-specific standardization, is vital for facilitating trade and boosting global competitiveness.
Adoption of Industry 4.0	Industry 4.0 technologies are pushing NQI systems to evolve, incorporating automation, robotics, and data-driven processes, which demand new standards and conformity assessments.
Investment in Infrastructure	Investing in modernizing NQI infrastructure and using PPPs is vital for accurate measurement standards, innovation, and economic growth.
Collaborative Policy Development	Develop a Halal Metrology Framework outlining standards for metrological practices in Halal products, ensuring measurements comply with Halal principles and support certification in OIC member countries.

4. CASE ANALYSES

In this study, Italy and the United States were chosen as cases of good practices. These states are both non-OIC member countries and were selected due to an efficient operation of their institutions, well established experience in quality infrastructure, and effective models of collaboration between public and private sectors. Their long-standing achievements in these areas render them useful for examining advanced quality infrastructure systems.

In addition, the UAE was used as an example from an OIC member countries due to its highly efficient and well-functioning quality infrastructure and metrology practices.

Furthermore, Kazakhstan and Senegal that are both OIC member countries were analyzed for their diverse geographic locations and differing levels of quality infrastructure development. These nations were considered valuable to the study because they offer insight into varying approaches to implementing quality infrastructure in different contexts.

When examining the selected countries, an initial background was provided to present each nation's historical and current standing in metrology and quality infrastructure. This was followed by a general overview of the state of quality infrastructure in the country, highlighting key data that reflected its level of development. Data from international reports were used to give an accurate, elaborate and objective assessment.

Then, key institutions involved in the area of quality infrastructure and metrology, as well as major initiatives that drive developments are highlighted in "Quality Infrastructure and Initiatives" section. Thereafter, a description of main policies and regulations that provide the framework of the country's quality infrastructure will be given. Finally, under "Conclusion of Review," the findings from the analysis were presented, including evaluations, observations, and recommendations based on the country's current standing and future potential in the field of quality infrastructure.

According to the study titled Global QI Index Report 2023 in which Germany, China and United States make up the top three, Türkiye ranked 18th is leading among the OIC Member Countries, under the category of general QI. Türkiye is followed by Indonesia (27) and Malaysia (33) and Egypt (34) respectively. Furthermore, Italy, the other country which is analyzed extensively in this study, occupies the sixth position in the ranking, positioning it as one of the standout performers within the group under consideration³⁶

4.1. Kazakhstan

The advantages of examining diverse countries in terms of level of development and geographic locations in metrology can offer significant benefits. It makes it possible to examine the unique problems and opportunities that different regions face in establishing effective metrology systems since their metrology systems are influenced by many factors, such as economic state, infrastructure, and environmental conditions. Kazakhstan would therefore be particularly useful to consider in this instance, as it would serve as a valuable study area with distinct geographical and developmental attributes.

³⁶ Global Quality Infrastructure Index Report 2023
https://www.researchgate.net/publication/380727111_GLOBAL_QUALITY_INFRASTRUCTURE_INDEX_REPORT_2023

Furthermore, Kazakhstan's NQI system serves as an example of how a transition economy, and rich in natural resources has developed its QI to support industrial growth, international trade, and economic diversification. Kazakhstan's efforts to modernize its economy and integrate into global markets, such as the Eurasian Economic Union (EEU) and its accession to the World Trade Organization (WTO) in 2015, make it a valuable case for exploring the effectiveness and challenges of NQI systems in similar transition or resource-based economies in OIC Members.

4.1.1. Background

Kazakhstan has achieved impressive economic growth over the past decade, largely due to its abundant natural resources, particularly oil and gas. Energy assets have played a major role in attracting FDI and raising export revenues. Ultimately, increased revenues helped vastly to strengthen the country's domestic economy and make it a major player in the global energy market. Kazakhstan has focused on a very ambitious economic diversification plan for building a strong and balanced economy. By spending a significant portion of the budget on infrastructure projects, the government is tasked with supporting various sectors, such as agriculture, manufacturing, and services. These are part of efforts to lead the country away from the energy-dependency toward a more diversified economy. In addition, Kazakhstan aims to improve the long-term economic stability of the country by encouraging investment and development in these areas.³⁷

4.1.2. General Outlook of Quality Infrastructure and Metrology

Kazakhstan is ranked 48th globally out of 185 countries in the Global QI Index. According to the indicators in the study, Kazakhstan seems to perform ahead of many regional powers and similar economies, especially in the area of accreditation. On the contrary, Kazakhstan is ranked lower in the standardization category compared to its positions in other subcategories, indicating that it lags behind other countries in this specific area.

³⁷ "Kazakhstan's National Energy Report 2023" S&P Global Commodity Insights

GQII 2023: Global Ranking and Subrankings				
Country	Global QI Index Rank 2023	Rank Metrology 2023	Rank Standardization 2023	Rank Accreditation 2023
Germany	1	2	2	2
China	2	3	1	6
United States	3	1	7	1
Ukraine	26	24	46	18
Kazakhstan	48	46	66	28
Russian Federation	50	26	17	105
Uzbekistan	67	80	80	39
Mongolia	73	75	78	61
Kyrgyz Republic	101	107	150	73
Tajikistan	166	145	163	165

Source: Global Quality Infrastructure Index

GQII Global Ranking and Subrankings (comparison in years)				
Kazakhstan	Global QI Index Rank 2023	Rank Metrology 2023	Rank Standardization 2023	Rank Accreditation 2023
GQII 2023	48	46	66	28
GQII 2021	48	45	65	30
GQII 2020	49	44	65	25

Source: Global Quality Infrastructure Index

It can be observed from the index that, in the area of QI and metrology, Kazakhstan has a stable course in the recent years. The country's global ranking in the aforementioned index and its position within the sub rankings have remained relatively stable, indicating minimal change.

Country	World	GDP: L	Income: Upper Middle	Europe-Central Asia
Kazakhstan	63	37	20	31

Source: Quality Infrastructure for Sustainable Development Index

Based on the QI for Sustainable Development Index, which evaluates how well countries' QI systems support the SDGs, Kazakhstan is ranked 112nd among the assessed nations. Within the upper middle category, Kazakhstan stands 20th out of 36 indicators that compose the index in 2023.

Standards and Regulatory Technical Documents	Reference and Reference Equipment	Verifications and Calibrations for Business Per Year
73.385	104	5.000

Source: Kazakhstan Institute of Standardization and Metrology

As seen in the table, the national file of standards in Kazakhstan now includes 73.385 rules and norms applied in all economic areas.

4.1.3. Main Actors and Initiatives

Key initiative that Kazakhstan launched is the modernization of the national metrology system, which includes upgrading measurement standards and ensuring compliance with international norms through collaboration with global organizations.

Kazakhstan Institute of Standardization and Metrology (KazStandard): The Kazakhstan Institute of Standardization and Metrology (KazStandard) is at the center of country's QI and metrology. It was established in accordance with the Decree of the Government of the Republic of Kazakhstan dated October 2, 2020 No. 639 "On some issues of republican state enterprises under the jurisdiction of the Ministry of Trade and Integration of the Republic of Kazakhstan".

Main objectives of the institute are to:

- **Support State Policy:** The participation in the implementation of state policy in technical regulation, standardization, and measurement uniformity.
- **System Development:** To develop and improve the national system of technical regulation, standardization, and measurement uniformity.
- **Measurement Uniformity:** Providing measurement uniformity throughout the country by raising the level and quality of the technical and regulatory framework.
- **Scientific Research:** Performance of scientific research works directed towards accurate and reliable results of measurements.
- **Metrological Support:** Provides information services and metrological support to enterprises and organizations.
- **Personnel Training:** Provides for personnel training and advanced education in metrology.
- **Project Management:** Managing projects and digitalization of processes concerning technical regulation, measurement uniformity, and standardization.

The company performs a variety of activities in the sphere of QI and measurement standards maintenance in the Republic of Kazakhstan. They develop and update national and interstate standards, review standardization documents, and arrange these documents for key industries.

They also manage the technical committees for standardization and make measurements uniform across the country.

Besides, the institute publishes and sells technical documents, maintains a state fund of these documents, and implements training programs on technical regulation, metrology, and standardization. It cooperates with international organizations on the convergence of Kazakhstan standards with international ones and maintains the national registry on standardization. It conducts scientific research, provides technical backing, and certifies and verifies measuring instruments to ensure all products and measurements meet the set quality and safety standard.³⁸

Committee of Technical Regulation and Metrology: The Technical Regulation and Metrology Committee is an Agency of the Ministry of Trade and Integration that performs regulatory, implementation and control functions and participates in the implementation of strategic objectives of the Ministry in the areas of technical regulation and metrology. It mainly determines state policy in the field of technical regulation, standardization, and metrology, their implementation, and uniformity of measurements. This includes setting strategic directions in these areas, aligning national policy with the international requirements, and promoting best practices in various industries. The Committee creates a regulatory framework that the industries are to adhere to in their activities, which ensures that all products and services acquired within Kazakhstan are at par and safe for consumption.

Besides policy making, the Committee supervises and coordinates all activities in the field of standardization and metrology, including those of the Kazakhstan Institute of Standardization and Metrology, KazStandard. This ensures that these institutions function properly and in relation to the national policies. The committee guides and supports KazStandard and other relevant bodies, ensuring that their activities take the course outlined by the country's strategic goals. It also examines the reports and performance metrics from these organizations to determine whether they are in line with regulatory requirements, be it compliance or improvement.

The Committee has an extremely significant role in the entire process of the accreditation process for testing and calibration laboratories. It would be responsible for the accreditation of laboratories required for maintaining the reliability and accuracy of measurements made in many sectors. The Committee provides accreditation of laboratories and supervises over their adherence to the regulatory standards of compliance, thereby protecting the integrity of Kazakhstan's QI. An accreditation process, such as this one, is relevant for creating consumer trust and promoting ethical trade practices by ensuring accuracy and reliability in measurement results.³⁹

³⁸ <https://ksm.kz/en/> Kazakhstan Institute of Standardization and Metrology website.

³⁹ <https://www.gov.kz/memleket/entities/mti-ktrm?lang=en> Committee of Technical Regulation and Metrology website.

The relation between the Committee of Technical Regulation and Metrology and the Kazakhstan Institute of Standardization and Metrology is based on supervision and functional subordination. The Committee implements state policies in the sphere of technical regulation, standardization, and metrology, thus forming the regulatory basis for KazStandard activities. It has the right to enforce laws and regulations, ensuring the due performance of works according to national and international standards in various industry sectors. Setting the strategic line of development of standardization and metrology in Kazakhstan, the Committee outlines the basis of KazStandard's activities.

KazStandard is the working body that implements the policy, and regulations developed by the Committee. It develops and updates national standards, makes metrology services, and conformity assessments. KazStandard provides practical solutions and services, including calibration, certification, and training to industries for compliance with standards and regulations. Essentially, the Committee provides regulatory oversight and strategic direction, while KazStandard handles practical implementation; their partnership is therefore important in the management of QI and metrology in the Kazakh Republic.

4.1.4. Policies and Regulations

Kazakhstan's quality infrastructure and metrology policy focus might be outlined as prioritizing the development of a robust quality infrastructure and aligning with international standards. This policy is an integral part of its broader economic strategy, aimed at fostering industrial development, ensuring product safety, and enhancing the country's global trade competitiveness.

On 5 October 2018, the Standardization Law of Kazakhstan 183-VI ZRK was adopted, under which there is a complete mechanism for the development, adoption, and application of standards in all fields of activity among all sectors. This ensures that products and services originating from Kazakhstan conform to the international and national quality standards. It defines the roles of the major parties involved, their responsibilities, including state bodies, organizations, and citizens associated with the standardization process. It also underlines the important role of aligning national standards with international practices, which will enable trade easier and increase the competitiveness of Kazakh products in the world market. The Law on Standardization clearly establishes the rules for the development and maintenance of standards, which will ensure the creation of reliable, safe, and good-quality goods and services in the Republic of Kazakhstan.

The Law on Technical Regulation serves as the framework guiding the development and enforcement of standards in sectors like chemical products, food safety, toys and machinery to safeguard consumers and boost trade competitiveness.

Another crucial regulation is the Law on Ensuring Measurement Unity, which focuses on maintaining measurements by outlining responsibilities for state entities, businesses and individuals to promote consistency in measurements. This law aims to protect consumer interests while aligning Kazakhstan's measurement systems with standards for scientific and industrial measurements.

Furthermore, the Law on Accreditation in Conformity Assessment plays a role in guaranteeing the reliability of testing and calibration laboratories by regulating the accreditation process to ensure compliance with required standards, for assessments. The laws are upheld by the Committee of Technical Regulation and Metrology within the Ministry of Trade and Integration working in partnership with the Kazakhstan Institute of Standardization and Metrology (KazStandard). These organizations collaborate to create, uphold and enforce standards and metrological practices that aid Kazakhstan's progress and help it integrate into the market.⁴⁰

The fuel quality violations in Kazakhstan serve as a significant example of the stringent measures the country takes to enforce compliance with national standards. Low-quality fuel has been a major concern in Kazakhstan, particularly as regards the selling substandard fuel. In 2019, several fuel stations sold low-quality contaminated fuel that did not meet national standards for quality. This caused massive damage to several motor vehicles operating in the country and attracted a number of consumers' complaints. The government responded by fining some of the fuel stations involved in the malpractice, revoking their licenses, and stepping up inspection of other fuel stations across the country to ensure they comply with the standard quality of fuel.⁴¹

4.1.5. Conclusion of Review

In Kazakhstan, various activities are initiated to raise awareness related to QI and metrology. Several institutions, such as KazStandard and the Committee for Technical Regulation and Metrology, organized meetings, workshops and collaboration projects that keep the community informed of innovations and practices in the field. However, awareness activities about QI and metrology should be increased for effective results. Raising awareness activities may include media campaigns and informational materials to help educate the public about the importance of national and international standards in addition to industry conferences, collaborative projects, competitions and awards. Kazakhstan can improve quality standards, raise its competitiveness and ensure reliability and safety in its products and services. Adjustments to the budget and personnel for QI and metrology in public and private sector in Kazakhstan could be quite beneficial.

⁴⁰ Kazakhstan Institute of Standardization and Metrology. Retrieved from: <https://ksm.kz/en/institute/legislative-framework/>

⁴¹ Tengrinews. Retrieved from: https://en.tengrinews.kz/kazakhstan_news/kazakhstan-tackles-issue-of-substandard-fuel-297821/

Allocating additional funds and personnel, as well as enhancing staff capacity through targeted trainings and development programs would ensure more effective application of standards, improved measurement accuracy and overall improving quality control processes.

Enhancing the role, responsibility, and effectiveness of non-state actors (such as associations, NGOs, firms, and other relevant players) in the areas of QI and metrology in Kazakhstan could bring significant benefits. Active engagement of these actors creates considerable benefits in terms of elaboration of new solutions, more efficient use of available resources and reaching a larger audience. As the non-state actors bring along experience and expertise, they can facilitate standard quality and increase the precision of measurement. The participation of these bodies also aims to disseminate better awareness among the people and contribute to the expansion of educational activities. Finally, boosting the effectiveness of non-state actors is crucial for sustainable development and continuous improvement in the fields of QI and metrology.

4.2. Senegal

Conducting an in-depth examination of countries with varying levels of development in metrology can be highly beneficial. It highlights various challenges and needs of different countries seeking to have a well-established measurement system. In this respect, it is aimed that the focus on Senegal may help to understand the implications of metrology at different levels of national development on a country's capacity with respect to adopting and applying standardized measurements in areas where its infrastructure and resources differ significantly from the other nations. Additionally, Senegal's diverse economy, reliance on agriculture and fisheries, and its role within regional organizations like Economic Community of West African States (ECOWAS) make it an ideal example. Studying Senegal can reveal insights into how NQI systems function in similar contexts, helping to identify both challenges and opportunities for development that can be applied to other OIC Members.

4.2.1. Background

Senegal has been among the dynamic economies in West Africa with steady and strong economic growth for the past years. A strong economic growth is driven by many important sectors such as agriculture, services and construction. Agriculture remains the backbone of Senegal's economy. Crops like peanuts, cotton, and rice are still crucial for both domestic consumption and export markets. The performance of the sector directly determines the country's economic stability and growth, and remains very important to Senegal's economic structure. On the other side, the Senegalese government has done much to improve economic performance by making selected investments in infrastructure projects.

The developments improve connectivity and efficiency while creating an enabling environment for business and economic activity. It has further diversified the economic base with the expansion of the tourism sector, which attracts many international visitors and generates more money. These efforts contribute to building a more resilient and diversified economy.

4.2.2. General Outlook of Quality Infrastructure and Metrology

Senegal holds the 115th position out of 185 countries in the Global QI Index, indicating major amendments are needed to meet international benchmarks in QI. Conversely, Senegal seems to perform relatively better in the standardization category, whereas in the metrology category, the picture is somewhat weaker.

GQII 2023: Global Ranking and Subrankings				
Country	GQII Rank 2023	Rank Metrology 2023	Rank Standardization 2023	Rank Accreditation 2023
Germany	1	2	2	2
China	2	3	1	6
United States	3	1	7	1
Nigeria	82	118	56	95
Ghana	100	91	75	130
Cote d'Ivoire	103	146	76	104
Senegal	115	133	107	113
Mali	126	148	117	129
Mauritania	157	148	149	153
Sierra Leona	160	148	154	152

Source: Global Quality Infrastructure Index

GQII Global Ranking and Subrankings (comparion in years)				
Country	Global QI Index Rank 2023	Rank Metrology 2023	Rank Standardization 2023	Rank Accreditation 2023
GQII 2023	115	133	107	113
GQII 2021	118	128	100	124
GQII 2020	112	127	104	110

Source: Global Quality Infrastructure Index

According to QI for Sustainable Development Index that summarizes the state of development of QI readiness to support the SDGs, the index value for Senegal is 16.6, placing the nation in the 112nd position for the countries assessed. On the other hand, it ranks 27th in the similar (lower middle) income countries in the index, which is made of several indicators, for a total of 36.

Country	World	GDP: M	Income: Lower Middle	SSA	African Union
SENEGAL	112	46	27	20	24

Source: Quality Infrastructure for Sustainable Development Index

Number of Standards	555
Electronics	67
Construction and Civil Engineering	95
Food Processing	163
Environment	58
Administration and Trade	4
Solar Energy	20
Other	148

Source: USA Department of Commerce

The Senegalese Association for Standardization (ASN) has published a catalog listing of 555 Senegalese standards in the following areas: electronics (67), construction and civil engineering (95), food processing (163), environment (58), administration and trade (4) and solar energy (20).

4.2.3. Main Actors and Initiatives

The ASN: The ASN plays a crucial role in QI ecosystem in Senegal. ASN is responsible for coordinating the implementation of Senegal's NQP , which was established under Decree No. 2017-46.

The Senegalese Institute for Standardization (ISN), established by Decree No. 78-228 on March 14, 1978, was replaced by the ASN following an institutional reform on July 19, 2002. The ASN operates as a public utility organization, governed by Laws No. 68-08 of March 26, 1968, and No. 79-02 of January 4, 1979.

The State of Senegal understands that to increase competitiveness in producing goods and services for both local and international markets, it is essential to improve quality control. This includes integrating standardization, quality management, metrology, and certification of standards. To achieve this, the creation of a more flexible and effective organization that works closely between the government and the private sector was seen as a necessary step. This is the main motive for the establishment of the ASN and transfer the responsibilities of Senegalese Institute for Standardization (ISN).

The ASN , under the administrative supervision of the Ministry of Commerce, is tasked with implementing Senegal's governmental policies related to standardization and QI. Additionally, ASN is responsible for representing Senegal in standards development organizations at the sub-regional, regional, and international levels.

ASN does not only identify needs, develop and publish national standards across all sectors but also carries out various other duties such as informing public, raising awareness and training key stakeholders especially private sector companies, academics, civil society associations and institutional players on the procedures and challenges of evaluating compliance with standards. As an example to the raising awareness activities, since February 1996, the ASN has been organizing the National Quality Prize, known as the "National Quality Oscar," which has become a significant event on the President of the Republic's agenda. This award aims to recognize and reward companies that distinguish themselves in quality management practices.

ASN represents Senegal in regional and international standardization bodies to actively participate in developing standards and promoting their adoption nationally. ASN adopted three key strategic orientations with the purpose of accomplishing its mission.

- 1- Development of human capital: Focused on building the skills and expertise necessary for effective standardization.
- 2- Implementation of a National Standardization Strategy: Aimed at creating a effective framework for standardization activities across the country.
- 3- Strengthening QI: Through developing partnerships to enhance ASN's capacity.

ASN has a modern decision-making bodies in which the private sector will be mainly represented (60%) alongside the State (40%) with which enables it to focus on the issues in a more realistic and solution oriented way. The supreme governing body of the ASN is the General Assembly, composed of all member companies. ASN is managed by a Board of Directors consisting of 9 members:

3 members elected by secret ballot during the Extraordinary General Assembly.

3 founding members appointed by the founding members.

3 members appointed by the State, representing the Ministries of Industry, Finance, and Trade.

Companies can join ASN by paying membership fees and an annual contribution.⁴²

⁴² www.asn.sn Senegalese Association for Standardization (Association Sénégalaise de Normalisation) website.

Ministry of Commerce: The Ministry of Commerce in Senegal is key to shaping and maintaining the country's QI and metrology systems. Its duties include developing and enforcing policies that ensure the accuracy and reliability of measurements, which are critical for fair trade, consumer protection, and legal compliance. Ministry coordinates with various institutions to develop and promote national standards, establishing certifications systems and promoting quality management practices.

Ministry of Commerce plays especially a unique role in legal metrology by regulating and overseeing the accuracy and reliability of measuring instruments. Legal metrology is practice and process of applying statutory and regulatory structure and enforcement to metrology. In other words, legal metrology refers to the system of laws and regulations that govern measuring instruments used in areas such as trade and law enforcement, where precise measurements are legally required. In this respect, Ministry of Commerce ensures that all measurements are precise and compliant with national and international standards.

Commissioners for Economic Investigations (Commissaires aux Enquêtes Économiques): Commissioners for Economic Investigations in Senegal are responsible for maintaining quality and accurate measurements in various sectors that fall under their scope of duties. They ensure that products and services meet national and international standards, as well as measuring tools are reliable. By conducting investigations and audits, they aim to secure that businesses comply with the standards and requirements.

4.2.4. Policies and Regulations

The Economic Commission of West African States adopted the ECOWAS Quality Policy (ECOQUAL) and its implementation framework on February 28, 2013 through Supplementary Act A/SA.1/02/13. The policy targets the improvement of good and services quality in the region to meet regional and international standards. The ECOQUAL implementation framework contains detailed guidelines for the development and improvement in QI system. The main elements of QI related to standardization, accreditation, metrology, and conformity assessment are thoroughly addressed in the regulation. In giving a comprehensive approach to member countries, ECOQUAL therefore aims at facilitating regional trade, enhancing consumer protection, and promoting economic development through a harmonized and coherent quality assurance system.

Furthermore, this policy was reinforced by Regulation C/REG.19/12/13, adopted by the Statutory Ministers on December 17, 2013, which established the ECOWAS Regional QI Scheme. Regulation C/REG.19/12/13 (Regional QI Scheme) provided the specific structure to achieve the goals determined by ECOQUAL that sets the primary policy framework for improving the quality of goods and services within the ECOWAS region.

As a result of ECOWAS regulations, Senegal adopted its NQP through decree 461-2017 on March 21, 2017, aligning with the ECOWAS Quality Policy and incorporating an action plan. Implementation of this action plan aims to establish the NQI and make it fully operational. This will ensure its recognition at both regional and international levels.⁴³

During the interviews, it was stated that a new legislation was being carried out in the field of QI and metrology in order to improve the policy framework and implementation.

The construction standards violations in Senegal, particularly the building collapse in Dakar, is a clear example of the serious impact and enforcement measures implemented against regional law violations. In Dakar, the capital of Senegal, there have been several incidents of building collapses due to violations of construction standards. In 2016, one of the most noticeable incidents involved the collapse of a multi-storey building that left a number of people dead. Investigations in the aftermath revealed that building did not comply with local construction regulations, among other irregularities, the use of substandard building materials, and not adhering to the approved architectural plans. The incident brought the government to strengthen building code enforcement and its penalties for violations.⁴⁴

4.2.5. Conclusion of Review

Establishing a national metrology institute in Senegal that meets international standards may bring significant benefits to the country. First, it will improve the accuracy and reliability of measurements within different sectors. Further, with a national metrology institute, Senegal can align its measurement standards with international norms. Therefore, it may obtain wider and more effective international recognition. It would also support scientific research and innovation by providing an efficient measurement facility necessary for technological advances. Last but not least, such an institute would provide training and development opportunities, enhancing the skills of local professionals and creating job opportunities.

Addressing personnel shortages and enhancing training for staff in institutions related to QI and metrology would be a great importance of improving the whole quality system. An increase in staff numbers, as well as improved competencies, would mean that measurement standards and quality control processes are better applied and as a result of this achieving better measurement results is obtained in various sectors such as trade, health, environment, and industry. Precise measurements and calibrations by well-trained personnel would ensure that products and services meet national and international standards.

⁴³ Senegalese Association for Standardization (Association Sénégalaise de Normalisation). Retrieved from: www.asn.sn

⁴⁴ Reuters. Retrieved from: <https://www.reuters.com/world/africa/least-five-killed-senegal-building-collapse-2023-08-24/>

This will also lead to enhanced consumer confidence and credibility in the country's products and service. Moreover, a well-equipped and knowledgeable workforce could undertake scientific research and innovation of new technologies for overall economic growth.

Overcoming budget limitations of QI and metrology in Senegal would remarkably enhance the effectiveness and efficiency of the quality environment. Institutes, if better financed, could take on more complex and higher-quality projects that adhere to international standards to produce higher levels of accuracy and reliability in measurements. Moreover, with sufficient financial resources, advanced equipment and technology can be procured for the precise and reliable calibration and measurement services. It could also support full-fledged programs on personnel training and development to ensure that the staff acquires relevant skills and knowledge to perform at the best level. All this investment in human resources may lead to greater efficiency and innovativeness among the institutions. Finally yet importantly, a larger share of the budget might allow important research and development activities that would drive technological advances and contribute to scientific progress.

Even though Senegal has made substantial gains in legal metrology, development and implementation of a new law that responds to current needs and resolves existing shortcomings would bring substantial benefits. A more inclusive legal framework for metrological practices that are aligned with the most recent international standards can strengthen measurements activities. Such a modernized legal framework would offer the ways to integrate new technologies and methodologies into metrological practice and foster innovation and efficiency. Finally, it would further provide essential support for the professional development of metrology personnel.

4.3. United Arab Emirates (UAE)

National Quality Infrastructure (NQI) is a vital foundation for the UAE's economic growth and global competitiveness, ensuring that products, services, and processes meet high standards of quality and safety. The UAE has invested heavily in building a robust NQI, supported by institutions and policies that drive innovation, protect consumers, and facilitate international trade. This framework is essential for enhancing the country's standing in global markets and for supporting key sectors such as construction, energy, healthcare, and manufacturing.

The UAE's NQI is centered around key components: standardization, technical regulations, conformity assessment, metrology, and accreditation. These elements work together to create a cohesive system that not only ensures quality but also promotes economic growth by fostering trust in UAE products and services both locally and internationally.

The Abu Dhabi Quality and Conformity Council (QCC) plays a crucial role in this infrastructure, setting quality standards and ensuring compliance through rigorous monitoring and assessment.

One of the key achievements of the UAE's NQI is its extensive development of standards. With over 23,000 standards and specifications developed across multiple sectors, the UAE has aligned many of these with international standards, facilitating smoother trade and market access. This alignment with global norms is critical in ensuring that UAE products are competitive in international markets, reducing technical barriers to trade.

Another important aspect of the UAE's NQI is the implementation of technical regulations, which ensure that products and services meet specific safety and quality requirements. From 2018 to 2023, the UAE introduced more than 500 technical regulations in areas such as construction, food safety, and energy. These regulations are designed to protect consumers and the environment while supporting the country's ambitious development goals.

In terms of conformity assessment, the UAE has issued over 15,000 certificates of conformity for consumer products in the last five years. These certificates ensure that products meet the established safety and quality standards before they are made available in the market, further safeguarding consumers and enhancing the country's reputation for high-quality products.

The UAE also has a strong system of conformity assessment bodies (CABs), with over 300 registered and accredited bodies that provide testing, inspection, and certification services across various sectors. These bodies ensure that products, processes, and systems comply with the required standards and regulations. By maintaining a well-organized and reliable CAB network, the UAE guarantees that products meet both national and international standards, supporting its role as a regional leader in trade and innovation.

Metrology, the science of measurement, is another critical component of the UAE's NQI. Accurate measurements are essential in sectors like manufacturing, healthcare, and environmental protection. The UAE has developed advanced metrology systems to ensure precision and consistency in measurements, which is crucial for quality control and innovation. Through partnerships with international metrology institutions, the UAE ensures that its measurement standards are globally recognized, further enhancing the credibility of its NQI system.

The Abu Dhabi Quality and Conformity Council (QCC) is a key institution within the UAE's NQI, leading efforts to enhance product quality, safety, and compliance. The QCC sets and monitors quality standards, ensuring that products in the market meet Abu Dhabi's stringent requirements.

Through initiatives like the Product Conformity Scheme and the awarding of quality marks, the QCC has significantly raised the standards of products entering the UAE market. These initiatives help build consumer trust and reinforce the UAE's commitment to high quality.

The UAE's success in building a strong NQI offers valuable lessons for other countries, particularly within the MENA region. The establishment of bodies like the QCC, the development of comprehensive standards, and the focus on metrology are best practices that can be replicated elsewhere. Additionally, the UAE's emphasis on aligning its regulations with international standards ensures that its products remain competitive in the global market, an approach that other nations can adopt to facilitate trade and enhance economic growth.

In summary, the UAE's National Quality Infrastructure is a cornerstone of its economic development and global competitiveness. By prioritizing standardization, technical regulations, conformity assessment, and metrology, the UAE has created a robust system that supports innovation, protects consumers, and enhances the country's role in international trade. The UAE's NQI serves as a model for other nations looking to strengthen their own quality infrastructure, particularly in the Middle East and North Africa region, where similar approaches could drive economic growth and improve market access.

4.3.1. Background

The UAE, a federation of seven emirates with Abu Dhabi as the capital, has transformed itself from a primarily oil-dependent economy to a highly diversified and dynamic economic powerhouse in the region.⁴⁵ Over the past few decades, the UAE has successfully reduced its reliance on oil and gas by investing in other key sectors, such as tourism, aviation, real estate, and financial services.⁴⁶ The UAE government's strategic vision, supported by significant infrastructure investments and a business-friendly environment, has positioned the country as a leading global trade and tourism hub.⁴⁷ The UAE's economy is now driven by sectors like real estate, tourism, and financial services, with Dubai and Abu Dhabi leading the way.⁴⁸ The government has focused on building world-class infrastructure, such as airports, seaports, and transportation networks, which have facilitated business activities and attracted FDI.⁴⁹

⁴⁵ UAE Government Portal (2021). *United Arab Emirates – The UAE's Federation and Capital*. Published by the UAE Government, detailing the transformation of the UAE's economy from oil dependence to diversification. Retrieved from [UAE Government Portal](#).

⁴⁶ Gulf News (2020). *UAE Diversifies Economy: From Oil Dependency to a Broad-Based Future*. Gulf News article discussing how the UAE has shifted from reliance on oil to other sectors. Published in Dubai, UAE.

⁴⁷ The National (2022). *The UAE's Strategic Vision for Growth*. The National, based in Abu Dhabi, provides an in-depth look at the infrastructure investments that have made the UAE a global hub for trade and tourism.

⁴⁸ Bloomberg (2021). *Dubai and Abu Dhabi Driving UAE's Economic Growth*. Bloomberg article analyzing the economic role of the two key emirates in pushing forward the UAE's diverse economy. Published in New York, USA.

⁴⁹ World Economic Forum (2022). *How the UAE Built a World-Class Infrastructure*. A report by the World Economic Forum, explaining the role of infrastructure development in the UAE's economic success. Published in Geneva, Switzerland.

Additionally, the UAE has become a center for innovation and technology, hosting numerous international events and initiatives aimed at fostering a knowledge-based economy.⁵⁰

4.3.2. General Outlook of Quality Infrastructure and Metrology

The UAE ranks highly in global quality infrastructure indices, reflecting its strong performance in metrology, standardization, and accreditation. According to the GQII (GQII) 2023, the UAE holds the 26th position globally, with particularly strong performances in metrology and standardization.

GQII 2023: Global Ranking and Subrankings				
Country/City	GQII Rank 2023	Rank Metrology 2023	Rank Standardization 2023	Rank Accreditation 2023
Germany	1	2	2	2
China	2	3	1	6
USA	3	1	7	1
UAE (Dubai)	26	21	18	30

Source: Global Quality Infrastructure Index

The UAE’s metrology system is underpinned by advanced infrastructure and the strategic role of the Emirates Metrology Institute (EMI). EMI ensures that all measurements used in trade, healthcare, and industry comply with international standards, which is essential for maintaining the country’s competitiveness in global markets. However, while the UAE performs well in metrology and standardization, there is still room for improvement, particularly in the area of accreditation, where the country aims to achieve greater global recognition.

GQII Global Ranking and Subrankings (Comparison in Years)				
Country/City	Global QI Index Rank 2023	Rank Metrology 2023	Rank Standardization 2023	Rank Accreditation 2023
GQII 2023	26	21	18	30
GQII 2021	30	25	20	35
GQII 2020	35	28	22	38

Source: Global Quality Infrastructure Index

⁵⁰ TechRadar Middle East (2021). *UAE as a Hub for Innovation and Technology*. A report covering the UAE’s initiatives in innovation and its goal to establish a knowledge-based economy. Published in Dubai, UAE.

According to the QI for Sustainable Development Index, which summarizes the state of development of QI readiness to support the SDGs, the UAE has an index value of 78.2, placing it in the 30th position globally. The country also ranks 5th among high-income nations, underscoring its advanced status in quality infrastructure.

World	GDP: H	Income: High	Middle East	GCC
UAE	30	5	2	1

Source: Quality Infrastructure for Sustainable Development Index

4.3.3. Main Actors and Initiatives

Emirates Authority for Standardization and Metrology (ESMA): The ESMA plays a pivotal role in Dubai's QI ecosystem. ESMA is responsible for developing and implementing the UAE's national standards and regulations, ensuring that they align with international benchmarks. Established by Federal Law No. 28 of 2001, ESMA operates under the administrative supervision of the UAE Ministry of Industry and Advanced Technology.

ESMA's key responsibilities include:

- Developing national standards for goods and services.
- Certifying products and services to ensure they meet safety, quality, and environmental standards.
- Representing the UAE in international and regional standardization organizations.
- Raising awareness and providing training on the importance of quality infrastructure.

ESMA's strategic goals include enhancing the UAE's global competitiveness, supporting sustainable development, and promoting innovation through the adoption of advanced technologies. ESMA has implemented several initiatives to strengthen Dubai's QI, including the development of the UAE Quality Mark, a certification scheme that ensures products meet the highest standards of quality and safety.

Emirates Metrology Institute (EMI): The Emirates Metrology Institute (EMI) is the national metrology institute of the UAE, responsible for maintaining and disseminating measurement standards. EMI provides calibration services to various industries, ensuring that measurements are accurate and traceable to international standards. The institute plays a crucial role in supporting Dubai's position as a global trade hub by ensuring that all measurements used in commerce are reliable and consistent.

EMI also contributes to scientific research and innovation by providing accurate measurements essential for technological advancements.

The institute collaborates with international metrology organizations to stay at the forefront of metrological practices and to ensure that the UAE's measurement standards are recognized globally.

Dubai Municipality's role in legal metrology is crucial for protecting consumers and ensuring fair trade practices. The municipality regularly inspects and verifies the accuracy of measuring instruments used in commercial transactions, such as scales and fuel pumps, to prevent fraud and ensure that consumers receive the correct amount of goods.

4.3.4. Policies and Regulations

The quality infrastructure in the UAE operates under a detailed regulatory framework that adheres to international standards, ensuring precise and trustworthy measurements across various industries. Central to this framework is the ESMA, which has established a NQP. This policy reflects the government's dedication to upholding high standards in metrology, standardization, and accreditation, supported by a robust set of laws and regulations that cover all facets of quality infrastructure.

Regionally, the UAE leverages its active participation in the Gulf Cooperation Council (GCC), particularly through the Gulf Standardization Organization (GSO). The GSO is instrumental in harmonizing standards and metrology practices among member countries, which facilitates trade and ensures that products consistently meet quality standards throughout the region. This cooperation strengthens the UAE's capacity to maintain and enhance its quality infrastructure, driving economic growth and boosting consumer confidence.

In Dubai, legal metrology is a vital and well-established component of the city's quality infrastructure. Legal metrology encompasses the laws, regulations, and enforcement practices that govern the use of measurement instruments in critical areas, such as trade, health, safety, and environmental protection. The primary goal of legal metrology is to guarantee that measurements are accurate and reliable, thus protecting consumers, ensuring fair trade, and upholding public safety.

Dubai Municipality plays a pivotal role in enforcing legal metrology regulations, particularly through the verification and calibration of measuring instruments used in commercial transactions, such as weighing scales, fuel pumps, and taximeters. The municipality regularly inspects and audits these instruments to ensure they meet the required legal standards. Instruments that fail to comply are either recalibrated or removed from service until they conform to the standards, thereby protecting consumers and businesses from measurement-related fraud or errors.

The Emirates Metrology Institute (EMI) supports Dubai's legal metrology efforts by offering essential calibration services for measuring instruments.

EMI ensures that these instruments are traceable to international measurement standards, a crucial factor in maintaining measurement consistency and reliability. This traceability is key to ensuring that Dubai's measurements are recognized and accepted in international trade. Additionally, EMI collaborates with Dubai Municipality to provide technical expertise and support in developing and enforcing legal metrology regulations, keeping the city's legal metrology framework aligned with the latest international standards and best practices.

Federal Law No. 28 of 2001: This law governs the establishment and operation of ESMA, outlining its responsibilities in setting and enforcing standards, including those related to metrology.

Cabinet Decision No. 31 of 2006: Mandates the verification and calibration of all measuring instruments used in trade and other legal purposes, requiring regular checks to ensure their accuracy and reliability.

Ministerial Decree No. 85 of 2013: Provides specific regulations for the calibration and verification of measuring instruments, including penalties for non-compliance.

Dubai Municipality's Local Order No. 11 of 2003: Specifies the legal requirements for verifying weighing and measuring instruments used in commercial transactions within Dubai, outlining businesses' responsibilities to ensure compliance.

These laws and regulations are the cornerstone of the UAE's legal metrology framework, ensuring that all measurements within the country are accurate, reliable, and consistent with international standards.

In the UAE, strict administrative and penal sanctions are enforced for non-compliance with National Quality Infrastructure (NQI) regulations. These regulations are essential for maintaining the country's standards in safety, quality, and consumer protection. The sanctions, which vary depending on the severity of the violation, are imposed through several laws, ensuring that businesses and organizations adhere to the highest quality practices. Various authorized institutions oversee the implementation and enforcement of these regulations, and they play a crucial role in safeguarding public interests.

The key laws governing NQI compliance in the UAE include the following:

Federal Law No. 28 of 2001 (Conformity Assessment Law): This law establishes the legal framework for conformity assessment and product certification. It mandates that products and services meet specific national standards for safety, quality, and environmental protection. Violations of this law can result in administrative fines, penalties, or even legal action. The law ensures that non-compliant products are not allowed in the market and that strict standards are maintained across industries.

Federal Law No. 2 of 2021 (Consumer Protection Law): A critical law focused on safeguarding consumers' rights, this legislation holds businesses accountable for providing goods and services that meet regulatory requirements. Non-compliance, particularly in terms of product safety and quality, can lead to significant penalties, including administrative sanctions, fines, and in some cases, criminal prosecution. The law emphasizes the importance of upholding consumer trust and maintaining the integrity of the UAE's markets.

Federal Law No. 24 of 1999 (Environmental Protection and Development Law): This law enforces compliance with environmental standards, ensuring that businesses operate sustainably and responsibly. Non-compliance, especially when it endangers public health or causes environmental damage, can result in severe sanctions, including fines and criminal penalties. This law is particularly relevant for industries whose activities affect natural resources or the environment.

Federal Law No. 6 of 2013 (Metrology Law): Ensuring accuracy in measurements, this law regulates the UAE's metrology system and ensures that all industries using measurements in trade, manufacturing, and other sectors adhere to international standards. Non-compliance with metrology standards can lead to significant fines, legal action, and the potential revocation of business licenses. Accurate metrology is crucial for maintaining quality in sectors such as healthcare, manufacturing, and trade.

The gold-related scandal in the UAE, where several refineries were found non-compliant with national standards, is a significant example of the stringent sanctions imposed for quality infrastructure violations in the UAE. The UAE, or more precisely Dubai, has been a hub for gold trade, and the DGCX - Dubai Gold & Commodities Exchange was supposed to follow the most strict gold standards. A few gold refineries in Dubai failed to adhere to the UAE standard for refined gold in 2020, raising concerns regarding the purity and origin of the gold. This led to tighter regulations and oversight within the gold trade, with the government imposing stricter penalties on non-compliant refineries, including fines and the potential revocation of licenses.⁵¹

4.3.5. Conclusion of Review

The UAE has made remarkable progress in establishing a robust NQI that aligns with international standards, reinforcing its status as a global trade hub and a leader in innovation. A key element of this advancement is the creation of a world-class national metrology institute that adheres to these standards.

⁵¹ The Sentry. Retrieved from: <https://thesentry.org/2020/11/10/4869/conflict-gold-flooding-dubai-linked-money-laundering-mass-violence/>

Such an institute plays a crucial role in enhancing the accuracy and reliability of measurements across various sectors, including trade, healthcare, and industry, ensuring that the precise measurements necessary for advanced research and development are available. This initiative supports the UAE's broader ambition of becoming a global leader in innovation.

However, despite the strength of the UAE's legal metrology framework, there are several challenges that present opportunities for further improvement. The integration of new technologies, such as digital and automated measuring instruments, necessitates updated regulations and calibration techniques. Additionally, addressing personnel shortages and enhancing training for those involved in quality infrastructure and metrology are essential steps in strengthening the overall quality system. It is vital that personnel are well-trained and stay current with the latest technologies and standards to maintain high levels of legal metrology throughout the UAE.

Another critical factor in sustaining and enhancing the UAE's quality environment is overcoming budget limitations. With adequate financial resources, the UAE could invest in advanced equipment and technologies to deliver precise and reliable calibration and measurement services. Moreover, better funding would support comprehensive training and development programs, ensuring that the workforce remains skilled and knowledgeable.

Raising public awareness about the importance of legal metrology is also crucial for boosting consumer confidence and encouraging business compliance. Public education campaigns can help inform consumers about their rights and the significance of accurate measurements in everyday transactions.

Modernizing and updating the UAE's legal metrology framework would further strengthen measurement activities and ensure they align with the latest international standards. A more inclusive and forward-looking legal framework would facilitate the integration of new technologies and methodologies into metrological practices, fostering innovation and efficiency. These advancements would also provide vital support for the professional development of metrology personnel, further solidifying the UAE's reputation as a global leader in quality infrastructure.

The UAE's strategic emphasis on high-quality standards across industries such as technology, construction, finance, and energy, along with its commitment to aligning with international benchmarks like ISO and IEC, illustrates how an effective NQI system can drive economic diversification and enhance global competitiveness. The UAE's ambitious development plans, particularly its Vision 2030, underscore the focus on innovation, sustainability, and excellence across various sectors. The success of the UAE in implementing high standards across these industries offers valuable insights for other nations looking to strengthen their own NQI systems.

It serves as a blueprint for other OIC countries aiming to enhance their global trade presence and ensure quality standards across industries, demonstrating how a nation can rapidly modernize and integrate into the global economy by fostering a strong quality infrastructure.

4.4. Italy

A close examination of Italy in terms of metrology and QI is considered beneficial since its strong institutions, inclusive legal framework and effective practices present valuable examples. Italy's strong focus on QI helps ensure product safety, sustainability, and compliance with European and international standards. By studying Italy's NQI, you can gain insights into how QI supports innovation and high-value industries while also addressing challenges like aligning national standards with EU directives. This makes Italy a valuable case study for understanding the role of NQI in supporting both traditional and modern industries in a competitive global landscape. Italy's membership in the European Union also adds an additional layer of complexity and integration within the broader European regulatory framework, making it a compelling case for studying how NQI systems function within multinational contexts. By examining Italy's NQI, you can explore how a strong QI supports innovation, sustains high-quality production, and addresses both the challenges and opportunities of aligning with regional and international standards.

4.4.1. Background

Italy has one of the largest economies in the European Union, with a strong industrial base that produces manufacturing, fashion, and automotive. Much of this is driven by northern Lombardy and Veneto, which play host to most of the large companies in the country. It has also emerged as one of the top international exporters of high-end goods like machinery, transportation equipment, chemicals, and processed food products—mainly responsible for the significant imprint left on world economic activity.

Aside from its industrial power, the services sector, dominated by tourism, banking, and retail, contributes a great deal toward the running of the economy. Tourism is another important factor in driving the country's economy, with millions of tourists visiting annually. Despite some hardships, such as high public debt and high unemployment, the Italian economy has been very resilient thanks to an emphasis on innovation and quality.

4.4.2. General Outlook of Quality Infrastructure and Metrology

The roots of Italian metrology go back to ancient Rome, where measurements such as the Roman mile (mille passus) established standards throughout the The European Metrology Programme for Innovation and Research (EMPIR).

This foundation evolved over the centuries and was significantly influenced by the commercial demands, scientific advances and technological innovations of the Renaissance, a period marked by profound scientific research and discovery. Italian metrology has its roots in the ancient Roman system of weights and measures, which laid the foundation for subsequent developments during the Renaissance and the Scientific Revolution. The works of Galileo Galilei and Evangelista Torricelli, for instance, were pivotal in advancing measurement techniques and instruments. Galileo's experiments with pendulums and Torricelli's invention of the barometer exemplify the innovative spirit of Italian science in this era.

The Age of Exploration and subsequent colonization facilitated the exchange of scientific knowledge across the Atlantic. Italian metrological concepts and instruments were among the many cultural and intellectual imports to the New World. The Italian diaspora, including scientists, engineers, and artisans, played a crucial role in this transatlantic knowledge transfer. Italy has made significant contributions in the field of metrology in history, covering a variety of sectors.

For example, Filippo Brunelleschi, renowned for his work on the Florence Cathedral dome, made significant contributions to architectural metrology. His innovative techniques for measuring and constructing large-scale structures influenced American architects and engineers in the 19th century, particularly during the construction boom of the Industrial Revolution.

Also, Giuseppe Campani, an Italian optician and instrument maker, was known for his advancements in telescopic and microscopic lenses. His precision instruments were highly valued in scientific communities across Europe and America. The importation and replication of Campani's instruments in the United States helped elevate the standards of scientific measurement.

Last but not least, Antonio Meucci, an Italian inventor, significantly impacted telecommunication metrology. His work on voice communication and the early prototypes of the telephone required precise measurements and standardization of electrical parameters. Meucci's contributions laid the groundwork for subsequent developments by Alexander Graham Bell and others in the United States.

Today, Italy has a sound and proficient QI and metrology system. Indeed, such infrastructure is recognized and reported in several international assessments. Global QI Index, where Italy ranks 6th globally with a higher number of certificates and participation in technical committee, highlighted the strength of Italy's well-established QI institutions.

Country	Sum of Total Certificates	Participation in Technical Committees	2023 GQII Ranking
Italy	138.487	709	6

Source: Global Quality Infrastructure Index

Italy's metrological infrastructure is supported by leading institutions such as INRIM. INRIM plays a critical role in the development and maintenance of national measurement standards and is actively involved in international metrology projects. This work is also supported by various other organizations and universities, backed by sound government regulations and policies. Italy is one of the major players in many innovative metrological technologies, including quantum metrology, which offers unprecedented measurement precision. These advances are crucial not only for scientific research but also for improving the global competitiveness of Italian industries.

4.4.3. Main Actors and Initiatives

National Metrology Institute of Italy (Istituto Nazionale di Ricerca Metrologica-INRIM): The INRIM in Turin is the primary organization in Italy responsible for research in metrology and the development of new measurement technologies. INRIM is also responsible for maintaining national measurement standards and harmonizing them with international standards. Time and frequency measurements play a critical role in areas such as nanotechnology and materials science metrology.⁵²

Italian National Agency for New Technologies, Energy and Sustainable Economic Development (Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile - ENEA): ENEA is another important organization active in the field of scientific research and technology development in Italy, including metrology. ENEA works on various applications of metrology, especially in the fields of energy, sustainable economic development and environmental monitoring, providing critical data and standards that help policy-making and industry regulation.⁵³

Istituto Italiano del Marchio di Qualità (Italian Institute for Quality Branding): IMQ is Italy's leading certification body and a major player in the metrology sector, particularly in the field of quality control. Although not a research organization like INRIM or ENEA, IMQ plays an important role in the application of metrological standards to consumer goods and industrial products, ensuring compliance with both national and international safety and quality standards.⁵⁴

Società Italiana di Metrologia (Italian Society of Metrology-SIM): Società Italiana di Metrologia (SIM) is a professional association rather than a government or research organization. It provides a platform for professionals in the field of metrology to exchange knowledge, advance metrological sciences and discuss innovations and challenges in the field. SIM also co-operates with educational institutions to promote metrology as a fundamental scientific discipline.⁵⁵

⁵² INRIM (2023): "Annual Report," Istituto Nazionale di Ricerca Metrologica. www.inrim.it/it/ricerca

⁵³ ENEA (2021): "Overview of Metrology Applications," Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile. www.enea.it/it/

⁵⁴ IMQ (2023): "Overview of Certification and Compliance," Istituto Italiano del Marchio di Qualità. www.imq.it

⁵⁵ Società Italiana di Metrologia (SIM) (2024): "Metrology and Professional Development," Società Italiana di Metrologia. www.societasim.it

Politecnico di Milano and Other Academic Institutions: Many Italian universities and polytechnics, notably Politecnico di Milano, play important roles in advancing metrology through research and education. These institutions conduct cutting-edge research in various aspects of metrology and contribute to the development of skilled professionals in the sector by offering specialized courses and degrees in metrology and related fields.⁵⁶ Major academic institutions and their contributions to the field of metrology might be outlined as follows:

Politecnico di Torino, Turin: Carries out extensive research in geometric and dimensional metrology, materials metrology and the development of new measurement methodologies (Politecnico di Torino, 2024).⁵⁷

University of Padua, Padua: Recognised for its pioneering research in mechanical and thermal metrology, focusing on applications ranging from industrial uses to fundamental physics (University of Padua, 2024).⁵⁸

University of Bologna, Bologna: Carries out important research in the field of electrical and thermal metrology and contributes to the development of measurement standards and technologies (University of Bologna, 2024).⁵⁹

Collectively, these organizations ensure that Italy remains at the forefront of metrological research and practice. They are involved in everything from basic research and standard setting to the application of these standards in the commercial, industrial and public sectors. Besides, there are significant initiatives and projects need to be stated briefly regarding metrology.

Quantum Metrology: It aims to develop new measurement standards based on quantum phenomena to improve the precision of measurements that are crucial for fields such as time measurement and electrical standards. The main institutions involved include INRIM and Politecnico di Torino (Quantum Metrology Project, 2021).⁶⁰

Nano-Metrology: Focuses on developing nanoscale measurement techniques essential for nanotechnology and materials science, with significant contributions from INRIM and the University of Padua (Nano-Metrology Initiative, 2021).⁶¹

⁵⁶ Politecnico di Milano (2024). www.mecc.polimi.it

⁵⁷ Politecnico di Torino (2024). www.polito.it

⁵⁸ University of Padua (2024). www.unipd.it

⁵⁹ University of Bologna (2024). www.unibo.it

⁶⁰ Quantum Metrology Project (2021): www.inrim.it/it/ricerca/progetti

⁶¹ Nano-Metrology Initiative (2021): www.inrim.it/it/ricerca/progetti

Environmental Metrology: It aims to develop measurement techniques for environmental monitoring, emphasizing air and water quality and climate-related parameters. This project involves INRIM and several Italian universities with environmental science departments (Environmental Metrology Project, 2021).⁶²

4.4.4. Policies and Regulations

Italy has a sound legal framework for metrology and QI that ensures the accuracy in measurements and the quality of a wide variety of products and services. These laws and regulations are guided by EU directives to make certain that Italy maintains high standards in line with its international commitments. Here are some key laws and regulations related to metrology and QI in Italy:

Legislative Decree No. 273/1991 is the main law which establishes the general principles of metrology in Italy. It defines the role of the INRIM as Italy's national metrology institute tasked with advancing the country's measurement standards. Besides, it sets out requirements for calibration and certification of measuring instruments used in trade and industry.

The European Metrological Directive was first published in the Italian Official Gazette in 2004 and implemented in Italy by Legislative Decree 22/2007. In May 2016, Legislative Decree 22/2007 was updated to finally incorporate the changes introduced by Directive 2014/32/EU. Legislative Decree 22/2007 basically transposes the EU Directive 2004/22/EC on measuring instruments (MID) into Italian law. It regulates the placement, accuracy, and reliability of measuring instruments before being used in commercial transactions. This law covers a vast area from gas, water and thermal meters to weighing instruments.

Legal framework related to metrology is supported by Legislative Decree No. 206/2005 that ensures products meet specific quality and safety standards, Legislative Decree No. 126/2010 that implements EU regulations on market surveillance of measuring instruments and Law No. 132/2001 that formally establishes the INRIM as Italy's national metrology institute.

Italy has imposed significant sanctions for violations of quality infrastructure and metrology regulations in various sectors. Striking example is a major scandal involving the contamination of mozzarella cheese, one of the country's most iconic products. In 2008, mozzarella produced in Campania was found to be contaminated with dioxins, a type of toxic chemical.

⁶² Environmental Metrology Project (2021): www.inrim.it/it/ricerca/progetti

Contaminations came from inappropriate waste disposal practices, thus several production facilities were shut down, products were withdrawn, and multi-millions of dollars in fines were levied. Upon this incident, the Italian government imposed further restrictions on food safety and started to monitor dairy production more closely.⁶³

4.4.5. Conclusion of Review

Metrology applications in Italy cover many sectors. In the industrial field, precision measurements are vital to ensure the quality and global competitiveness of Italian products, from automotive components to luxury fashion items. In healthcare, metrology supports the efficacy and safety of medicines and medical devices. Furthermore, environmental monitoring relies on accurate data to effectively manage and mitigate the effects of climate change.

In order to maintain and advance its position in the field of metrology, Italy emphasizes education and training in this field. Universities and technical institutes offer specific programmes designed to train the next generation of metrology experts, while continuous professional development helps existing experts keep pace with technological and methodological progress. Despite these strengths, Italy faces the challenges of integrating the latest technologies and ensuring adequate funding for research and development. The rapidly changing nature of global markets and technological advances requires constant adaptation and investment.

Italy's active participation in international metrology through standard-setting organizations and joint research projects not only strengthens its scientific capabilities but also ensures that Italian industries remain competitive in the international stage.

Looking to the future, metrology in Italy is poised for further breakthrough innovations, especially in areas such as nano-metrology and digital metrology. These developments are expected to redefine precision in a variety of fields. Italy's ongoing commitment to this critical scientific field emphasizes its role as a key player in advancing global metrological standards.

4.5. USA

The United States has the largest economy in the world thanks to its advanced industrial base, strong consumer spending and sound financial markets. The US, as a global economic power, leads innovations and sets trends in a variety of sectors such as technology, finance and healthcare, influencing economic policies and practices worldwide. A thorough analysis of the United States is regarded as valuable due to its significant role in advancing metrological capabilities.

⁶³ BBC. Retrieved from: <http://news.bbc.co.uk/2/hi/europe/7318391.stm>

The NQI system of the USA as an example because the U.S. has one of the most advanced and well-established NQI frameworks globally. The country's strong emphasis on standardization, accreditation, metrology, and certification processes across a wide range of industries—spanning from manufacturing to technology to healthcare—illustrates the critical role that a robust NQI plays in fostering innovation, ensuring consumer safety, and supporting global trade. The U.S. NQI system is also a benchmark for how PPPs can effectively enhance quality standards, contribute to regulatory frameworks, and facilitate international trade agreements. Studying the U.S. system offers insights into best practices for maintaining a balance between regulation and innovation, and how an advanced NQI can drive economic leadership on a global scale. Analyzing the U.S. system provides valuable lessons on the integration of cutting-edge technology, the importance of regulatory compliance, and the role of QI in maintaining a competitive global edge, which can be applicable to other countries looking to enhance their own NQI systems.

4.5.1. Background

The US leads in global trade and finance; therefore, its economic policy and performance have profound effects on international markets. Despite facing challenges such as economic inequality and economic downturns, the U.S. economy is strong and resilient and continues to attract heavy investment from outside its borders. Its innovation-driven growth, alongside a vibrant labor market, keeps it very much at the forefront of global economic leadership.

4.5.2. General Outlook of Quality Infrastructure and Metrology

The metrology and QI in the United States is the cornerstone of its industrial, scientific, and economic base. Centered around the National Institute of Standards and Technology (NIST), the United States has built an complicated system that allows for accurate and reliable measurements in all fields. NIST, recognized as one of the world's leading metrology institutes, plays a significant role, from standards of measurements to advanced research in metrology. In 2024, NIST's budget for Scientific and Technical Research Services is set at approximately \$995 million, reflecting a \$104.5 million increase.

The United States has a very advanced QI and metrology system today, as shown in the Global QI Index 2023. In this index, the U.S. ranks first globally in the field of metrology, a testament to its advanced capabilities in this area. This leadership is also demonstrated by the amount of certifications and the wide range of participation in various technical committees. Besides, the US ranks 3rd in the world in general evaluation consisting of 3 elements, namely, metrology, standardization, accreditation, which shows that it has a very thorough and functioning infrastructure.

Country	Sum of Total Certificates	Participation in Technical Committees	2023 GQII Ranking
USA	40.796	565	3

Source: Global Quality Infrastructure Index

This effectiveness of metrology and QI in the United States can be attributed to the institutional framework that is very well organized and moreover to the regulations that are designed and implemented with great efficiency. The cooperation between agencies, such as NIST and various regulatory agencies allows for the enforcement of standards among industries.

Public private partnerships (PPPs) are essential to support the U.S.'s major role in metrology and its applications. The government, through institutions such as the NIST, needs to partner with the private sector in areas such as improving technological innovation, quality, and economic growth. These partnerships bring industry leaders and NIST together to develop initial measurement techniques and work on their improvement.

One of the most critical elements of these partnerships is combining the expertise and resources of public and private sector. NIST often collaborates with private firms in the development of new measurement standards and test methods that overcome a specific industry problem.

In this respect, such PPPs ensure that metrology standards are in tune with technological development. These partnerships enable the fast commercialization of new products with the correct measurement infrastructure in place to support innovation. For example, NIST's work with industry consortia, like QED-C exemplifies how these collaborations can propel advances by the most innovative technology while ensuring their roots are solidly founded in sound measurement science.

A very good example of this type of collaboration is the Advanced Manufacturing Partnership (AMP) initiative, a collaboration between the NIST and industry. This is a program that combines NIST and industry, academia to work on measuring problems in advanced manufacturing processes, additive manufacturing (3D printing) specifically. Another important public-private collaboration in metrology is the Quantum Economic Development Consortium (QED-C) co-led by NIST. This will allow the integration of the development of quantum technologies with the unique challenges of measurement in quantum systems. Through QED-C, NIST partners with industry giants in private sector businesses, like IBM and Google, to come up with measurement standards that are of importance in the commercialization of quantum technologies. Another great example of the results of effective public-private collaboration is the CPS Program sponsored by NIST.

The CPS Program works directly with industries involved in smart technologies—things like autonomous vehicles or smart grids to develop measurement tools and standards.

Working with companies like General Electric and Siemens enables NIST to overcome a key barrier between cutting-edge development and practical, standardized implementation.

US Standards in Numbers (Estimate)	
Total Inventory of Standards	100.000
Standards Coming From Private Sector	50.000
Distinct Statutes, Technical Regulations or Purchasing Specifications	44.000
Standards Organizations	600

Source: International Organization for Standardization

The U.S. federal government is the single creator and user of standards and regulations, with over 44,000 unique laws, technical regulations, or purchasing guidelines. While individual agencies decide which standards to adopt, there is a growing trend of using voluntary standards from both national and international organizations. When adding the estimated 50,000 standards from the private sector, the total number of standards in the U.S. approaches nearly 100,000.

4.5.3. Main Actors and Initiatives

NIST : is the primary federal agency responsible for developing and maintaining measurement standards in the United States. Established in 1901, NIST provides the scientific and technical foundation for the nation’s measurement system, ensuring accuracy and consistency across various industries.

NIST develops and distributes SRMs, which are used to calibrate instruments and validate measurement methods. Furthermore, it conducts cutting-edge research to advance measurement science and develop new measurement technologies. The NIST also offers calibration services to ensure the accuracy of measurement instruments used in various sectors.

NIST is at the forefront of developing quantum-based measurement standards, which promise unprecedented levels of accuracy and precision. These initiatives include:

Quantum Voltage Standards: Development of Josephson junction arrays to provide highly accurate voltage references based on quantum principles.

Quantum Electrical Metrology: Research on quantum Hall effect devices to establish resistance standards with extremely low uncertainty.

Optical Clocks: Development of next-generation atomic clocks using optical transitions, which are more stable and accurate than traditional microwave-based atomic clocks.

The NIST-on-a-Chip program aims to miniaturize and disseminate NIST's world-class measurement capabilities, making them accessible to a broader range of industries and applications. Key projects under this initiative include:

Microelectromechanical Systems (MEMS) Sensors: Development of MEMS-based sensors that provide precise measurements in a compact form factor.

Portable Standards: Creation of portable and deployable measurement standards that can be used in the field for on-site calibrations and measurements.

NIST conducts extensive research to support the advancement of manufacturing technologies, ensuring high precision and quality in production processes. Significant projects in this area include:

Smart Manufacturing Systems: Development of standards and tools for integrating advanced sensors, data analytics, and control systems into manufacturing processes.

Additive Manufacturing: Research on measurement techniques and standards for additive manufacturing (3D printing), focusing on material properties, dimensional accuracy, and quality control.

NIST is heavily involved in developing standards and guidelines to enhance cybersecurity and protect privacy. Key initiatives include:

Framework for Improving Critical Infrastructure Cybersecurity: A voluntary framework that provides guidelines for managing cybersecurity risks in critical infrastructure sectors.

Privacy Framework: Development of a framework to help organizations manage privacy risks and protect individuals' data.

American National Standards Institute (ANSI): The ANSI is a private, non-profit organization that oversees the development of voluntary consensus standards in the United States.⁶⁴ ANSI also represents the U.S. in international standardization efforts, ensuring that American interests are considered in global standards development.

ANSI accredits standards-developing organizations and ensures their compliance with international best practices. In addition, ANSI coordinates the development of national standards and facilitates their adoption by various industries. Finally, it represents the U.S. in the ISO and the IEC.

⁶⁴ American National Standards Institute (ANSI). (n.d.). Retrieved from <https://www.ansi.org>

ANSI's Standards Collaborative focuses on coordinating and streamlining the development of standards across various sectors.⁶⁵ Key projects include:

Energy Efficiency Standards: Collaboration with industry stakeholders to develop standards that improve energy efficiency in appliances, buildings, and industrial processes.

Healthcare Standards: Development of standards for healthcare information technology, medical devices, and patient safety.

Sustainable Agriculture: Initiatives to create standards that promote sustainable agricultural practices and enhance food safety.

ANSI BY THE NUMBERS	
American National Standards Members	14.070
ANSI-Accredited Standards Developers	1.432
ISO-US Technical Advisory Groups	234
US Administered ISO Secretariats	245
US Held ISO Chairs	93
	96

Source: American National Standards Institute

American Association for Laboratory Accreditation (A2LA): The A2LA (A2LA) is a non-profit, non-governmental organization that provides accreditation services to testing and calibration laboratories, inspection bodies, proficiency testing providers, and reference material producers.⁶⁶

A2LA mainly accredits laboratories to international standards, such as ISO/IEC 17025, ensuring their competence and reliability. It also has other responsibilities, such as accrediting inspection bodies to standards such as ISO/IEC 17020 and offering proficiency-testing programs to help laboratories demonstrate their competence in performing specific tests or calibrations.

A2LA develops and manages proficiency testing programs that help laboratories demonstrate their competence in performing specific tests or calibrations.⁶⁷ Key projects include:

Interlaboratory Comparisons: Organizing interlaboratory comparisons to assess the performance of laboratories and ensure the accuracy of their measurements.

Reference Material Production: Development and certification of reference materials used for calibrating instruments and validating measurement methods.

⁶⁵ American National Standards Institute (ANSI). (n.d.). Retrieved from <https://www.ansi.org>

⁶⁶ American Association for Laboratory Accreditation (A2LA). (n.d.). Retrieved from <https://www.a2la.org>

⁶⁷ American Association for Laboratory Accreditation (A2LA). (n.d.). Retrieved from <https://www.a2la.org>

Laboratory Accreditation; A2LA's laboratory accreditation programs ensure that laboratories meet international standards for competence and reliability [52]. Key initiatives include:

ISO/IEC 17025 Accreditation: Accreditation of testing and calibration laboratories to ISO/IEC 17025 standards, ensuring their ability to produce valid and reliable results.

Inspection Body Accreditation: Accreditation of inspection bodies to ISO/IEC 17020 standards, promoting consistency and accuracy in inspections.

National Conference on Weights and Measures (NCWM): The NCWM is a professional organization that develops and promotes uniform standards for weights and measures in the United States.⁶⁸ NCWM works in partnership with NIST to ensure the accuracy and consistency of measurements used in commerce. NCWM develops and maintains Handbook 44, which sets the standards for weighing and measuring devices used in commercial transactions. Besides, it develops model regulations for weights and measures, which are adopted by state and local governments. Last but not least, NCWM provides training and educational resources for weights and measures officials to ensure the consistent application of standards. NCWM; is responsible for developing and maintaining Handbook 44, which sets the standards for weighing and measuring devices used in commercial transactions.⁶⁹ Key projects include:

Device Standardization: Updating standards for various types of weighing and measuring devices to ensure their accuracy and reliability.

Emerging Technologies: Developing standards for new and emerging technologies, such as electric vehicle charging stations and advanced metering infrastructure. NCWM provides training and certification programs for weights and measures officials to ensure the consistent application of standards [53]. Key initiatives include:

Professional Development: Offering courses and workshops on the latest standards and measurement techniques.

Certification Programs: Developing certification programs for weights and measures professionals to validate their expertise and competence.

⁶⁸ National Conference on Weights and Measures (NCWM). (n.d.). Retrieved from <https://www.ncwm.net>

⁶⁹ National Conference on Weights and Measures (NCWM). (n.d.). Retrieved from <https://www.ncwm.net>

International Bureau of Weights and Measures (BIPM): Although not a U.S.-based organization, the BIPM plays a crucial role in the global metrological infrastructure, of which the U.S. is a key participant.⁷⁰ BIPM ensures international uniformity of measurements and maintains the International System of Units (SI).

4.5.4. Policies and Regulations

The United States' metrology and QI are governed by a comprehensive set of laws and regulations. Well-established legal framework is centered around the work of the NIST.

One of the keystone laws in U. S. metrology is the Weights and Measures Act of 1966. This act provides the legal foundation for establishing measurement standards for all goods and services sold by weight, measure, or count. This allows state and local governments to uphold laws that require the precision of weighing and measuring instruments (i. e. scales, gas pumps, and consumer packaging) are accurate. It's a necessary act to keep fairness in business deals and to protect consumers from unethical actions. Another significant legislation is NIST Act (1988), established the NIST as a federal agency within the U.S. Department of Commerce. It describes the function of NIST which is to create and uphold the national standards of measurement. The work NIST does under this act affects many industries by providing the base scientific knowledge that is essential for innovation, manufacturing, and commerce. The NIST Act also enables the agency to work with industry and other government bodies to assure that American measurement standards are in line with international standards.

The National Technology Transfer and Advancement Act (NTTAA) of 1995 mandates that federal agencies utilize voluntary consensus standards in their regulatory and purchasing practices when possible. The NTAA has a vital part in the US QI because it promotes the partnership between government and private industry in the creation of standards.

NIST advises the agencies on how to implement the NTTAA and also helps in the creation of these standards. The violation of quality infrastructure and metrology regulations in the United States comes with a great deal of legal and financial costs. One prominent example was the Volkswagen emissions scandal, in which it was discovered that the company used software specifically to cheat the regulators into considering that its vehicles were meeting emissions standards. This led to massive fines totaling over \$30 billion, including criminal charges and regulatory penalties.⁷¹

⁷⁰ International Bureau of Weights and Measures (BIPM). (n.d.). Retrieved from <https://www.bipm.org>

⁷¹ United States Environmental Protection Agency. Retrieved from <https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement>

Another example is with the automotive sector in which General Motors (GM) is taken to task in court and fined for not standing up to the quality standards as related to safety features in the car manufactured by the company. The delay in recalling cars with defective ignition switches, which led to shutting off of the engine and disabled airbags resulting in fatal accidents.

The National Highway Traffic Safety Administration imposed a fine of \$35 million on GM due to its delayed report of the defect. Further, GM paid \$900 million in criminal fines after entering a settlement with the Department of Justice.⁷²

4.5.5. Conclusion of Review

The United States plays a vital global role in the field of metrology. As a major player in developing and upholding measurement standards, the U.S. sets benchmarks that are widely adopted and respected in the world. In addition, the U.S. influences global standards through its active participation in international metrology organizations like the BIPM and the ISO.

In the future, the influence of US leadership in metrology may increase as technologies and industries develop. Because of the strong correlation between emerging technologies and equivalent new measurements, the U.S. is expected to maintain its impact on the metrology world. For example, the standards for quantum technologies are going to be essential for the future of computers, communication, and encryption. In a similar way, the requirement for accurate and trustworthy measures will only increase as society becomes more and more dependent on digital and automated technologies. The United States has the knowledge and strong metrological infrastructure to lead in these areas. On the other hand, the fast rate of technological development may also pose a challenge for the United States' metrology system. Emerging technologies (quantum computing, nanotechnology, biotechnology) require new measurement standards that are not yet fully developed. Therefore, the US will need to change to accommodate these changes, but it can be slow and costly to develop and apply new standards.

Moreover, the United States has a complicated regulatory environment, with metrology standards and QI affected by a mixture of federal, state, and local law. That results in inconsistent and unproductive application and interpretation of standards throughout the United States. For the firms that operate in multiple states this could mean greater compliance expenses and trouble maintaining consistent quality. Playing a pivotal role in global metrology can be resource consuming because of consistent research, technological advancements, and international cooperation.

⁷² Department of Justice. Retrieved from: <https://www.justice.gov/opa/pr/justice-department-reaches-900-million-agreement-general-motors>

Nevertheless, budgetary pressures and shifting priorities of governments may influence the investment made in metrological infrastructure. This may result in obsolete equipment, slower rates of adopting new technologies, and less ability to innovate. Despite the many benefits, there are also challenges and criticisms associated with the influence of US metrology and NQI practices. One major issue is regulatory burden, in which excessively high US standards put smaller companies and developing countries at a distinct disadvantage because they are not in a position to afford the expenditures that go along with such standards.

Therefore, their ability to access the international markets and their room for innovation is eliminated. Besides, dominance of the US companies' ad standards might actually lead to greater market concentration, less competition, and lack of diversity.⁷³

Finally, there are cultural and situational differences, which may not be directly applicable or suitable without major adaptation and modification. American metrology and NQI practices strongly influence the international world standards and regulations, mainly in the technological and pharmaceutical areas.⁷⁴ Even though this influence has significant benefits, it also presents some challenges.⁷⁵

Balancing the advantages of harmonized standards with the need for inclusivity and adaptability is crucial for fostering a global environment that supports innovation, competition, and equitable growth.⁷⁶

Comparative Analysis of Quality Infrastructure (QI) Systems Across: Kazakhstan, Senegal, UAE, Italy, and USA				
Country	Global QI Rank 2023	Metrology Rank 2023	Standardization Rank 2023	Accreditation Rank 2023
Kazakhstan	48	46	66	28
Senegal	115	133	107	113
UAE	26	21	18	30
Italy	6	6	6	6
USA	3	1	7	1

⁷³ Federal Communications Commission (FCC). (n.d.). Retrieved from <https://www.fcc.gov>

⁷⁴ National Institute of Standards and Technology (NIST). (n.d.). Retrieved from <https://www.nist.gov>

⁷⁵ U.S. Food and Drug Administration (FDA). (n.d.). Retrieved from <https://www.fda.gov>

⁷⁶ American National Standards Institute (ANSI). (n.d.). Retrieved from <https://www.ansi.org>

Comparative Analysis of Quality Infrastructure (QI) Systems Across: Kazakhstan, Senegal, UAE, Italy, and USA			
Country	Main Metrology Institution	Key Policy Focus	Challenges
Kazakhstan	Kaz Standard	Modernization, Intl. Integration	Infrastructure, Standardization Development
Senegal	ASN	Capacity Building, ECOWAS Policy	Resource Allocation, Legal Framework Updates
UAE	Emirates Metrology Institute (EMI)	Alignment with Global Standards, Innovation	Accreditation Improvements, Personnel Shortages
Italy	INRIM	Adherence to EU Standards, Technological Advancement	Technology Integration, Funding for R&D
USA	NIST	Advanced Research, Public-Private Partnerships	Complex Regulatory Environment, Technology Evolution

5. GUIDING PRINCIPLES AND RECOMMENDED PRACTICES

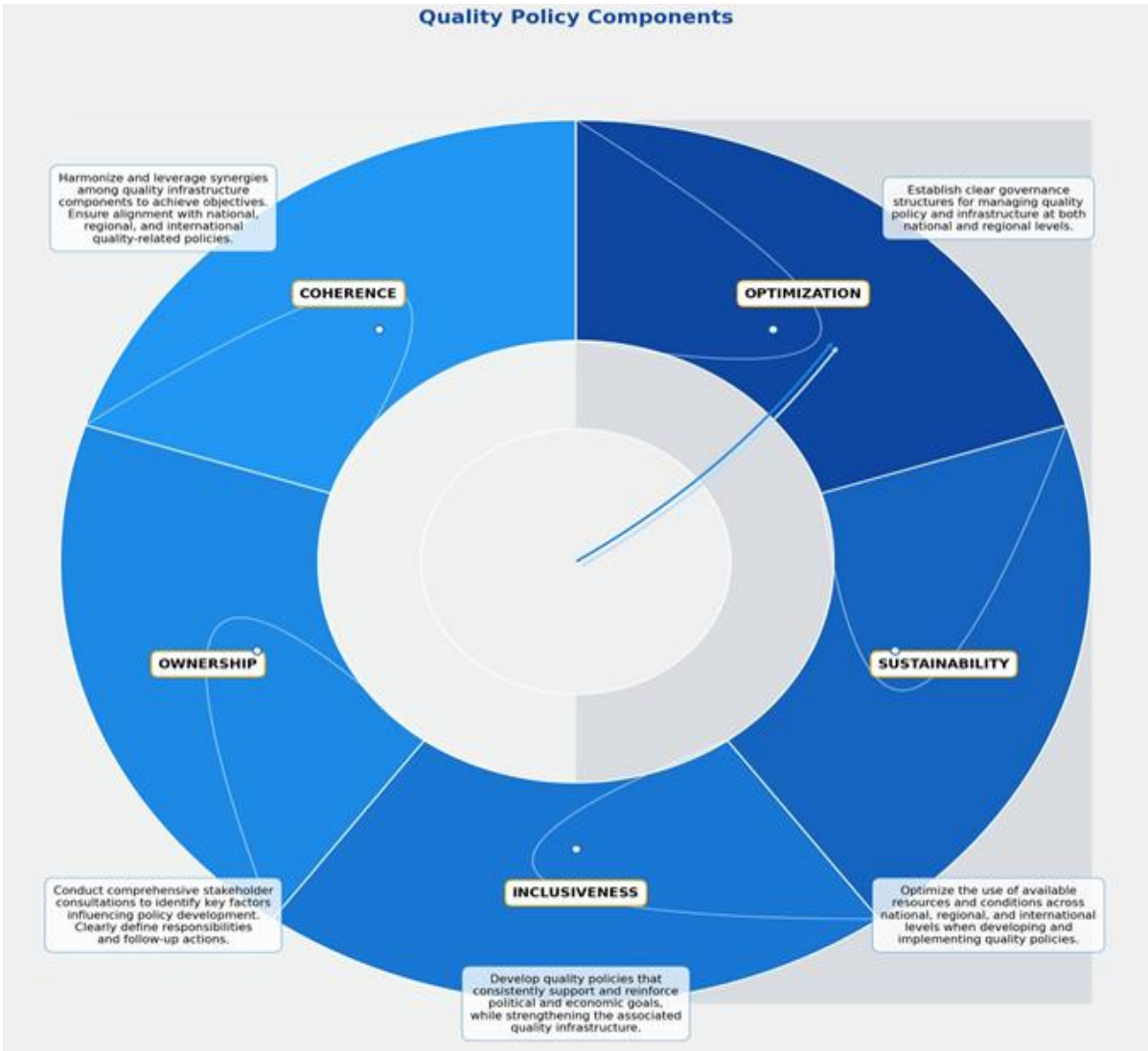
The enhancement of QI for trade in OIC countries is of paramount importance for the improvement of competitiveness, the assurance of product safety, and the facilitation of access to international markets. However, the achievement of this goal is contingent upon the resolution of a number of challenges, which can be broadly categorised into institutional, technical, financial, and operational issues.

In a considerable number of OIC countries, the QI is characterized by a high degree of fragmentation, with multiple agencies and institutions responsible for the oversight of standards, accreditation, metrology, and conformity assessment. This fragmentation results in inconsistencies, duplication of efforts, and a lack of coordination. The existence of differing standards and regulations across OIC countries creates barriers to trade. The lack of harmonized standards makes it challenging for businesses to export to other OIC markets without undergoing multiple conformity assessments. Some OIC countries have regulatory frameworks that are not aligned with international best practices. This includes outdated or inadequate laws, regulations, and enforcement mechanisms, which undermine the effectiveness of QI.

There is frequently a dearth of technical expertise in domains such as metrology, standardization, accreditation, and conformity assessment. This constrains the capacity of OIC countries to develop and implement high-quality standards and testing procedures. A considerable number of OIC countries are deficient in modern and well-equipped laboratories for testing, calibration, and certification. This constrains their capacity to provide reliable conformity assessment services, which are critical for international trade. The adoption of advanced technologies, such as digital platforms for conformity assessment or blockchain for traceability, is slow in many OIC countries. This impedes the efficiency and effectiveness of QI services.

The development and maintenance of a robust QI necessitates a considerable investment of resources. However, a considerable number of OIC countries are constrained by budgetary limitations, which may result in the prioritization of other areas over QI, leading to underfunded institutions and programs. The costs associated with compliance with standards, certification, and testing are often high for SMEs. These costs can be prohibitive, limiting their ability to participate in both regional and international trade. The economic disparities between OIC countries lead to varying levels of investment in QI. Wealthier countries may have more advanced QI systems, while less developed countries struggle to keep up, creating imbalances within the region.

Figure 15. Five Guiding Principles for Quality Policy Development



Source: Quality Infrastructure: Good Governance in Quality Policy Design⁷⁷

Complex and inefficient bureaucratic processes have the potential to impede the implementation of QI initiatives. This encompasses delays in standards development, protracted certification procedures, and onerous regulatory approvals. Inadequate coordination between government agencies, private sector organisations, and international partners frequently results in the replication of efforts, conflicting priorities, and the ineffective implementation of QI initiatives.

⁷⁷ https://hub.unido.org/sites/default/files/publications/QUALITY_POLICY_final.pdf

In some OIC countries, there is inconsistent enforcement of standards and regulations, which creates an uneven playing field where some businesses may circumvent quality requirements, thereby undermining the overall effectiveness of QI.

A comprehensive quality policy is also needed as a top policy document to develop a QI taking into account all these challenges faced by OIC countries. The role of the quality policy (QP) is to provide a transparent and non-discriminatory framework to define the roles and responsibilities of the QI accurately, link it to other national policies, and technically support it. As policy ambiguities and inconsistencies are identified and addressed, organizational inconsistencies and misalignments become much more apparent, leading to better and more sustainable resources. Understanding what is actually required and what is already in place, operational and internationally recognized in relation to national and/or regional QI enables the identification of institutional capacity and capability overlaps and gaps. Activities to address these identified gaps through strengthening QI capability and/or capacity should actively consider and appropriately utilize QI components. Such an assessment will also help to find solutions that further strengthen regional and global integration and promote greater alignment with established QI best practices and principles. Following a review of previous national and regional interventions in QI development around the world, five key principles were identified as underlying elements for effective QP development. These are Ownership, Inclusiveness, Coherence, Optimisation and Sustainability.

Ownership underlines the need to address the way in which the QP and the associated QI infrastructure are overseen, directed, and implemented at the national and regional levels. In order to establish and maintain a more cost-effective QP/QI system, governments need to be the main driving force in initiating, implementing, and sustaining the processes. In addition, the support of the private sector and civil society as end beneficiaries of the initiatives taken by governments will be an important contribution. Furthermore, the QP has the potential to influence the work of many ministries, requiring the cooperation of many relevant departments across ministries. Therefore, a lead ministry, relevant ministries, QI organizations, the private sector, and civil society should be represented at the decision-making level in the ownership process, and an agreed structure should be developed. Finally, high-level endorsement and support are needed to ensure high-level support and continuity.

Inclusiveness emphasizes the need for issues and/or areas that may affect the development of the QP to be addressed using appropriate consultation processes involving all stakeholders necessary to promote the necessary and mandatory ownership of the intended outcomes and subsequent actions. The implementation of the QP requires active support in a variety of roles to capitalize on its impact in promoting quality throughout society.

While the government normally leads and often provides resources for the establishment of a set of policies and related legislation for the QI system, the private sector should also be encouraged to actively participate in governance structures, including technical committees of QI bodies, and to present its perspectives in negotiations on standards, metrology and accreditation at regional and international level. The concept of inclusiveness should include the right of suppliers to access conformity assessment systems developed on the basis of QI on a non-discriminatory basis, in accordance with WTO Agreements. Where permitted, this right should be extended to ensure the rights of service providers to participate in such systems. It is important that an appropriate, inclusive, and ongoing consultation process is established, appropriately resourced, and maintained. Such a process should seek to promote broader and deeper understanding through consensus building. The results of such consultations can also provide important inputs to the subsequent monitoring and review process.

Coherence emphasizes that the various QP and QI elements should seek and achieve appropriate synergies, agree on common goals, and promote mutual support in achieving agreed outcomes. It also includes appropriate integration and alignment with other national, regional and international policies aimed at addressing quality-related needs. National, inter-regional and intra-regional efforts to build and sustain QI should also include the integration of QI with and support for trade and investment policies, business competitiveness sustainability and environmental impacts, including national business climate reform, affordability and national and regional climate change adaptation and mitigation needs. It is therefore vital that during the development of a QP, the issue of more coherent policymaking is adequately addressed. Organizational separation of mandatory and voluntary activities is also required, as are activities related to institutional involvement and subsequent compliance.

Optimization implies the most effective and efficient use of the applicable and available national, regional and international situation(s) and/or resource(s) when developing a QP. It is crucial that QP is used to create and maintain an appropriate link between the services offered by QI institutions and the targeted markets and consumers. Given the many and varied challenges faced in successfully and sustainably accessing foreign markets, and recognizing that the technical complexities specific to each sector or product can be significantly different, the QP should promote the need for and establish mechanisms to identify an agreed set of priority sectors, products and services. Periodic review of these is also important. An agreed set of priority sectors, products and services helps to identify and optimize the level of national and regional QI that is appropriate at a given time for each of the selected areas, taking into account current levels of functioning and acceptance in the market and further QI capacity and capability development.

Sustainability refers to the need to ensure that the QP and related QI supporting appropriate political, social and economic objectives are sustained at the required level over the long term with the necessary technical capability and capacity. While governments are obliged to fund QI institutions, they also often provide funding for other QI-related activities through specific agreements between the government and designated institutions. These core activities are considered being in the public interest as they are intended to benefit all citizens of the country, not a specific, well-segmented group. It is important that the QP ensures that the government clearly articulates its commitment to provide long-term funding for QI activities that cannot be funded by others, providing the necessary assurance and associated stability that such organizations need to establish and maintain national, regional and international confidence in these activities under its mandate. In the case of QI institutions that are incentivized to generate income from some of the services they provide, the QP should clarify that the government can specifically designate funding for certain activities that are in the broader public interest⁷⁸.

In order to establish, develop and ensure international recognition of the national QI among the member countries of the OIC, especially for the countries that do not have calibration measurement capacity (CMC) and have low visibility in the world metrology system, it would be beneficial to address the following topics in detail.

The development of QI for trade in OIC countries is of great importance in terms of increasing competitiveness, ensuring product safety and facilitating access to international markets. By implementing some of the policies and practical strategies suggested here, the OIC member countries can significantly improve regional and international harmonisation of QI and make their products more competitive in global markets. This harmonisation not only facilitates intra-regional trade but also strengthens the global competitiveness of OIC countries, promoting economic growth and integration into international markets. In other words, strong QI not only facilitates trade but also promotes economic development, consumer protection, and sustainable growth. In order to improve the QI and to establish a sustainable quality policy, the policy recommendations developed based on extensive analyses, field visits, principles accepted in the international literature, the challenges faced by OIC countries, and the practical applications necessary to achieve the ultimate goal can be listed as follows.

⁷⁸ https://hub.unido.org/sites/default/files/publications/QP_GUIDING_PRINCIPLES_0.pdf

5.1. Guiding Principle

Improvement of international collaboration of NQI Institutions with a view to aligning with global standards as well as benefitting best practices

Strengthening collaboration among NQI institutions in OIC member countries can harmonize standards, accreditation, and certification procedures. This will reduce technical barriers to trade within the OIC, boosting intra-OIC trade and supporting the broader goal of economic integration among members. Aligning with global standards ensures that products can move more easily across borders without additional compliance costs. Aligning their NQI systems with international standards and best practices allows their products to meet global quality and safety requirements, making them more attractive to international buyers and investors. This improves the export potential of goods from these countries, particularly in sectors like agriculture, textiles, and manufacturing. By collaborating internationally and adopting best practices in their NQI systems, OIC member countries can ensure that their products meet these requirements, facilitating access to global supply chains and foreign markets. This is especially important for industries like food, pharmaceuticals, and electronics, where certification plays a crucial role in market access. Many OIC member countries face challenges related to limited technical expertise and infrastructure in quality management systems. International collaboration among NQI institutions provides opportunities for knowledge transfer, capacity building, and technical training. By partnering with advanced economies and experienced NQI institutions, OIC member countries can enhance their domestic capabilities, improve their institutional frameworks, and foster long-term economic growth. Collaboration in the realm of NQI allows OIC countries to keep pace with technological developments and industrial innovations. By adopting international best practices, they can create an enabling environment for industries to innovate while maintaining high quality standards. When OIC member countries align their quality infrastructure with global standards, they create an attractive environment for foreign direct investment (FDI) and industrial development. Investors are more likely to invest in countries with robust, globally recognized quality management systems, as this reduces risk and ensures compliance with international norms. This can lead to increased economic growth, job creation, and industrial diversification within OIC member countries.

Survey results (Question 6) indicate that the presence or absence of a strategic roadmap for national metrology plays a critical role in the Effective Management of the National Quality Infrastructure for Trade.

Countries with a clear roadmap are better equipped to support trade through compliance with international standards, while those in the process of developing such roadmaps are on a promising trajectory toward enhanced NQI management. However, countries without a roadmap need to prioritize the development of a metrology strategy to improve their trade capabilities and overall economic growth. Investing in metrology development, guided by a strategic roadmap, is essential for OIC countries to ensure that their goods meet international standards, facilitating smoother trade and fostering economic growth.

In the survey results (Question 16), the primary challenges in implementing the roadmap for national metrology development in OIC member countries include securing adequate funding, addressing technical expertise gaps, and improving public-private partnerships. Effective management of the National Quality Infrastructure requires targeted efforts to address these challenges, enhance coordination, and leverage international support. By focusing on these areas, OIC member countries can strengthen their metrology systems and support the overall development of their National Quality Infrastructure for trade.

Recommended Practices Related to Guiding Principle 5.1	
RP 5.1.1. Essential Frameworks	The first step of forming NQI is to develop foundational institutions that are critical for effective quality management. These include national metrology institutes, accreditation bodies, and conformity assessment organizations. The creation of these institutions requires a concerted effort from both government and industry stakeholders to design and implement the necessary legislative and regulatory frameworks.
RP 5.1.2. Training Programs and Professional Development	Partnerships with international organizations, such as the ISO and the ILAC, can provide access to specialized training and certification programs. These programs should be tailored to meet the specific needs of local professionals and should include both technical skills and managerial competencies.
RP 5.1.3. Ongoing Professional Development	Continuous learning and professional development are crucial for keeping pace with advancements in technology and changes in international standards. Regular workshops, seminars, and conferences should be organized to provide ongoing education and update professionals on the latest trends and best practices in quality management.
RP 5.1.4. Leveraging International Technical Assistance	International organizations often provide technical assistance and funding to support the development of NQI. OIC member countries should seek out these opportunities to access resources, expertise, and support for their quality infrastructure initiatives. This assistance can accelerate the establishment and improvement of NQI institutions and contribute to the overall success of quality management efforts.
RP 5.1.5. Global Best Practices	International collaboration is key to ensuring that NQI institutions adopt best practices and align with global standards. Engaging with international standards organizations and networks helps OIC member countries to stay updated on global trends, integrate international standards into local practices, and improve their quality infrastructure.

5.2. Guiding Principle

Encourage to harmonizing standards and regulations in alignment with international standards like ISO, IEC, and Codex Alimentarius, and work towards enhancing MRAs) to mutually recognize conformity assessments, certifications, and accreditations.

Harmonizing standards and regulations across OIC member countries in alignment with international benchmarks such as ISO, IEC, and Codex Alimentarius is essential for fostering regional integration, enhancing trade, and ensuring product safety and quality. This alignment facilitates smoother trade by reducing technical barriers and ensuring that products and services meet globally recognized standards. For many OIC member countries, where varying national standards can create inconsistencies and obstacles in trade, harmonization offers a pathway to greater market access both within the OIC region and internationally.

In the survey (Question 12), the responses indicate varying levels of involvement in bilateral, regional, and international metrology cooperation among OIC member countries. Active and very active participation is associated with better alignment with international standards and improved management of the NQI, which supports trade and quality assurance. In contrast, inactive or very inactive participation suggests gaps that can hinder the effectiveness of the NQI. Addressing these gaps and enhancing international cooperation can significantly benefit the management of quality infrastructure and support trade objectives in OIC member countries.

Moreover, establishing MRAs among OIC countries is critical for building trust and cooperation in recognizing each other's conformity assessments, certifications, and accreditations. MRAs help to eliminate redundant testing and certification processes, thereby reducing costs and time for businesses. This mutual recognition is particularly important for SMEs, which often lack the resources to navigate multiple national certification requirements. By streamlining these processes, OIC countries can create a more efficient and competitive economic environment, stimulate intra-OIC trade, and enhance their global trade participation.

This policy recommendation is also vital for enhancing consumer protection, as harmonized standards ensure that products meet consistent safety and quality criteria across borders. Aligning with international standards further ensures that OIC countries' products are competitive on a global scale, fostering innovation and encouraging investment.

In the long term, this harmonization and mutual recognition will contribute to the economic growth and development of OIC member countries by creating a unified and reliable quality infrastructure that supports trade, protects consumers, and promotes industrial growth.

Recommended Practices Related to Guiding Principle 5.2	
RP 5.2.1. Practices for Regional Standards Organizations	The role of regional standards organizations (RSOs) can be strengthened by enhancing their involvement in developing and adopting harmonized standards, ensuring alignment with international standards across member countries.
RP 5.2.2. Joint Standards Committees	These committees should include representatives from member countries to collaboratively develop and review standards, aiming to establish unified standards that address regional needs while meeting international requirements.
RP 5.2.3. Utilize Benchmarking	Benchmarking is recommended to evaluate and compare the effectiveness of national standards with international ones. It helps identify gaps and areas for improvement, ensuring national standards remain competitive and aligned with global practices.
RP 5.2.4. Identify and Address Discrepancies	Identifying discrepancies between national standards and international benchmarks is essential. Once identified, these discrepancies should be addressed through targeted revisions to achieve greater harmonization and compliance with international norms.
RP 5.2.5. MRA Coordination Committee	This committee should oversee the development, negotiation, and implementation of MRAs. It is recommended that representatives from each member country form the committee to ensure effective coordination and communication throughout the MRA process.
RP 5.2.6. Develop Regional MRA Frameworks	Developing regional MRA frameworks is recommended to provide a structured approach to mutual recognition principles, procedures, and standards among member countries. These frameworks should align with international best practices to facilitate the recognition of conformity assessments, certifications, and accreditations.
RP 5.2.7 Negotiate MRAs	The committee may negotiate MRAs for mutual recognition of conformity assessments, certifications, and accreditations, aiming to reduce trade barriers and enhance regulatory cooperation.
RP 5.2.8. Mandate and Roadmap	Defining the mandate and roadmap for MRAs is essential to set clear objectives, deadlines, and responsibilities. The roadmap should outline a structured approach for achieving mutual recognition and the necessary steps for successful implementation.
RP 5.2.9. Clear Objectives and Scope	To ensure a unified approach to MRA implementation, it's crucial to clearly define the objectives and scope of each MRA. This ensures all parties share a common understanding of the agreement's purpose. Additionally, it is necessary to specify the types of conformity assessments, certifications, and accreditations that will be recognized.
RP 5.2.10. Implement Equivalency Agreements	Equivalency Agreements are crucial to the MRA process, allowing recognition of standards or procedures that, while not identical, meet the same essential requirements. These agreements promote mutual recognition by showing that the standards and processes yield equivalent outcomes.
	A dispute resolution framework should address conflicts arising during MRA implementation, providing fair and efficient mechanisms to resolve disputes transparently.
	All relevant parties should be kept informed of the dispute resolution process, ensuring it is conducted openly and impartially. Additionally, transparency should be maintained throughout the entire MRA process.

5.3. Guiding Principle

Strengthen NQI institutions by investing in capacity building to enhance their technical and operational capabilities while fostering PPPs to leverage private sector expertise and resources.

Strengthening NQI institutions is crucial for ensuring that they can effectively support the quality, safety, and competitiveness of products and services in OIC member countries. Investing in capacity building is essential to enhance the technical and operational capabilities of these institutions, enabling them to develop, implement, and enforce standards, metrology, accreditation, and conformity assessment procedures that meet international benchmarks. By improving the expertise and efficiency of NQI institutions, countries can ensure that their industries are better equipped to produce goods that comply with global standards, thus facilitating access to international markets and boosting economic growth.

Fostering PPPs is another vital strategy in this context. The private sector often possesses specialized knowledge, cutting-edge technology, and practical experience that can significantly enhance the effectiveness of NQI institutions. By leveraging private sector expertise and resources through PPPs, governments can accelerate the development and implementation of robust quality infrastructure. These partnerships can also lead to innovation in NQI services, such as the creation of more advanced testing and certification processes that keep pace with evolving industry needs. Moreover, involving the private sector in NQI initiatives encourages greater industry buy-in and ensures that the standards and procedures developed are practical, relevant, and widely adopted.

Survey results (Question 7) show that the role of the private sector in the development and enforcement of metrology standards is a critical factor in the Effective Management of the NQI for Trade. Countries with high private sector involvement are better positioned to ensure that their metrology systems meet international standards, fostering trade and economic growth. Conversely, countries with limited private sector engagement face challenges in maintaining effective NQI systems, which can hinder their trade competitiveness. Strengthening PPPs and incentivizing greater private sector participation are key strategies for improving NQI management across OIC member countries. Strengthening NQI institutions through capacity building and PPPs will not only improve the quality and reliability of products and services, but also increase consumer confidence and protect public health and safety. In the long term, these measures will contribute to the overall competitiveness of OIC member countries, making their economies more resilient and better integrated into the global trading system.

Survey results (Question 8) have also mentioned that the level of collaboration between the business sector and public institutions in metrology-related activities is a critical factor in the Effective Management of the NQI for Trade in OIC member countries. Countries with high or very high levels of collaboration are more likely to have effective NQI systems that support trade, while those with moderate collaboration need to build on existing foundations to enhance their effectiveness. Countries with low collaboration face significant challenges in managing their NQI systems and may need to implement reforms to improve coordination and support their trade sectors. Strengthening PPPs and fostering better collaboration across sectors is essential for improving the effectiveness of NQI systems and enhancing trade competitiveness in OIC member countries.

Recommended Practices Related to Guiding Principle 5.3	
RP 5.3.1. <i>Formulate NQP</i>	A National Quality Policy (NQP) should be developed to guide capacity building within the NQI, defining the roles of standards bodies, metrology institutes, accreditation bodies, and conformity assessment organizations while providing a development framework.
RP 5.3.2. <i>Technical Skills Development</i>	Advancing technical competencies within NQI institutions is essential, including training in metrology, standards development, conformity assessment, and accreditation. Continuous professional development programs should be implemented to keep staff updated on the latest advancements and best practices.
RP 5.3.3. <i>Upgrade Laboratories and Technical Facilities</i>	National metrology institutes and conformity assessment organizations need to upgrade their laboratories and facilities. This requires investment in modern equipment, technology, and infrastructure to improve their capacity for accurate and reliable testing, calibration, and certification services.
RP 5.3.4. <i>Specialized Courses and Certifications</i>	Specialized courses and certifications should be developed and offered to NQI personnel. These programs should cover advanced topics in quality management, metrology, standards development, and accreditation, enhancing expertise and competency within the workforce.
RP 5.3.5. <i>Business Outreach Programs</i>	Initiate business outreach programs to engage the private sector in NQI development. These programs should build relationships with industry leaders, raise awareness of quality standards, and encourage participation through workshops, forums, and regular consultations for ongoing collaboration.
RP 5.3.6. <i>Sectoral Agreements</i>	Formulate sectoral agreements between public NQI institutions and private sector bodies for specific industries. These agreements should define common goals, roles, and responsibilities in developing and maintaining QI, addressing sector-specific challenges, and promoting compliance with quality standards.
RP 5.3.7 <i>Regulatory Dialogue</i>	Promote ongoing regulatory dialogue between government and private sector representatives to harmonize regulations, streamline compliance, and incorporate private sector input in NQI policies. Open communication will bridge gaps between public standards and private sector needs, resulting in more practical and effective QI solutions.

5.4. Guiding Principle

Modernizing metrology infrastructure by upgrading laboratories to meet international standards and gain global recognition and actively engaging in international forums on standards, metrology, accreditation, and conformity assessment to advance knowledge and practices in these areas.

Modernizing metrology infrastructure, strengthening national accreditation bodies, and actively engaging in international forums are critical actions for OIC member countries to ensure the accuracy, reliability, and global acceptance of their measurement standards and quality systems. Upgrading metrology laboratories is essential for providing accurate and reliable measurements that are the foundation of quality control in manufacturing, trade, and public safety. Modernized laboratories equipped with state-of-the-art technology can ensure that national measurements align with international standards, which are crucial for product quality, compliance with regulatory requirements, and facilitating international trade. For OIC member countries, global recognition of their accreditation bodies is a key step toward integrating into the international trade system and enhancing economic growth.

Active participation in international forums on standards, metrology, accreditation, and conformity assessment is also vital. Engagement in these forums allows countries to stay updated on the latest developments and best practices in these fields, influencing international standards and policies while also gaining insights that can be applied domestically. This participation fosters knowledge exchange, capacity building, and collaboration, ensuring that OIC member countries are not only adopting global standards but are also contributing to their evolution. Collectively, these actions will enhance the overall quality infrastructure, enabling OIC countries to produce higher-quality goods and services, protect consumer safety, and participate more fully in the global economy.

Recommended Practices Related to Guiding Principle 5.4	
RP 5.4.1. Online Standardization Databases	Create online databases with up-to-date measurement standards, guidelines, and technical specifications for easy access by metrology professionals, industry stakeholders, and regulators.
RP 5.4.2. Digital Conformity Assessment Tools	Adopt digital conformity assessment tools to automate data collection, analysis, and reporting, improving efficiency and reducing errors. These tools also enable remote assessments, making the process more accessible and flexible.
RP 5.4.3. Digital Accreditation Platforms	Develop digital accreditation platforms to manage and monitor accreditation processes online, enabling real-time tracking of applications, assessments, and renewals. These platforms enhance transparency, reduce administrative burdens, and centralize accreditation documents and information.
RP 5.4.4. Digital Transformation	Enhance digital transformation in metrology by integrating technologies like cloud computing, big data analytics, and AI into laboratories and processes. This will improve measurement accuracy, data management, and decision-making, ensuring metrology infrastructure meets modern industry needs.
RP 5.4.5. IoT and Smart Devices	Integrate IoT and smart devices into metrology infrastructure for real-time monitoring and data collection. These devices enhance measurement accuracy and reliability while enabling remote monitoring and control to increase efficiency and flexibility in metrology processes.
RP 5.4.6. Automated Measurement Systems	Implement automated measurement systems to minimize manual intervention and enhance measurement consistency. Automation boosts accuracy and repeatability, providing more reliable results, especially in large-scale calibration and testing operations, making them crucial for modern metrology labs.
RP 5.4.7 Sector-Specific Accreditation	Develop sector-specific accreditation programs for industries like healthcare, manufacturing, and agriculture. Tailoring accreditation to each sector enhances relevance, meets industry-specific needs, and promotes specialization within accreditation bodies, leading to higher standards of assessment.
RP 5.4.8. New and Emerging Fields	Expand accreditation services into emerging areas like digital technologies, renewable energy, and biotechnology. As these industries grow, accreditation bodies must assess conformity to standards, support innovation, and ensure the relevance and sustainability of national accreditation systems.
RP 5.4.9. Participate in Technical Committees	Encourage active participation in technical committees of international organizations. This allows OIC member countries to influence global standards, ensure their needs are considered, and gain insights into the latest developments in standards, metrology, and accreditation.
RP 5.4.10. Form Strategic Alliances	Form alliances with other countries and organizations in international fora to boost influence and share knowledge. These strategic partnerships enhance collective bargaining power, facilitate the exchange of best practices, and enable joint initiatives that benefit all parties involved.
RP 5.4.11. Disseminate Knowledge	After participating in international fora, it is crucial to share the knowledge gained with relevant national stakeholders. This can be done through workshops, seminars, and publications, helping to build local capacity and ensure national institutions stay aligned with global trends and best practices.

5.5. Guiding Principle

A Metrology Centre of Excellence within the OIC will conduct international-scale metrological studies, particularly for Halal products trade, to meet the diverse needs of all member countries and enhance their global competitiveness.

The Metrology Centre of Excellence within the OIC is essential to address the growing need for precise and internationally recognized metrological standards, particularly in the context of Halal products trade. As OIC member countries increasingly engage in global markets, the demand for accurate, reliable, and harmonized measurement standards is critical to ensure the quality, safety, and authenticity of Halal products. A dedicated Metrology Centre of Excellence would provide a centralized facility for conducting international-scale metrological studies, filling the current gap in metrology infrastructure across member countries. This center would not only standardize measurements related to Halal products but also serve the broader needs of various industries, enhancing the overall quality infrastructure of the OIC region.

By providing expertise, advanced technology, and standardized methodologies, the center would enable OIC member countries to align their metrology practices with global standards, ensuring that their products meet international quality and safety requirements. This alignment is particularly important for the Halal industry, where precise measurements are crucial for verifying compliance with religious and safety standards, thus maintaining consumer trust. Moreover, the Metrology Centre of Excellence would foster collaboration among member countries, promote knowledge sharing, and facilitate research and development in metrology, driving innovation and improving measurement capabilities across the region. Ultimately, this initiative would enhance the global competitiveness of OIC countries by ensuring that their products are recognized and trusted worldwide, thereby boosting trade opportunities and economic growth.

Recommended Practices Related to Guiding Principle 5.5	
RP 5.5.1. <i>Develop a Legal Framework for Halal Metrology</i>	Develop a Halal Metrology Framework that outlines the specific requirements and standards for metrological practices related to Halal products. This framework might be designed to ensure that all measurements and testing processes comply with the principles of Halal compliance, thereby supporting the integrity of the Halal certification process in all OIC member countries.
RP 5.5.2. <i>Halal Standards and Certification</i>	Implement Halal standards and certification protocols within the Centre of Excellence. These standards might be developed in collaboration with international and regional Halal certification bodies to ensure global recognition and acceptance. The Centre should play a leading role in defining, maintaining, and updating these standards to keep pace with industry developments and consumer expectations.
RP 5.5.3. <i>Comprehensive Calibration Services</i>	Provide comprehensive calibration services to support the metrological needs of OIC member countries. The Centre of Excellence might be equipped with state-of-the-art calibration laboratories capable of providing accurate and reliable calibration services for various measurement instruments. These services are essential to maintain high-quality standards in the testing and certification of Halal products.
RP 5.5.4. <i>Performance Metrics</i>	Develop and monitor performance metrics to assess the effectiveness and efficiency of the Centre's operations. These metrics should include key indicators related to the quality of metrological services, the impact of the Centre on the halal trade and the satisfaction of member countries with the Centre's offerings. Regular assessment of these metrics will help to ensure continuous improvement and alignment with the needs of OIC member countries.
RP 5.5.5. <i>Operational Plan</i>	Formulate a detailed operational plan that outlines the Centre's objectives, governance structure, resource allocation, and timelines for achieving key milestones. The plan should include strategies for engaging with member countries, building partnerships with international metrology institutions, and expanding the Centre's capabilities to address emerging challenges in halal metrology and beyond.

5.6. Guiding Principle

Provide technical assistance, training, financial support, and awareness campaigns to help SMEs in OIC countries comply with quality standards and adopt internationally recognized certification schemes.

Supporting SMEs in complying with quality standards and adopting internationally recognized certification schemes is crucial for enhancing their competitiveness and integration into global markets. SMEs are the backbone of many economies within OIC countries, yet they often face significant challenges in meeting the stringent requirements of quality infrastructure due to limited resources, technical expertise, and awareness. By providing targeted technical assistance and training, SMEs can develop the necessary skills and knowledge to meet quality standards, ensuring their products and services are safe, reliable, and meet market expectations.

Enhancing the engagement of the private sector (Question 17) in metrology standards development and enforcement requires a multifaceted approach. Regulatory reforms and incentive programs are prioritized strategies that can significantly improve private sector involvement. Complementing these with training, partnership models, and awareness campaigns will further support the effective management of the NQI for trade in OIC member countries.

Financial support is also essential, as the costs associated with obtaining certifications and upgrading processes to comply with international standards can be prohibitive for many SMEs. Subsidies, grants, or low-interest loans can help alleviate these financial burdens, enabling more SMEs to pursue and achieve certification, which in turn opens up new market opportunities and enhances their credibility both domestically and internationally.

In addition to these direct forms of support, implementing awareness campaigns is key to educating SMEs about the importance of quality infrastructure and the benefits of adherence to standards and certifications. Many SMEs may not fully understand how compliance with quality standards can lead to increased customer trust, access to new markets, and improved operational efficiency. Awareness campaigns can also highlight success stories and best practices, motivating more SMEs to invest in quality compliance. By adopting these comprehensive support measures, OIC member countries can significantly boost the capacity of their SMEs, fostering innovation, improving product quality, and driving economic growth across the region.

Recommended Practices Related to Guiding Principle 5.6	
RP 5.6.1. SME Assistance Programs	SME assistance programmes might provide tailored support to help SMEs understand and implement quality standards. These programmes should include workshops, seminars and practical training sessions that address the specific challenges SMEs face in achieving compliance. The aim is to provide practical guidance that is directly applicable to their operations.
RP 5.6.2. Comprehensive Guidance Documents	Produce and disseminate comprehensive guidance documents that outline step-by-step procedures for meeting quality standards. These documents should be easy to understand and cover various aspects of quality compliance, including certification procedures, documentation requirements, and best practices. Providing clear, accessible information will help SMEs navigate the complexities of quality standards more effectively.
RP 5.6.3. Implement Peer Evaluations	Introduce peer evaluations as a tool for SMEs to assess each other's compliance efforts. By participating in peer evaluations, SMEs can share experiences, identify gaps in their practices and learn from each other. This collaborative approach fosters a supportive environment where SMEs can improve their quality standards through peer feedback and collective learning.
RP 5.6.4. Mentorship Programs	Mentorship programmes that link SMEs with experienced professionals or larger companies that have successfully implemented quality standards. Mentors can provide personalised advice, share insights and guide SMEs through the process of achieving compliance. This one-to-one support is invaluable in helping SMEs overcome barriers and build confidence in their ability to meet quality requirements.
RP 5.6.5. Subsidize Certification Costs	Provide financial support by subsidising certification costs for businesses, especially SMEs. Reducing the financial burden associated with certification encourages more companies to pursue internationally recognised standards, making compliance more accessible and feasible.
RP 5.6.6. Industry Partnerships	Foster industry partnerships to facilitate the certification process. Working with industry leaders, certification bodies and trade associations can provide companies with the necessary resources, expertise and networking opportunities. These partnerships can also help to create a supportive ecosystem where companies are encouraged and supported to achieve certification.
RP 5.6.7 Streamline Certification Procedures	Work to streamline certification procedures to make the process more efficient and less time consuming for businesses. By simplifying documentation requirements, reducing red tape and providing clear guidance on the steps involved, the path to certification can be significantly eased. This approach will make it easier for companies, especially SMEs, to adopt and maintain internationally recognised certification schemes.
RP 5.6.8. Marketing and Branding Strategies	Develop comprehensive marketing and branding strategies to promote the importance of QI and standards. These strategies might include various channels, such as social media, industry publications and local events to reach SMEs. Effective branding and marketing can raise awareness, generate interest, and highlight the benefits of complying with quality standards.
RP 5.6.9. Showcase Achievements	Highlight and showcase the achievements of companies that have successfully met standards and achieved certification. By showcasing case studies, success stories and notable achievements, awareness campaigns can provide tangible examples of the positive impact of quality compliance. This approach can inspire other SMEs to follow suit and demonstrate the practical benefits of certification.
RP 5.6.10. Feature Testimonials	Include testimonials from companies that have benefited from adopting quality standards and certification. Testimonials from industry peers or well-known companies can provide credible and relatable insights into the benefits of quality compliance. These endorsements can help build trust and encourage other SMEs to consider certification.

5.7. Guiding Principle

Integrate quality management principles into educational curricula at all levels, strengthen consumer protection legislation, and enhance consumer awareness of the importance of quality and safety standards.

Integrating quality management principles into educational curricula at all levels is crucial for cultivating a culture of quality from an early age, ensuring that future professionals, entrepreneurs, and consumers understand the importance of quality in all production and service delivery aspects. By embedding these principles in vocational training, higher education, and even earlier stages of learning, students will develop a deep appreciation for the value of quality management, which will translate into higher standards in their professional lives and foster a culture of continuous improvement across industries. This foundational education is essential for equipping the next generation with the skills and mind-set needed to drive innovation, efficiency, and competitiveness in the global market.

Survey results (Question 1) show that the variation in awareness levels suggests that NQI implementation may be inconsistent across different sectors or regions in OIC countries. Some sectors may effectively leverage metrological standards to enhance trade, while others fall behind, resulting in uneven trade performance. Effective NQI management in OIC countries requires harmonizing awareness and application of metrological principles across all sectors. Countries with higher levels of metrological awareness will likely experience fewer trade barriers, as their products will meet international quality and safety standards. Conversely, countries or sectors with low awareness may face difficulties in meeting these standards, resulting in lost opportunities in international trade. This disparity underscores the need for OIC countries to invest in capacity-building programs to raise awareness about the importance of metrology. The distribution of responses highlights varying levels of metrological awareness within sectors in OIC countries. While there is a base level of understanding, significant gaps exist that could hinder the effective management of NQI for trade. OIC countries should prioritize raising awareness, ensuring consistent application of metrological standards across all sectors, and addressing the specific needs of under-resourced or under-informed industries to enhance their participation in global trade.

Simultaneously, strengthening consumer protection legislation and enhancing consumer awareness are critical for ensuring that products and services meet rigorous quality and safety standards. Robust consumer protection laws provide the legal framework necessary to hold businesses accountable and safeguard public health and safety.

When consumers are well-informed about quality and safety standards, they can make better purchasing decisions and demand higher standards from businesses, creating a powerful incentive for companies to prioritize quality. Awareness campaigns can educate consumers on their rights and the importance of quality, leading to increased demand for certified products and services, which in turn drives businesses to comply with these standards. Together, these measures create a comprehensive approach to building a quality-conscious society where both producers and consumers contribute to raising standards and enhancing overall well-being.

Recommended Practices Related to Guiding Principle 5.7	
RP 5.7.1. <i>Integrate Simulations and Labs</i>	Incorporate simulations and labs into educational programs to provide hands-on experience with quality management principles. Through practical exercises and lab work, students can engage in real-life scenarios that reflect industry practices. This experiential learning approach helps to reinforce theoretical knowledge and improves students' understanding of quality management concepts.
RP 5.7.2. On-the-Job Training	Implement on-the-job training programs to bridge the gap between theoretical knowledge and practical application. Partner with companies and organizations to provide students with opportunities to gain experience in real working environments. This training allows students to apply quality management principles in practice, learn from industry professionals and gain valuable insights into the demands of quality related roles.
RP 5.7.3. Career Pathways	Develop clear career pathways that guide students from education to professional roles in quality management. These pathways should include information on required qualifications, skills development, and career progression opportunities. By outlining potential career routes and providing support for the transition from education to employment, students will be better prepared for roles that emphasize quality management and consumer awareness.
RP 5.7.4. <i>Certification Labels</i>	Introduce and widely promote certification labels that indicate compliance with established quality and safety standards. These labels should be prominently displayed on products and services to help consumers easily identify items that meet strict quality requirements. Certification labels serve as a visible assurance of quality, helping consumers to make informed purchasing decisions.
RP 5.7.5. <i>Consumer Hotlines</i>	Develop consumer hotlines to provide direct assistance and information on quality and safety standards. These hotlines should be accessible and staffed by knowledgeable personnel who can answer consumer questions, report problems, and provide guidance on how to verify the authenticity of certification labels. Consumer hotlines play a crucial role in building trust and ensuring that consumers have access to reliable information.
RP 5.7.6. <i>Consumer Rights Campaigns</i>	Disseminate consumer rights campaigns to raise awareness of the importance of quality and safety standards. These campaigns should include educational materials, workshops and outreach programmes to inform consumers about their rights and the importance of meeting quality standards. By raising consumer awareness, these campaigns help to promote a culture of quality and empower consumers to make informed choices.

5.8. Guiding Principle

Implement a periodic assessment system to evaluate the alignment of harmonized standards, MRAs, and related initiatives, and establish feedback mechanisms for businesses and stakeholders to report compliance challenges and issues with regional quality infrastructure.

Survey results (Question 9) show that the use of specific performance measurements to evaluate the effectiveness of metrology implementations is a critical factor in the Effective Management of NQI for Trade in OIC member countries. Countries with established performance indicators are more likely to have effective NQI systems that support trade by ensuring that metrology services are accurate, reliable, and aligned with international standards. However, the large number of respondents who are unsure about the existence of performance measurements indicates a need for greater awareness and capacity building within the metrology sector. Countries that lack performance measurements face significant challenges in managing their NQI systems effectively and may need to prioritize the development of evaluation mechanisms to support trade facilitation and improve their competitiveness in global markets.

Implementing a periodic assessment system to evaluate the alignment of harmonized standards, MRAs, and related initiatives, alongside establishing feedback mechanisms for businesses and stakeholders, is crucial for ensuring the ongoing effectiveness and relevance of a NQI. Regular assessments are essential to verify that harmonized standards and MRAs remain up-to-date and effective in addressing current industry needs and international requirements. This proactive approach allows for the identification and rectification of any gaps or inefficiencies in the implementation of quality standards, ensuring that they continue to meet their intended objectives and support seamless trade and compliance.

Improving performance measurements and indicators (Question 18) in metrology requires a combination of strategies. Regular audits and assessments, along with technological upgrades, are prioritized actions that can significantly enhance the effectiveness of the NQI. Standardizing indicators, incorporating stakeholder feedback, and considering international benchmarking further support a comprehensive approach to performance measurement and management in OIC member countries.

The effectiveness of enforcement and penal provisions for metrology standards is a key aspect of the Effective Management of NQI for Trade in OIC member countries. The responses (Question 10) indicate a range of effectiveness, from very effective to very ineffective, highlighting differences in how countries manage and enforce metrology standards.

Countries with strong enforcement mechanisms are better positioned to support trade by ensuring product quality and compliance. In contrast, countries with ineffective or very ineffective enforcement face significant challenges that can hinder trade and affect market competitiveness. Improving enforcement systems and addressing gaps in the regulatory framework are crucial for enhancing the effectiveness of the NQI and supporting trade objectives.

Moreover, feedback mechanisms play a vital role in this process by providing a structured way for businesses and stakeholders to communicate their experiences and challenges in adhering to standards and utilizing regional quality infrastructure. This feedback is invaluable for understanding the practical difficulties faced by users and for making informed adjustments to improve the quality of infrastructure. By systematically collecting and analyzing feedback, authorities can identify recurring issues, address specific concerns, and enhance the overall functionality and user-friendliness of the NQI.

Together, these measures not only help maintain the integrity and effectiveness of quality standards and agreements but also foster a responsive and adaptive quality management system. This approach ensures that the NQI remains dynamic and capable of supporting the evolving needs of businesses and industries, ultimately driving higher levels of compliance, improving quality assurance, and enhancing regional and global competitiveness.

Recommended Practices Related to Guiding Principle 5.8	
RP 5.8.1. Distribution of Duties	Form a structured division of labor to assign clear responsibilities for the periodic evaluation of the alignment processes. This includes defining the roles of the various stakeholders involved in monitoring and evaluating the effectiveness of harmonized standards and MRAs. A proper allocation of tasks will ensure that reviews are carried out systematically and that all relevant aspects are addressed.
RP 5.8.2. Data Management Systems	Develop and use data management systems for monitoring and evaluation to track the performance and impact of harmonized standards, MRAs, and related initiatives. These systems should be capable of collecting, analyzing, and reporting data on the effectiveness of these processes. Effective data management supports informed decision-making and helps identify areas for improvement.
RP 5.8.3. Impact Assessments	Develop processes for conducting impact assessments to evaluate the effectiveness of feedback mechanisms. This involves systematically collecting and analyzing feedback from businesses and stakeholders to understand their challenges. Impact assessments help identify key issues, measure the effectiveness of existing standards and infrastructure, and inform necessary adjustments.
RP 5.8.4. Future Projections	Incorporate future projections to anticipate and address potential challenges to compliance with harmonized standards and regional QI. By analyzing trends and forecasting future needs, feedback mechanisms can be designed to adapt to evolving requirements and address issues pre-emptively. This proactive approach ensures that feedback systems remain relevant and effective over time.

Guiding Principles 1,2,3	
Guiding Principle 1: <i>Improvement of international collaboration of National Quality Infrastructure Institutions with a view to aligning with global standards as well as benefiting best practices.</i>	1.1. Essential Frameworks
	1.2. <i>Training Programs and Professional Development</i>
	1.3. <i>Ongoing Professional Development</i>
	1.4. Leveraging International Technical Assistance
	1.5. Global Best Practices
Guiding Principle 2: <i>Encourage harmonizing standards and regulations in alignment with international standards like ISO, IEC, and Codex Alimentarius, and work towards enhancing Mutual Recognition Agreements (MRAs) to recognize conformity assessments, certifications, and accreditations mutually.</i>	2.1. <i>Practices for Regional Standards Organizations</i>
	2.2. <i>Joint Standards Committees</i>
	2.3. <i>Utilize Benchmarking</i>
	2.4. <i>Identify and Address Discrepancies</i>
	2.5. <i>MRA Coordination Committee</i>
	2.6. <i>Develop Regional MRA Frameworks</i>
	2.7. <i>Negotiate MRAs</i>
	2.8. <i>Mandate and Roadmap</i>
	2.9. <i>Clear Objectives and Scope</i>
	2.10. <i>Implement Equivalency Agreements</i>
	2.11. <i>A Dispute Resolution Framework</i>
	2.12. <i>Transparency in Resolution Processes</i>
Guiding Principle 3: <i>Strengthen NQI institutions by investing in capacity building to enhance their technical and operational capabilities while fostering public-private partnerships to leverage private sector expertise and resources.</i>	3.1. <i>Formulate NQP</i>
	3.2. <i>Technical Skills Development</i>
	3.3. <i>Upgrade Laboratories and Technical Facilities</i>
	3.4. <i>Specialized Courses and Certifications</i>
	3.5. <i>Business Outreach Programs</i>
	3.6. <i>Sectoral Agreements</i>
	3.7. <i>Regulatory Dialogue</i>

Guiding Principles 4,5,6	
<p>Guiding Principle 4: Modernizing metrology infrastructure by upgrading laboratories to meet international standards and gain global recognition and actively engaging in international forums on standards, metrology, accreditation, and conformity assessment to advance knowledge and practices in these areas.</p>	4.1. <i>Online Standardization Databases</i>
	4.2. <i>Digital Conformity Assessment Tools</i>
	4.3. <i>Digital Accreditation Platforms</i>
	4.4. <i>Digital Transformation</i>
	4.5. <i>IoT and Smart Devices</i>
	4.6. <i>Automated Measurement Systems</i>
	4.7. <i>Sector-Specific Accreditation</i>
	4.8. <i>New and Emerging Fields</i>
	4.9. <i>Participate in Technical Committees</i>
	4.10. <i>Form Strategic Alliances</i>
	4.11. <i>Disseminate Knowledge</i>
<p>Guiding Principle 5: A Metrology Centre of Excellence within the OIC to conduct international-scale metrological studies, particularly for Halal products trade, to meet the diverse needs of all member countries and enhance their global competitiveness.</p>	5.1. <i>Develop a Legal Framework of Halal Metrology</i>
	5.2. <i>Halal Standards and Certification</i>
	5.3. <i>Comprehensive Calibration Services</i>
	5.4. <i>Performance Metrics</i>
	5.5. <i>Operational Plan</i>
<p>Guiding Principle 6: Provide technical assistance, training, financial support, and awareness campaigns to help SMEs in OIC countries comply with quality standards and adopt internationally recognized certification schemes.</p>	6.1. <i>SME Assistance Programs</i>
	6.2. <i>Comprehensive Guidance Documents</i>
	6.3. <i>Implement Peer Evaluations</i>
	6.4. <i>Mentorship Programs</i>
	6.5. <i>Subsidize Certification Costs</i>
	6.6. <i>Industry Partnerships</i>
	6.7. <i>Streamline Certification Procedures</i>
	6.8. <i>Marketing and Branding Strategies</i>
	6.9. <i>Showcase Achievements</i>
	6.10. <i>Feature Testimonials</i>

Guiding Principles 7,8,9	
Guiding Principle 7: Integrate quality management principles into educational curricula at all levels and strengthen consumer protection legislation while enhancing consumer awareness of the importance of quality and safety standards.	7.1. <i>Integrate Simulations and Labs</i>
	7.2. <i>On-the-Job Training</i>
	7.3. <i>Career Pathways</i>
	7.4. <i>Certification Labels</i>
	7.5. <i>Consumer Hotlines</i>
	7.6. <i>Consumer Rights Campaigns</i>
Guiding Principle 8: Implement a periodic assessment system to evaluate the alignment of harmonized standards, MRAs, and related initiatives, and establish feedback mechanisms for businesses and stakeholders to report compliance challenges and issues with regional quality infrastructure.	8.1. <i>Distribution of Duties</i>
	8.2. <i>Data Management Systems</i>
	8.3. <i>Impact Assessments</i>
	8.4. <i>Future Projections</i>
Guiding Principle 9: Utilizing digitization and artificial intelligence technologies and techniques to raise the efficiency and effectiveness of quality infrastructure activities.	9.1. <i>A Centralized Digital NQI Platform</i>
	9.2. <i>Automate Calibration and Testing Procedures Using AI</i>
	9.3. <i>AI-Driven Data Analytics for Quality Assurance</i>
	9.4. <i>Digital Twin Technology for NQI Activities</i>
	9.5. <i>AI-Driven Metrology Data Exchange Network</i>

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ANNEX 1: SURVEY

1.1. Analysis of Survey Findings

Question 1. How would you rate the current level of awareness about metrology and its significance within your sector?

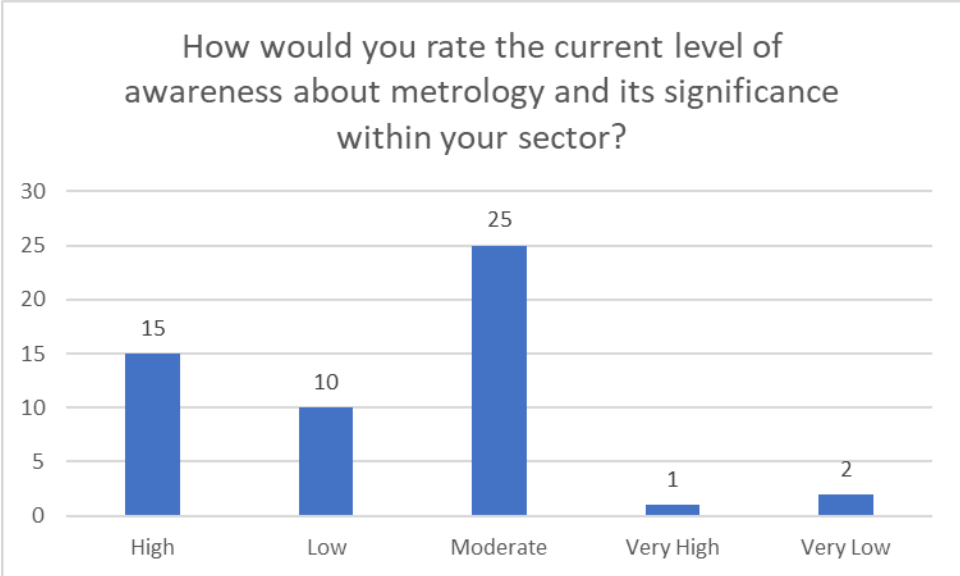
Moderate Awareness (25 responses): This indicates that the largest group has a basic but not deep understanding of metrology.

High Awareness (15 responses): A significant portion of respondents is well-informed about metrology.

Low Awareness (10 responses): There is a notable group with insufficient awareness.

Very High Awareness (1 response): Only one individual demonstrates expert-level awareness.

Very Low Awareness (2 responses): A small number of respondents have a limited understanding of metrology.



The majority (25 respondents) rate their awareness as moderate, implying that while there is some understanding of metrology's role in NQI, it is not fully developed. This can result in incomplete implementation of metrological standards, leading to inconsistencies in trade quality and compliance with international standards. In the context of OIC countries, where trade barriers can be significant, this level of awareness may hinder full integration into global markets.

High and Very High Awareness (16 responses combined): The presence of high awareness among 15 respondents and very high awareness in one case suggests that certain sectors or individuals are well-equipped with knowledge about metrology. These individuals or sectors may be more competitive in international trade, as they are likely to adhere more strictly to international standards. In OIC countries, this could reflect better trade performance in specific sectors, such as energy or manufacturing, that prioritize metrological standards.

Low and Very Low Awareness (12 responses combined): The low and very low awareness responses indicate a significant portion of the sector is inadequately informed about metrology. In OIC countries, this suggests that many sectors, particularly in developing or under-resourced economies, may struggle with technical barriers to trade, such as product certification and quality assurance, which are critical for international market access.

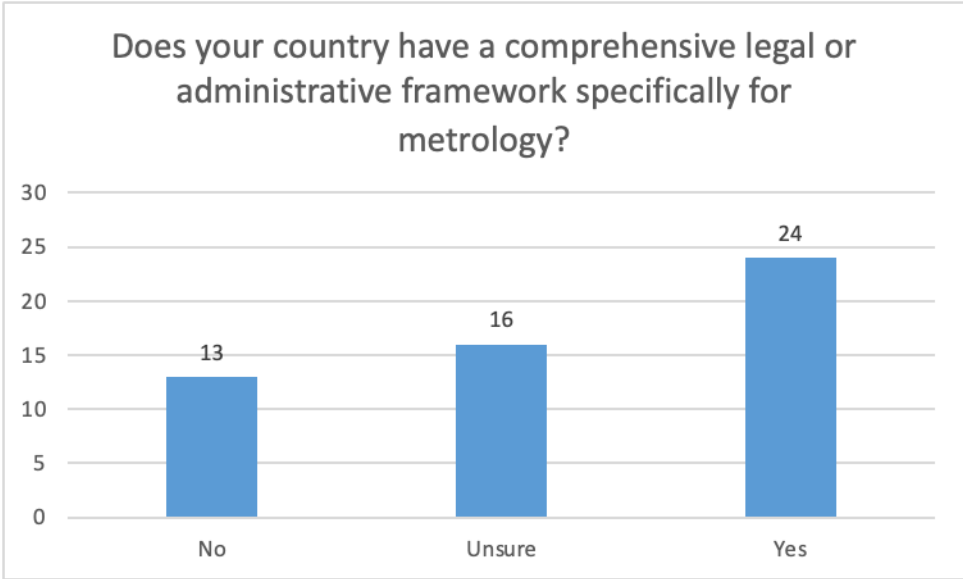
The variation in awareness levels suggests that NQI implementation may be inconsistent across different sectors or regions in OIC countries. Some sectors may effectively leverage metrological standards to enhance trade, while others fall behind, resulting in uneven trade performance. Effective NQI management in OIC countries requires harmonizing awareness and application of metrological principles across all sectors. Countries with higher levels of metrological awareness will likely experience fewer trade barriers, as their products will meet international quality and safety standards. Conversely, countries or sectors with low awareness may face difficulties in meeting these standards, resulting in lost opportunities in international trade. This disparity underscores the need for OIC countries to invest in capacity-building programs to raise awareness about the importance of metrology. The distribution of responses highlights varying levels of metrological awareness within sectors in OIC countries. While there is a base level of understanding, significant gaps exist that could hinder the effective management of NQI for trade. OIC countries should prioritize raising awareness, ensuring consistent application of metrological standards across all sectors, and addressing the specific needs of under-resourced or under-informed industries to enhance their participation in global trade.

Question 2. Does your country have a comprehensive legal or administrative framework specifically for metrology?

Yes (24 responses): A majority affirm that their country has a legal or administrative framework specifically for metrology.

Unsure (16 responses): A significant portion of respondents are uncertain about the existence of such a framework in their country.

No (13 responses): A notable minority indicate that their country does not have a comprehensive legal or administrative framework for metrology.



The 24 "yes" responses suggest that these countries have a structured and potentially well-developed metrology system that is integrated into their NQI. This is a positive indicator for effective NQI management, as the existence of a legal framework ensures the standardization and regulation of metrological practices. Such frameworks are essential for maintaining product quality, ensuring accurate measurements, and complying with international trade standards. Countries with these frameworks are likely to have fewer barriers to trade, as their metrology systems align with global expectations, thereby fostering smoother international trade relations.

The 16 respondents who are unsure about their country's metrological framework reflect a lack of clarity or awareness within their sectors. This uncertainty may signal weak communication between government authorities and the private sector regarding NQI policies. It could also suggest that the framework exists but is not adequately enforced or recognized by key stakeholders, resulting in inconsistent application of metrological standards. When there is uncertainty about the existence of a metrology framework, it indicates potential gaps in the effective management of NQI. This lack of clarity can lead to inconsistent standards and practices within industries, increasing the risk of non-compliance with international trade regulations. For OIC countries, this could hinder the ability of businesses to meet export requirements, resulting in trade inefficiencies and reduced competitiveness.

The 13 "no" responses highlight a critical gap in these countries' NQI. Without a legal or administrative framework for metrology, these countries face significant challenges in ensuring accurate and reliable measurements, which are fundamental to product quality and safety in trade. The absence of such a

framework means that businesses in these countries may struggle to meet international standards, creating technical barriers to trade.

The responses to the questionnaire indicate varying degrees of preparedness and awareness regarding metrology frameworks in OIC member countries. While some countries have established legal and administrative structures for metrology, others lack them or are unsure of their existence. Effective management of NQI in OIC countries will require addressing these gaps by strengthening legal frameworks, raising awareness, and providing support for countries that lack metrological governance. By doing so, OIC countries can enhance their trade competitiveness, foster food security, and support sustainable agricultural development.

Question 3. Say If yes, how adequate are you in finding the existing legal or administrative framework for addressing metrology needs?

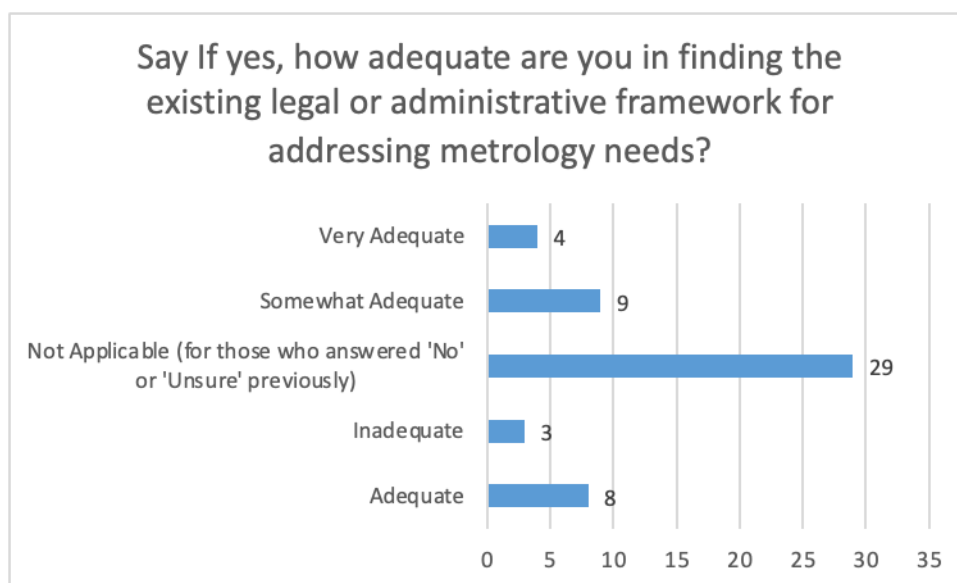
Very Adequate (4 responses): A small number of respondents feel that the existing legal framework is very well-suited to address metrology needs.

Somewhat Adequate (9 responses): A moderate number believe the framework is somewhat effective but may have room for improvement.

Not Applicable/Unsure (29 responses): A large group of respondents either do not know or find the question not applicable, indicating uncertainty or lack of interaction with the framework.

Inadequate (3 responses): A small group finds the framework inadequate for addressing metrology needs.

Adequate (8 responses): A moderate group feels the framework is adequately meeting metrology needs but likely not exceeding expectations.



Very Adequate and Adequate Responses (4 + 8 = 12 Responses) suggest that in certain OIC countries, the legal or administrative frameworks for metrology are sufficiently robust to meet the needs of industries and facilitate trade. This indicates effective NQI management, where metrological standards are well-integrated into the regulatory system, ensuring accurate measurements, product quality, and compliance with international standards. Countries with these systems in place likely experience fewer trade barriers and have better trade facilitation due to their strong quality infrastructure. The adequacy of metrology frameworks in these countries contributes positively to trade competitiveness by ensuring that products meet international quality standards and measurement requirements. This fosters trust among trade partners and enhances the country's ability to participate in global trade, benefiting both domestic industries and the national economy.

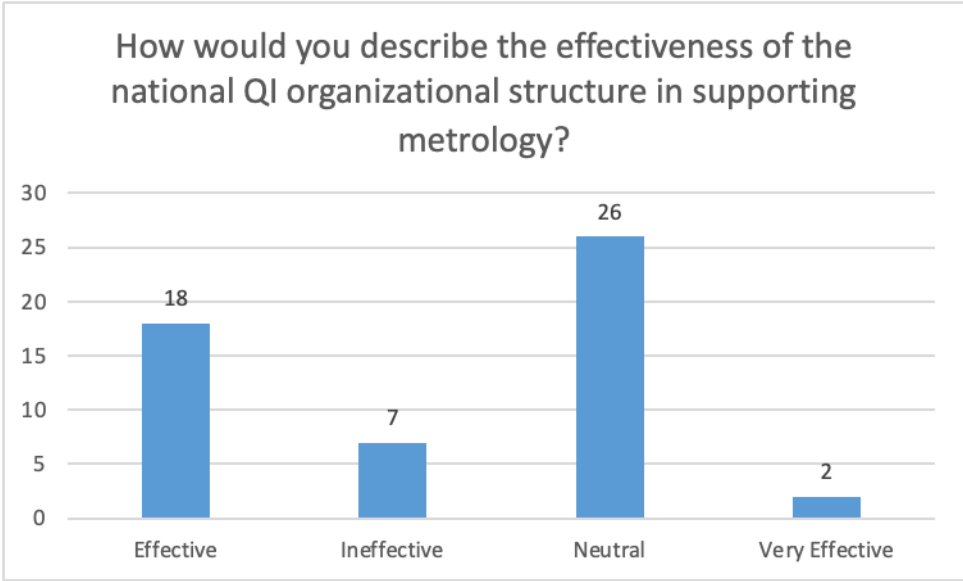
The 9 respondents who find the frameworks "somewhat adequate" suggest that while there is a legal framework in place, it may not fully address the evolving metrology needs of industries. This could point to gaps in enforcement, outdated regulations, or limited coverage of metrological services. For example, countries with developing infrastructure might have basic metrology laws but lack the institutional capacity or resources to implement them effectively across all sectors.

The 3 respondents who find the frameworks inadequate indicate significant challenges in these countries' ability to address metrology needs. Inadequate legal or administrative frameworks could result in poor measurement standards, lack of calibration services, or ineffective enforcement, all of which undermine the credibility of the country's quality infrastructure. For trade, this inadequacy could create substantial barriers, as products may not meet international standards, leading to rejections, delays, and increased costs for businesses trying to engage in global markets.

The largest group of responses, those indicating "not applicable" or "unsure," reflects a substantial lack of awareness or knowledge about the metrology framework in these countries. This could signify that either the framework is not well-publicized, poorly understood by stakeholders, or not relevant to their day-to-day operations. This disconnect suggests that many OIC countries may have weak communication and engagement between the authorities responsible for NQI and the industries relying on metrological services. The high number of uncertain responses points to a critical issue in the management of NQI. If stakeholders are unaware or unsure of the existence and adequacy of the legal framework for metrology, it implies that the framework may not be effectively integrated into the country's quality infrastructure. For trade, this could result in compliance issues, as businesses may not be fully informed about the metrological standards they must adhere to. Addressing this gap will require better dissemination of information, capacity building, and outreach efforts by governments to ensure that industries are aware of and can access metrological services.

The responses to this questionnaire provide insights into the varying levels of adequacy in addressing metrology needs across OIC member countries. While some countries have robust frameworks that effectively support their NQI, others face challenges due to inadequacies or lack of awareness. To improve trade facilitation and the effectiveness of NQI in OIC countries, there is a need for ongoing reforms, capacity building, and enhanced stakeholder engagement to ensure that metrology systems are well-integrated and capable of supporting international trade standards.

Question 4. How would you describe the effectiveness of the national QI organizational structure in supporting metrology?



Effective (18 responses): A significant number of respondents find the national QI organizational structure effective in supporting metrology.

Neutral (26 responses): The largest group is neutral, indicating that they neither see the QI structure as particularly effective nor ineffective.

Ineffective (7 responses): A smaller portion of respondents believes that the structure is not effective.

Very Effective (2 responses): Only a small number of respondents find the structure to be highly effective.

Effective and Very Effective Responses (18 + 2 = 20 Responses) suggest that in certain OIC countries, the national QI organizational structure is well-designed to support metrology. This means that metrological services, such as calibration, standardization, and measurement traceability, are integrated into the national QI system in a way that effectively meets the needs of industries. An effective QI structure that supports metrology enables countries to ensure the accuracy and reliability of measurements, which is critical for maintaining product quality and compliance with international standards. This, in turn, reduces technical barriers to trade, boosts competitiveness, and enhances trust with international partners.

The large number of neutral responses indicates that many respondents are either unsure about the effectiveness of their national QI structure or see it as moderately effective, but with room for improvement. This could suggest that while the QI systems in these countries are functioning, they may not be optimally structured to support metrology comprehensively.

The 7 responses indicating that the QI organizational structure is ineffective suggest that some OIC countries have significant challenges in their QI systems. These countries may lack the institutional framework, resources, or coordination needed to effectively support metrology, which can hinder product quality, measurement accuracy, and compliance with international standards. An ineffective QI structure negatively impacts trade by creating technical barriers, reducing product reliability, and limiting market access. Businesses in these countries may struggle to meet international standards, resulting in difficulties in exporting goods.

The small number of respondents who find the QI structure very effective suggest that in a few OIC countries, the organizational structure supporting metrology is highly functional and well-aligned with the needs of both industry and trade. These countries likely have strong metrology institutions, excellent coordination between government and industry, and high levels of investment in quality infrastructure.

The effectiveness of the national QI organizational structure in supporting metrology varies across OIC member countries. While some countries demonstrate strong support for metrology through effective

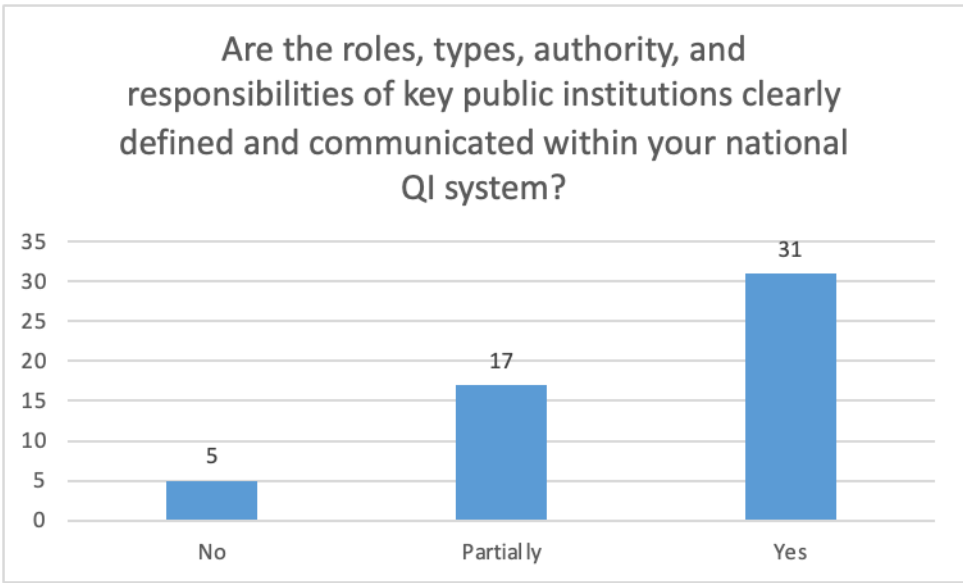
or very effective QI structures, others remain neutral or ineffective, indicating a need for further development and reform. Strengthening QI systems in terms of metrological support is key to enhancing trade competitiveness, reducing technical barriers, and fostering economic growth in OIC member countries. For the region as a whole, improving the effectiveness of QI structures will be essential for building a strong foundation for international trade and sustainable development.

Question 5. Are the roles, types, authority, and responsibilities of key public institutions clearly defined and communicated within your national QI system?

Yes (31 responses): The majority of respondents indicate that the roles, authority, and responsibilities of key public institutions within the QI system are clearly defined and communicated.

Partially (17 responses): A significant number of respondents indicate that this clarity and communication exist but may be incomplete or inconsistent.

No (5 responses): A small group of respondents reports that the roles and responsibilities of QI institutions are not clearly defined or communicated.



Clear Definition and Communication (31 Yes Responses) in these countries, the roles and responsibilities of public institutions involved in the QI system are well-defined and clearly communicated. This indicates a well-structured institutional framework where each organization understands its functions within the QI system, leading to efficient management and coordination.

Partial Definition and Communication (17 Partially Responses) in these countries, the institutional roles within the QI system are partially defined but may suffer from gaps or ambiguities. This could

mean that some institutions have clear mandates, while others may have overlapping or unclear responsibilities, leading to inefficiencies or conflicts. These countries would benefit from reviewing and refining their QI systems to ensure that all key institutions have clearly defined roles and that these roles are effectively communicated. Strengthening coordination mechanisms between agencies and improving legal frameworks could address these partial gaps and lead to more coherent and efficient QI management.

Lack of Clarity and Communication (5 No Responses) for these countries, the lack of clearly defined and communicated roles within the QI system suggests a weak or underdeveloped institutional framework. This can lead to significant inefficiencies, such as duplication of efforts, regulatory gaps, or institutional conflicts, which undermine the effectiveness of the QI system. These countries need to prioritize the development of a comprehensive legal and administrative framework that clearly outlines the roles and responsibilities of all public institutions involved in the QI system. This is essential to create a well-coordinated system that supports trade and economic development.

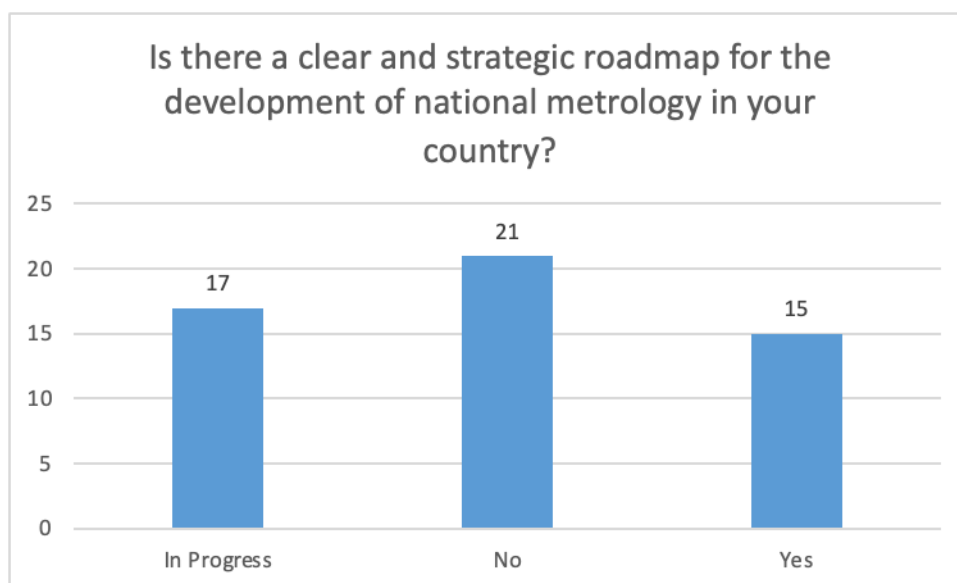
The clarity and communication of the roles, types, authority, and responsibilities of key public institutions within the national QI system are critical for the Effective Management of NQI for Trade. Countries where these roles are well-defined and communicated are more likely to have efficient, well-coordinated QI systems that support international trade and foster economic development. For countries with partial or unclear institutional frameworks, improving the definition and communication of roles is essential to enhance the effectiveness of their QI systems and support trade-related activities in line with global standards.

Question 6. Is there a clear and strategic roadmap for the development of national metrology in your country?

Yes (15 responses): Some countries have a clear and strategic roadmap for the development of national metrology.

In Progress (17 responses): A larger group of countries is in the process of developing such a roadmap.

No (21 responses): Many countries do not have a roadmap for the development of national metrology.



Countries with a Clear and Strategic Roadmap (15 Yes Responses), these countries have taken proactive steps to establish a clear and strategic roadmap for developing their national metrology systems. This indicates strong government commitment and strategic planning in ensuring that the metrology infrastructure aligns with national development goals and trade facilitation. A roadmap guides investment in infrastructure, human capital, and technology within the metrology sector, leading to a more effective NQI system. This clarity also fosters public and private sector collaboration, ensuring that the metrology system can support industries ranging from manufacturing to agriculture and pharmaceuticals, all critical for trade.

Countries Developing a Roadmap (17 In Progress Responses), these countries are recognizing the importance of metrology in trade and are working on establishing a strategic roadmap. This indicates a positive shift toward developing a more structured and effective metrology system, though these efforts are still ongoing. Countries in this category may require external support in terms of capacity building, training, and technical assistance to finalize and implement their metrology roadmaps. This development phase presents an opportunity for regional cooperation among OIC countries to share best practices and accelerate the progress of metrology systems.

Countries Without a Roadmap (21 No Responses), countries without a metrology roadmap likely face significant challenges in developing and managing their national metrology systems. The absence of a strategic framework may lead to fragmented or underdeveloped metrology services, which can hinder the country's ability to comply with international trade standards and reduce competitiveness in global markets. These countries urgently need to develop a national metrology strategy as part of their broader NQI reform. A clear roadmap would guide investment in metrology infrastructure, training,

and technology, helping them meet international standards and supporting economic growth through improved trade outcomes.

The presence or absence of a strategic roadmap for national metrology plays a critical role in the Effective Management of the NQI for Trade. Countries with a clear roadmap are better equipped to support trade through compliance with international standards, while those in the process of developing such roadmaps are on a promising trajectory toward enhanced NQI management. However, countries without a roadmap need to prioritize the development of a metrology strategy to improve their trade capabilities and overall economic development. Investing in metrology development, guided by a strategic roadmap, is essential for OIC countries to ensure that their goods meet international standards, facilitating smoother trade and fostering economic growth.

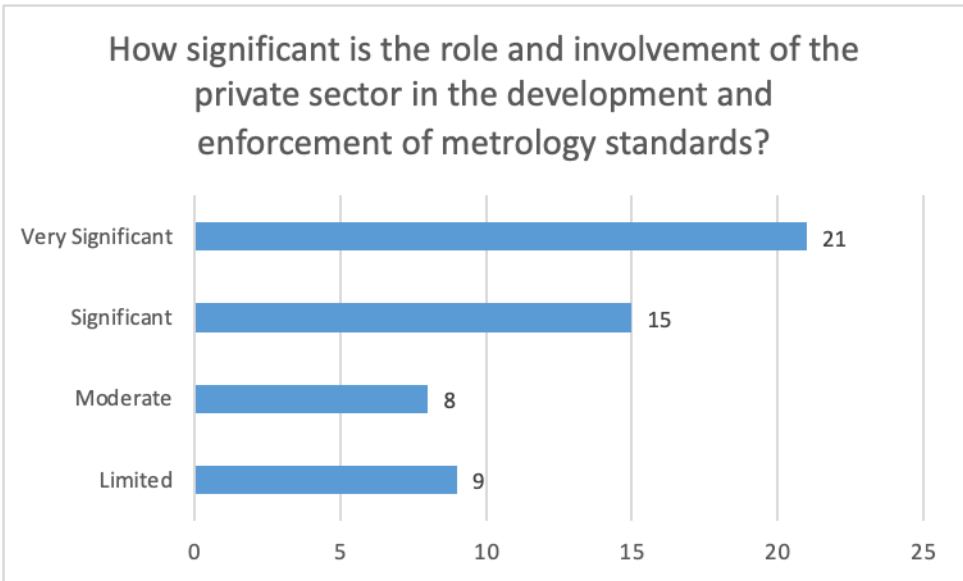
Question 7. How significant is the role and involvement of the private sector in the development and enforcement of metrology standards?

Very Significant (21 responses): A substantial portion of respondents believe the private sector plays a very important role.

Significant (15 responses): Many respondents feel the private sector is significantly involved.

Moderate (8 responses): Some respondents see the private sector’s role as moderate.

Limited (9 responses): A smaller group perceives limited involvement of the private sector.



A majority of respondents (21 + 15 = 36) believe that the private sector's role in developing and enforcing metrology standards is either very significant or significant. This indicates that in many OIC member countries, the private sector is actively engaged in shaping metrology standards and ensuring they are implemented across industries. Effective management of the NQI for trade is enhanced when the private sector plays a significant role. This leads to improved calibration services, testing laboratories, and certification processes that align with international standards, allowing countries to participate more effectively in global trade. For example, industries that require precise measurements, such as manufacturing, pharmaceuticals, and electronics, benefit from robust metrology standards supported by the private sector.

Moderate Involvement (8 responses) for countries where the private sector's involvement is moderate, the metrology system may still be developing, with some collaboration between government and industry. In these cases, there is room for improvement in engaging businesses more fully in the development and enforcement of metrology standards. Countries with moderate private sector involvement could enhance their NQI by creating incentives for businesses to participate more actively in the standards-setting process. Strengthening partnerships between the public and private sectors can lead to better alignment between metrology standards and industry needs, improving trade outcomes. Countries with emerging industries may fall into this category, where private sector involvement is growing but not yet fully integrated into NQI management.

Limited Involvement (9 responses) in countries where the private sector's involvement is limited, the development and enforcement of metrology standards may be overly reliant on government institutions. This can lead to slower adaptation to industry needs, lack of innovation, and weaker alignment with international trade standards. Limited private sector involvement often reflects challenges such as insufficient collaboration, lack of awareness, or regulatory barriers that prevent businesses from actively participating in metrology development. This can hinder the overall effectiveness of the NQI system in supporting trade. Countries with less developed industrial sectors or where government agencies dominate standard-setting processes may experience these challenges. Addressing these barriers is crucial for improving the NQI and trade facilitation.

The role of the private sector in the development and enforcement of metrology standards is a critical factor in the Effective Management of the NQI for Trade. Countries with high private sector involvement are better positioned to ensure that their metrology systems meet international standards, fostering trade and economic growth. Conversely, countries with limited private sector engagement face challenges in maintaining effective NQI systems, which can hinder their trade competitiveness. Strengthening PPPs and incentivizing greater private sector participation are key strategies for improving NQI management across OIC member countries.

Question 8. Rate the level of collaboration between the business sector and public institutions in metrology- related activities?

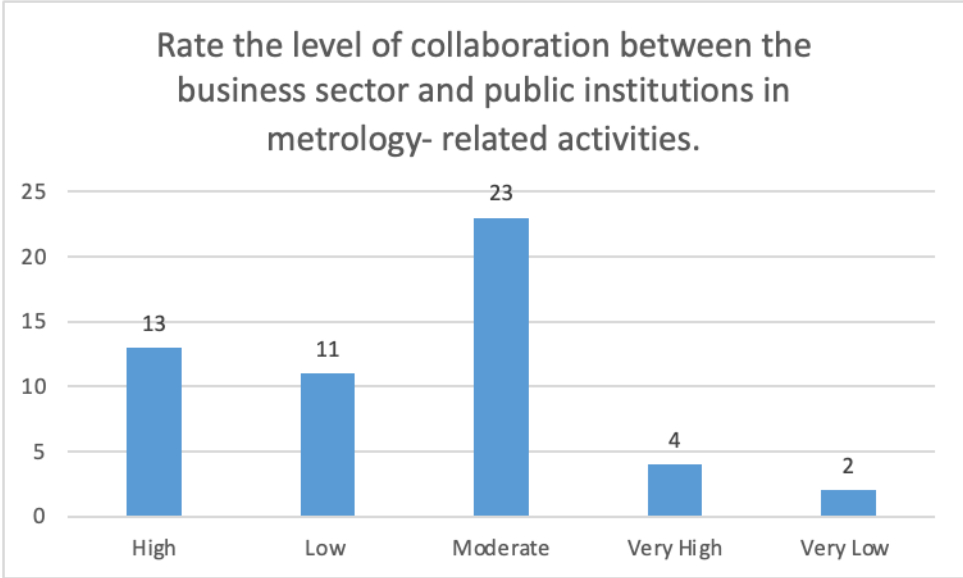
High Collaboration (13 responses): Indicates strong collaboration between the business sector and public institutions.

Low Collaboration (11 responses): Suggests limited collaboration between these sectors.

Moderate Collaboration (23 responses): Reflects a middle ground where collaboration exists but may not be optimal.

Very High Collaboration (4 responses): Signifies exceptional collaboration between sectors.

Very Low Collaboration (2 responses): Represents minimal to no collaboration.



A total of 17 respondents (13 high + 4 very high) indicate strong collaboration between the business sector and public institutions. This reflects effective PPPs, which are key for managing the NQI. In countries where collaboration is strong, the NQI is likely more responsive to the needs of both industry and government, facilitating smoother trade processes.

The majority of respondents (23) indicate moderate collaboration, suggesting that while there is cooperation between the business sector and public institutions, there is room for improvement. This level of collaboration is likely sufficient to maintain basic metrology functions, but it may not be fully optimized for enhancing trade. Moderate collaboration may reflect ongoing efforts to improve coordination among sectors. To advance the effectiveness of the NQI, these countries may need to enhance communication, streamline processes, and incentivize stronger private sector involvement in metrology activities. By doing so, they can improve the adaptability and competitiveness of their

industries in international markets. Countries with developing economies and emerging industries may fall into this category, where collaboration is still evolving.

A significant portion of respondents (11 low + 2 very low) indicate low collaboration between the business sector and public institutions. This signals a disconnect between the needs of industry and the actions of public institutions, which can lead to inefficiencies in the NQI and hinder trade facilitation. Limited collaboration may result in outdated or misaligned metrology standards that do not fully support industrial needs, leading to challenges in maintaining product quality and meeting international trade requirements. Countries facing these challenges may struggle to effectively manage their NQI and enhance their trade capabilities. Addressing these collaboration gaps is critical for these countries to strengthen their NQI systems and better support their trade sectors.

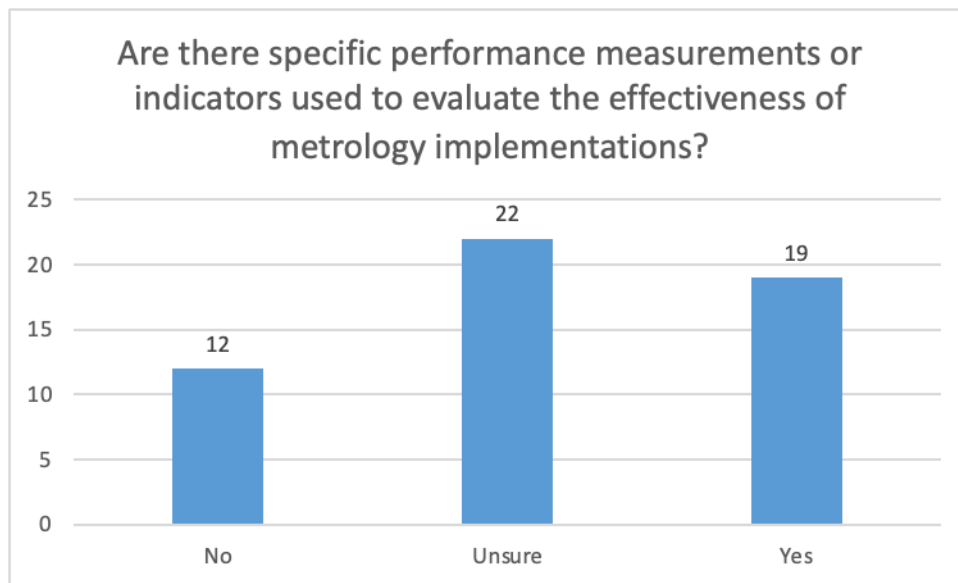
The level of collaboration between the business sector and public institutions in metrology-related activities is a critical factor in the Effective Management of the NQI for Trade in OIC member countries. Countries with high or very high levels of collaboration are more likely to have effective NQI systems that support trade, while those with moderate collaboration need to build on existing foundations to enhance their effectiveness. Countries with low collaboration face significant challenges in managing their NQI systems and may need to implement reforms to improve coordination and support their trade sectors. Strengthening PPPs and fostering better collaboration across sectors is essential for improving the effectiveness of NQI systems and enhancing trade competitiveness in OIC member countries.

Question 9. Are there specific performance measurements or indicators used to evaluate the effectiveness of metrology implementations?

19 Yes: Indicates that these respondents are aware of specific performance measurements or indicators used to evaluate metrology implementations.

22 Unsure: Reflects uncertainty or lack of knowledge about the existence of such performance measurements.

12 No: Suggests the absence of any formal performance measurements or indicators for metrology in these respondents' countries.



The fact that 19 respondents indicate the use of performance measurements suggests that these countries have a relatively well-developed framework for managing and evaluating their metrology systems. Performance indicators help ensure that metrology services are aligned with national trade goals, including accuracy in measurements, timely certification, and adherence to international standards.

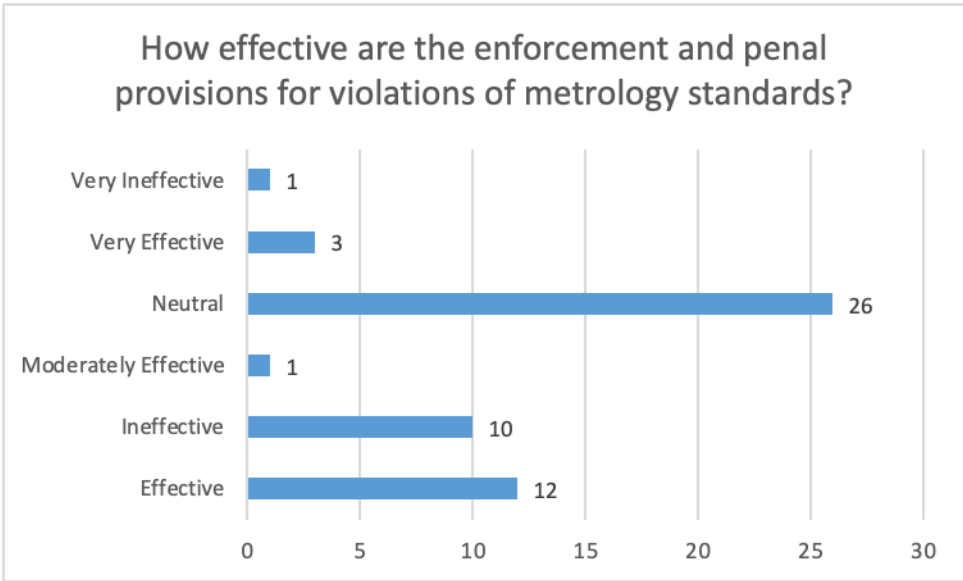
Countries with Uncertainty or Lack of Knowledge (22 Unsure Responses, the largest group of respondents) is unsure about the existence of performance measurements for metrology. This indicates a gap in awareness or communication regarding the management of the metrology system within these countries. The uncertainty could reflect either a lack of formal indicators or a disconnect between policymakers and stakeholders in the metrology sector. This uncertainty can point to challenges in effectively managing the NQI, particularly in ensuring that metrology services are regularly evaluated and improved. Without clear performance measurements, countries may struggle to align their metrology systems with trade needs, potentially leading to inefficiencies and obstacles in meeting international standards.

For the 12 respondents indicating that their countries do not have performance measurements, this suggests a significant gap in the management and oversight of metrology services. Without formal evaluation mechanisms, it is difficult to assess the effectiveness of metrology systems or ensure that they meet the demands of the trade sector. The absence of performance indicators may lead to outdated or inadequate metrology systems, which can create trade barriers due to non-compliance with international measurement standards. This lack of evaluation may also hinder the country's ability to participate in global markets effectively, as product quality and measurement accuracy are critical for export success. These countries may need to prioritize the development of performance

measurements as part of broader NQI reforms. By introducing structured evaluation mechanisms, they can improve the effectiveness of their metrology systems and better support trade.

The use of specific performance measurements to evaluate the effectiveness of metrology implementations is a critical factor in the Effective Management of NQI for Trade in OIC member countries. Countries with established performance indicators are more likely to have effective NQI systems that support trade by ensuring that metrology services are accurate, reliable, and aligned with international standards. However, the large number of respondents who are unsure about the existence of performance measurements indicates a need for greater awareness and capacity building within the metrology sector. Countries that lack performance measurements face significant challenges in managing their NQI systems effectively and may need to prioritize the development of evaluation mechanisms to support trade facilitation and improve their competitiveness in global markets.

Question 10. How effective are the enforcement and penal provisions for violations of metrology standards?



1 Very Ineffective: Indicates that, in this case, the enforcement and penal provisions are perceived as not achieving their intended purpose at all.

3 Very Effective: Suggests that, in these instances, enforcement and penal provisions are working exceptionally well.

26 Neutral: Reflects a lack of strong opinions or experience regarding the effectiveness of enforcement and penal provisions.

1 Moderately Effective: Implies that enforcement and penal provisions are somewhat effective but may have room for improvement.

10 Ineffective: Indicates that in these cases, enforcement and penal provisions are perceived as failing to address violations effectively.

12 Effective: Suggests that in these cases, enforcement and penal provisions are working well to uphold metrology standards.

Countries with Very Effective Enforcement (3 Responses), for the countries where enforcement and penal provisions are considered very effective, it suggests they have a robust legal framework and enforcement mechanisms in place. These countries likely have clear regulations, well-defined penalties, and efficient enforcement bodies that contribute to maintaining high standards in metrology.

Countries with Effective Enforcement (12 Responses), countries with a moderate number of responses indicating effective enforcement are likely to have functional systems for upholding metrology standards. However, there may be areas for improvement to achieve even higher levels of effectiveness.

Countries with Neutral Responses (26 Responses), the high number of neutral responses indicates a significant uncertainty or lack of clarity regarding the effectiveness of enforcement and penal provisions. This could reflect a lack of awareness, experience, or detailed information about the enforcement mechanisms in place. These countries may need to assess their enforcement systems more critically and improve communication about how well their provisions are working. Understanding and addressing any gaps or inefficiencies can help enhance the overall effectiveness of their NQI systems.

Countries with Ineffective Enforcement (10 Responses), for countries where enforcement and penal provisions are considered ineffective, it suggests there are significant challenges in the legal and regulatory frameworks. These countries may face difficulties in implementing and enforcing metrology standards, which can impact their ability to maintain product quality and meet international requirements. These countries might need to undertake substantial reforms to strengthen their enforcement mechanisms. This could include revising legal frameworks, enhancing enforcement capabilities, and increasing resources dedicated to metrology.

Countries with Very Ineffective Enforcement (1 Response), a response indicating very ineffective enforcement suggests a severe gap in the enforcement and penal provisions for metrology standards. This implies that the country is struggling significantly with its regulatory and enforcement

mechanisms. Addressing this critical weakness is essential for ensuring that metrology standards are upheld. The country may need to undertake comprehensive reforms to develop and implement effective enforcement strategies.

The effectiveness of enforcement and penal provisions for metrology standards is a key aspect of the Effective Management of NQI for Trade in OIC member countries. The responses indicate a range of effectiveness, from very effective to very ineffective, highlighting differences in how countries manage and enforce metrology standards. Countries with strong enforcement mechanisms are better positioned to support trade by ensuring product quality and compliance. In contrast, countries with ineffective or very ineffective enforcement face significant challenges that can hinder trade and affect market competitiveness. Improving enforcement systems and addressing gaps in the regulatory framework are crucial for enhancing the effectiveness of the NQI and supporting trade objectives.

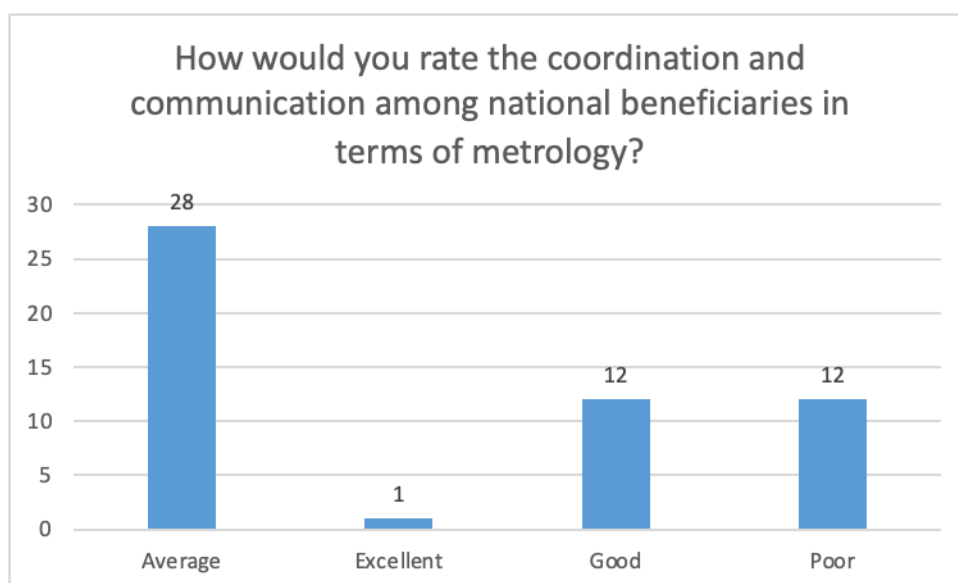
Question 11. How would you rate the coordination and communication among national beneficiaries in terms of metrology?

1 Excellent: Indicates that in this case, coordination and communication are perceived as outstanding.

12 Good: Reflects that a relatively small number of respondents view coordination and communication positively, suggesting good practices are in place.

28 Average: Suggests that a significant number of respondents see the coordination and communication as neither strong nor weak, indicating a standard level of effectiveness.

13 Poor: Indicates that a notable number of respondents view coordination and communication negatively, suggesting substantial challenges.



The country with an "excellent" rating likely has highly effective mechanisms for coordination and communication among stakeholders involved in metrology. This can be seen as a model for others, demonstrating best practices in ensuring smooth collaboration and information sharing.

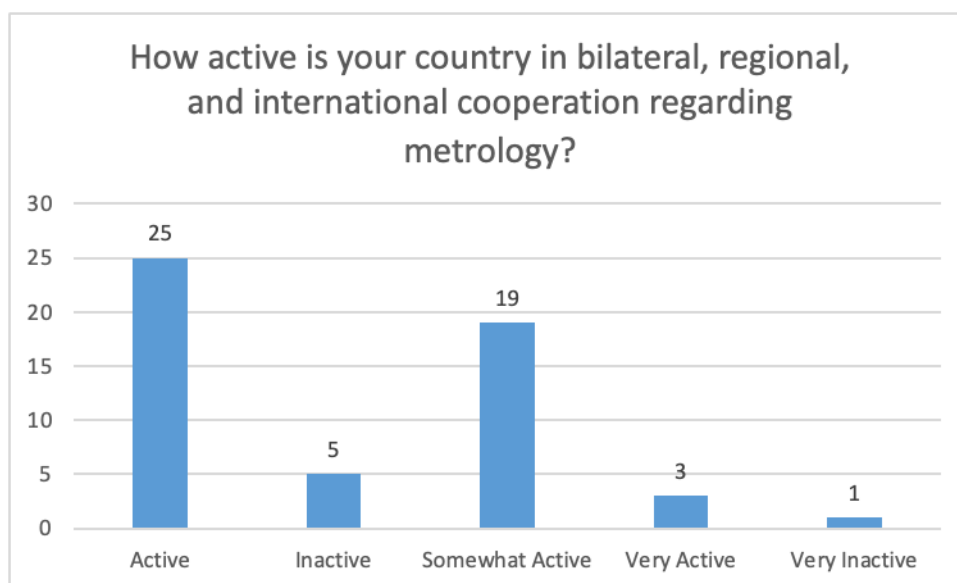
Countries with a "good" rating have relatively strong coordination and communication practices. This indicates that while there are positive efforts and structures in place, there may still be room for further improvement.

Countries with Average Coordination and Communication (28 Responses) indicate an average level of coordination and communication. This suggests that while basic mechanisms are in place, they may not be fully optimized or efficient. Average coordination and communication may lead to some inefficiencies in the NQI. Stakeholders might face challenges in aligning their efforts and sharing information effectively, which can impact the overall effectiveness of metrology standards and trade facilitation.

A notable number of respondents view coordination and communication as poor, indicating serious issues in how stakeholders interact and share information regarding metrology. Poor coordination and communication can lead to fragmented efforts, misunderstandings, and inefficiencies within the NQI. This negatively affects the implementation and enforcement of metrology standards, potentially leading to issues in trade and quality assurance.

The responses regarding coordination and communication among national beneficiaries in metrology reveal a range of effectiveness, from excellent to poor. This variation impacts the overall Effective Management of the NQI for Trade. Countries with excellent or good coordination can manage their NQI more effectively, enhancing trade and quality assurance. In contrast, those with average or poor coordination face significant challenges that can hinder the effectiveness of their metrology systems. Addressing these issues through improved communication, enhanced coordination mechanisms, and targeted interventions is crucial for advancing the management of the NQI and supporting trade objectives in OIC member countries.

Question 12. How active is your country in bilateral, regional, and international cooperation regarding metrology?



25 Active: Reflects that a majority of countries are actively engaged in cooperation regarding metrology.

5 Inactive: Indicates a smaller number of countries are not involved in such cooperation.

19 Somewhat Active: Shows that a significant number of countries are engaged in some form of cooperation, but not to a high degree.

3 Very Active: Represents a very small number of countries that are highly engaged in international metrology cooperation.

1 Very Inactive: Indicates one country has minimal involvement in metrology cooperation.

Countries that are rated as "active" are participating in bilateral, regional, and international metrology cooperation to a significant extent. This engagement likely involves collaboration on standardization, shared technical resources, and joint efforts to address metrology challenges. Active participation enhances the effectiveness of the NQI by fostering alignment with international standards, facilitating trade, and improving the quality of metrology practices. It supports harmonization efforts and strengthens the infrastructure necessary for managing quality and trade.

Countries rated as "somewhat active" are engaged in cooperation, but their involvement may be limited or less consistent. This could involve selective participation in international forums or limited bilateral agreements. While somewhat active participation supports the NQI, there may be missed opportunities for deeper collaboration and integration with international practices. Enhancing the level of engagement could further improve the effectiveness of the NQI and support better trade outcomes.

Countries with "very active" status are highly involved in international metrology cooperation. This level of engagement indicates a strong commitment to aligning with global standards and participating in advanced collaborative efforts.

Countries rated as "inactive" have limited or no engagement in international metrology cooperation. This suggests a potential gap in aligning with global standards and practices. Inactive participation can result in a lack of integration with international metrology systems, leading to potential challenges in trade and quality management. These countries may face difficulties in ensuring that their metrology practices meet international requirements.

The country with "very inactive" status has minimal involvement in international metrology cooperation. This indicates a significant gap in engagement and collaboration. Very low engagement can severely impact the effectiveness of the NQI, potentially leading to challenges in aligning with international standards and difficulties in trade. The country may need to significantly increase its involvement to address these issues.

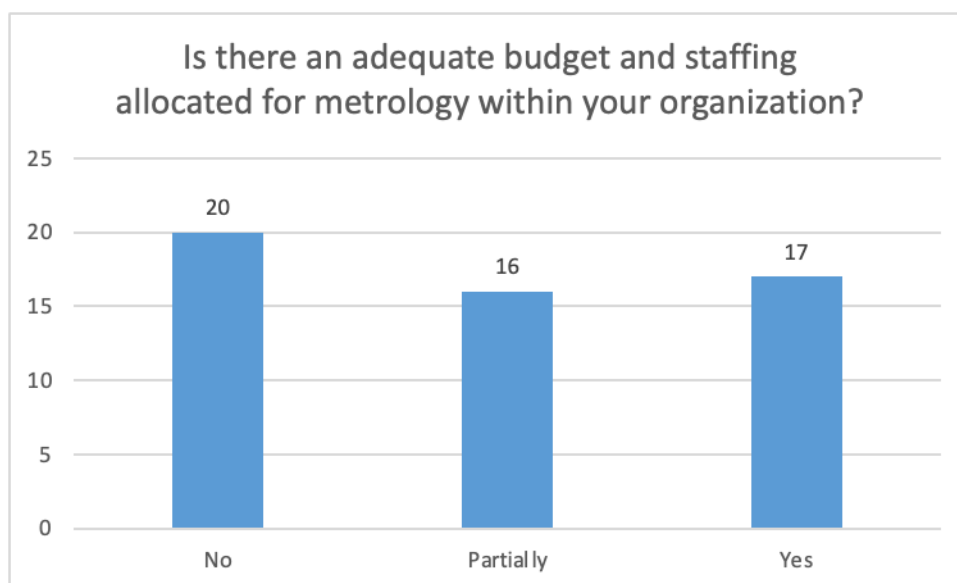
The responses indicate varying levels of involvement in bilateral, regional, and international metrology cooperation among OIC member countries. Active and very active participation is associated with better alignment with international standards and improved management of the NQI, which supports trade and quality assurance. In contrast, inactive or very inactive participation suggests gaps that can hinder the effectiveness of the NQI. Addressing these gaps and enhancing international cooperation can significantly benefit the management of quality infrastructure and support trade objectives in OIC member countries.

Question 13. Is there an adequate budget and staffing allocated for metrology within your organization?

20 No: Indicates that a significant number of organizations believe their budget and staffing for metrology are inadequate.

16 Partially: Suggests that some organizations have limited or partial adequacy in their budget and staffing for metrology.

17 Yes: Reflects that a smaller number of organizations find their budget and staffing for metrology adequate.



The high number of organizations reporting inadequate budget and staffing indicates a significant issue. Insufficient financial and human resources can hinder the effectiveness of metrology programs, leading to challenges in maintaining standards, conducting measurements, and ensuring quality. Inadequate resources can impact the ability of the NQI to function effectively, affecting trade facilitation and quality management. Organizations may struggle to meet international standards, leading to potential barriers in trade and reduced credibility.

Organizations reporting partial adequacy in budget and staffing have some resources but may still face limitations. This can lead to constraints in implementing comprehensive metrology programs and addressing all necessary aspects of quality management. While partial adequacy allows for some level of functioning, it may not be sufficient to fully support the NQI's objectives. These organizations might experience difficulties in achieving and maintaining international standards, which can impact their trade capabilities and quality assurance.

Organizations that find their budget and staffing adequate are likely to have the necessary resources to effectively manage metrology functions. This can support the implementation of robust metrology practices and contribute to the overall effectiveness of the NQI. Adequate resources enable organizations to perform their roles effectively, maintain high standards, and facilitate trade. These organizations are better positioned to align with international standards and enhance their quality infrastructure.

The responses indicate a varied level of adequacy in budget and staffing for metrology within organizations in OIC member countries. A significant number of organizations face challenges due to inadequate resources, which can affect the effectiveness of the NQI and trade facilitation. Addressing

these issues through increased investment and strategic resource management is crucial for enhancing the management of quality infrastructure and supporting trade objectives in OIC member countries.

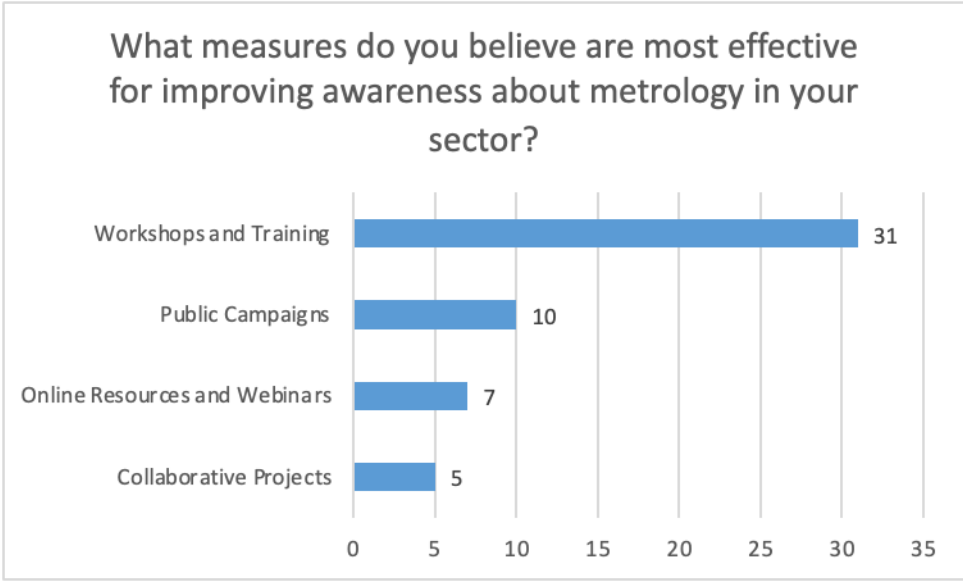
Question 14. What measures do you believe are most effective for improving awareness about metrology in your sector?

31 Workshops and Training: This is the most popular response, indicating that many believe hands-on, in-person learning opportunities are the most effective for raising awareness about metrology.

10 Public Campaign: This suggests that a significant but smaller group supports broad, public-focused initiatives to increase metrology awareness.

7 Online Resources and Webinars: A moderate number of respondents favor digital approaches, such as online resources and webinars, for education and awareness.

5 Collaborative Projects: Fewer respondents see collaborative projects as a primary method for enhancing awareness about metrology.



Workshops and training sessions are perceived as highly effective for improving awareness. This approach allows for interactive learning, direct engagement, and tailored content that can address specific needs within the sector. By prioritizing workshops and training, OIC member countries can build a more knowledgeable workforce, leading to improved implementation of metrology standards and better support for the NQI. This hands-on approach can enhance understanding and practical skills among professionals, contributing to more effective management of quality infrastructure.

Public campaigns can raise awareness broadly but might not provide in-depth, specialized knowledge. They are useful for reaching a wider audience and promoting a general understanding of metrology's

importance. Public campaigns can help in generating general awareness and support for metrology, but may need to be complemented with more detailed educational efforts to address specific technical and professional needs within the sector.

Online resources and webinars offer flexibility and accessibility, allowing individuals to learn at their own pace and from various locations. However, they may lack the interactive and personalized aspects of in-person training. Utilizing online platforms can broaden the reach of educational efforts and support continuous learning. Integrating these resources into a broader strategy can help in reaching a diverse audience and providing ongoing support for metrology education.

Collaborative projects can foster knowledge sharing and innovation but may require more time to set up and achieve results. They can also be less focused on direct education compared to workshops. Collaborative projects can contribute to long-term improvements in metrology awareness and practice by engaging multiple stakeholders and fostering partnerships. However, they might be less immediate in addressing current awareness gaps compared to more direct educational measures.

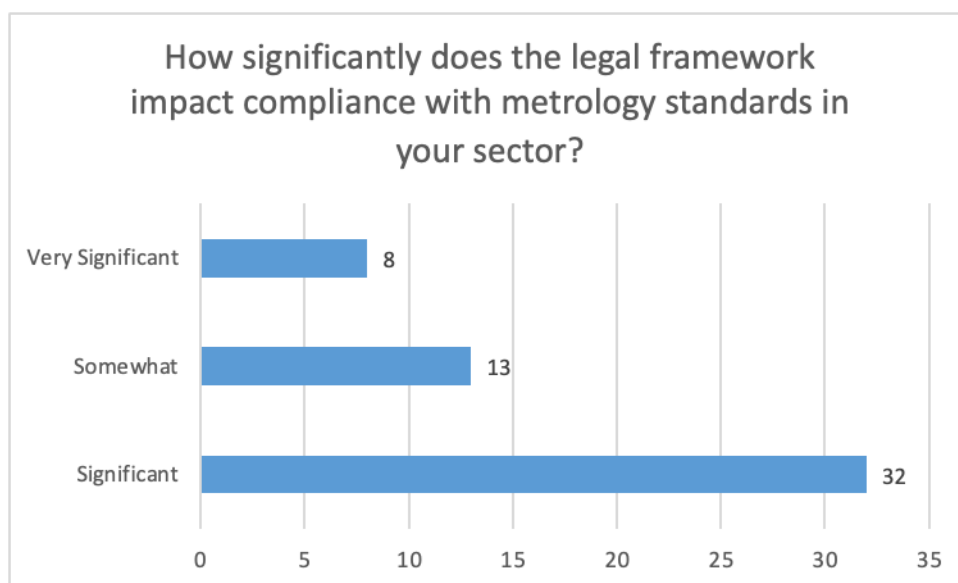
The responses suggest that workshops and training are considered the most effective measure for improving awareness about metrology. However, a balanced approach that includes public campaigns, online resources, and collaborative projects can provide a comprehensive strategy for enhancing metrology awareness and supporting the effective management of the NQI in OIC member countries.

Question 15. How significantly does the legal framework impact compliance with metrology standards in your sector?

8 Very Significant: A small proportion of respondents believe that the legal framework has a very significant impact on compliance.

13 Somewhat Significant: A moderate number of respondents feel that the legal framework has a somewhat significant impact.

32 Significant: The majority of respondents consider the legal framework to have a significant impact on compliance.



The majority view that the legal framework has a significant impact indicates that the existing laws and regulations play a crucial role in ensuring compliance with metrology standards. This suggests that a well-defined and enforced legal framework is critical for the effective management of metrology practices. For OIC member countries, a strong legal framework helps ensure that metrology standards are adhered to, which supports the integrity of trade practices and the quality of products. Effective enforcement mechanisms and clear legal guidelines are essential for maintaining high standards and fostering confidence in the NQI.

Somewhat Significant (13 Responses) indicates that while the legal framework is important, its impact on compliance might not be as strong or consistent as desired. It suggests that there may be gaps in the current legal framework or challenges in its implementation and enforcement. OIC member countries may need to address these gaps by strengthening legal provisions and improving enforcement practices. This could involve updating laws, providing better training for regulatory bodies, or enhancing the transparency and accountability of metrology standards.

A small number of respondents view the legal framework as having a very significant impact, highlighting its critical importance in achieving high levels of compliance. This reflects the view that legal frameworks, when robust and well-implemented, can lead to exceptional adherence to metrology standards. For those countries where the legal framework is very effective, it can serve as a model for other OIC member countries looking to enhance their own legal frameworks. These countries likely have strong regulatory environments that contribute to excellent management of the NQI.

The responses indicate that the legal framework has a significant role in ensuring compliance with metrology standards, which is crucial for the effective management of the NQI in OIC member countries. Strengthening legal provisions, improving enforcement, and addressing gaps in

implementation can help enhance compliance and support the integrity of trade practices and product quality.

Question 16. What are the primary challenges faced in implementing the roadmap for national metrology development?

Technical Expertise (18 Responses): The largest number of respondents identified a lack of technical expertise as a primary challenge.

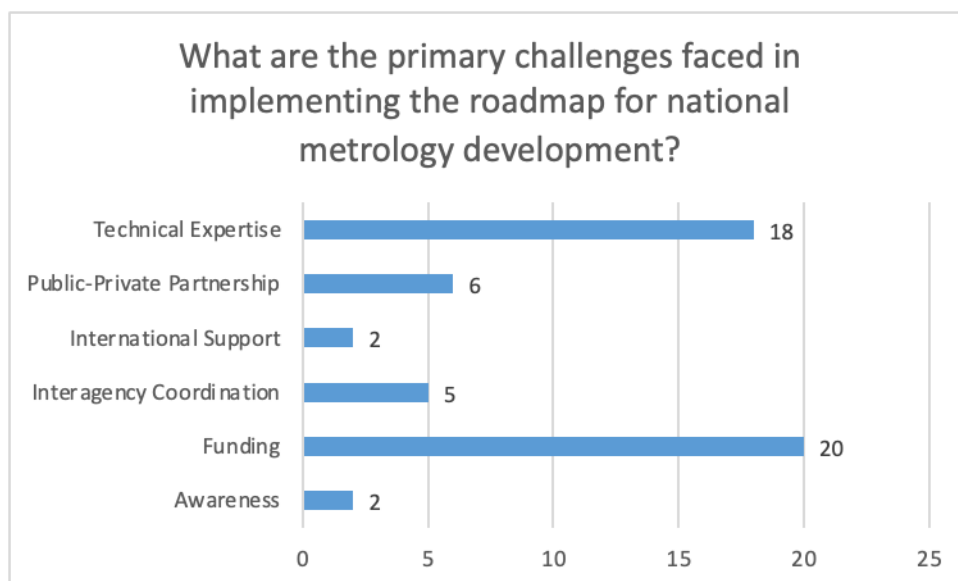
PPP (6 Responses): A moderate number of respondents noted challenges related to PPPs.

International Support (2 Responses): Fewer respondents saw a lack of international support as a major challenge.

Interagency Coordination (5 Responses): Some respondents highlighted issues with coordination among different agencies.

Funding (20 Responses): The highest number of respondents pointed to inadequate funding as a significant challenge.

Awareness (2 Responses): A small number of respondents identified awareness as a key challenge.



Funding is the most frequently cited challenge, highlighting that financial constraints are a major barrier to implementing the roadmap for national metrology development. This indicates that securing adequate resources for metrology infrastructure, training, and technology is crucial. Inadequate funding can impede the development and maintenance of metrology systems, affecting the quality and reliability of measurements. Effective management of the NQI requires addressing this challenge by

securing sustainable funding sources, potentially through government budgets, international grants, or PPPs.

The lack of technical expertise is a significant challenge, suggesting that there may be a shortage of skilled personnel or insufficient training opportunities in metrology. Technical expertise is essential for implementing and maintaining metrology systems. Addressing this challenge involves investing in training programs, attracting skilled professionals, and fostering knowledge exchange with international experts.

Challenges related to PPPs indicate that collaboration between the public sector and private industry is not fully optimized. Effective PPPs can enhance resource mobilization, improve metrology practices, and facilitate the implementation of standards. Strengthening these partnerships can support the development of a robust NQI by leveraging the strengths of both sectors.

Issues with interagency coordination point to difficulties in aligning the efforts of various government and regulatory bodies involved in metrology. Effective coordination among agencies is crucial for cohesive policy implementation and enforcement. Addressing this challenge involves improving communication and collaboration mechanisms among different agencies involved in metrology.

The relatively low number of responses related to international support suggests that while international collaboration is helpful, it may not be seen as the primary challenge. International support can provide technical assistance, funding, and best practices. However, it is not perceived as a major challenge compared to funding and technical expertise. Nevertheless, seeking international support can still be beneficial for supplementing national efforts.

A small number of respondents identified awareness as a challenge, indicating that while important, it may not be the most pressing issue. Increasing awareness about the importance of metrology can help garner support and resources. However, addressing funding and technical expertise may take precedence to ensure that awareness efforts are effective.

The primary challenges in implementing the roadmap for national metrology development in OIC member countries include securing adequate funding, addressing technical expertise gaps, and improving PPPs. Effective management of the NQI requires targeted efforts to address these challenges, enhance coordination, and leverage international support. By focusing on these areas, OIC member countries can strengthen their metrology systems and support the overall development of their NQI for trade.

Question 17. What strategies could enhance the engagement of the private sector in metrology standards development and enforcement?

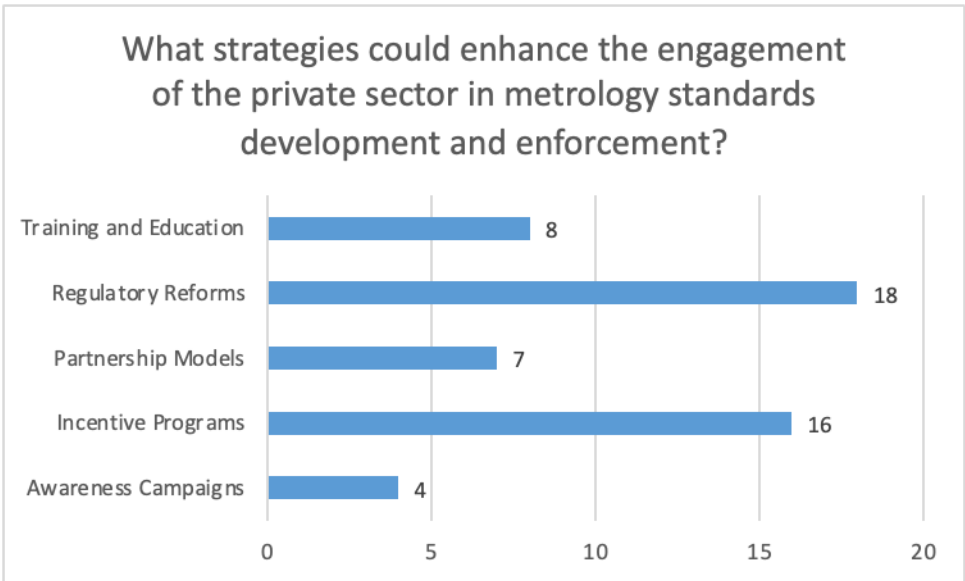
Training and Education (8 Responses): Training and education were seen as a strategy by 8 respondents.

Regulatory Reforms (18 Responses): Regulatory reforms were identified by 18 respondents as a key strategy.

Partnership Models (7 Responses): Partnership models were favored by 7 respondents.

Incentive Programs (16 Responses): Incentive programs were selected by 16 respondents.

Awareness Campaigns (4 Responses): Awareness campaigns were chosen by 4 respondents.



Regulatory reforms are the most commonly suggested strategy, indicating that changes in regulations and policies are seen as crucial for improving private sector engagement. Reforms could simplify compliance, create clearer guidelines, and align regulations with international standards, making it easier for the private sector to participate in metrology standards development and enforcement. This can improve the overall efficiency and effectiveness of the NQI.

Incentive programs are also a popular suggestion, reflecting a strong belief that financial or other incentives can motivate private sector involvement. Offering incentives such as tax breaks, grants, or recognition can encourage private sector companies to actively participate in metrology standards and enforcement. Incentives can lower the cost of compliance and promote investment in metrology infrastructure and training.

Training and education are less emphasized but still considered important. This suggests that improving knowledge and skills in metrology can help engage the private sector. Providing training and education can enhance the private sector's understanding of metrology standards, thus improving

compliance and active participation. It can also help build a skilled workforce that is capable of implementing and enforcing standards.

Partnership models are seen as a useful strategy but are less prioritized compared to regulatory reforms and incentives. Developing partnership models between public institutions and private entities can foster collaboration and resource-sharing. Effective partnerships can lead to more robust metrology systems and better alignment of private sector practices with national standards.

Awareness campaigns received the fewest responses, suggesting that while important, they are not viewed as the primary strategy for enhancing engagement. Awareness campaigns can help inform the private sector about the importance of metrology standards and their role in compliance. However, they may need to be complemented with more tangible strategies, like regulatory reforms and incentive programs to be effective.

Enhancing the engagement of the private sector in metrology standards development and enforcement requires a multifaceted approach. Regulatory reforms and incentive programs are prioritized strategies that can significantly improve private sector involvement. Complementing these with training, partnership models, and awareness campaigns will further support the effective management of the NQI for trade in OIC member countries.

Question 18. What are your top recommendations for improving performance measurements or indicators in metrology?

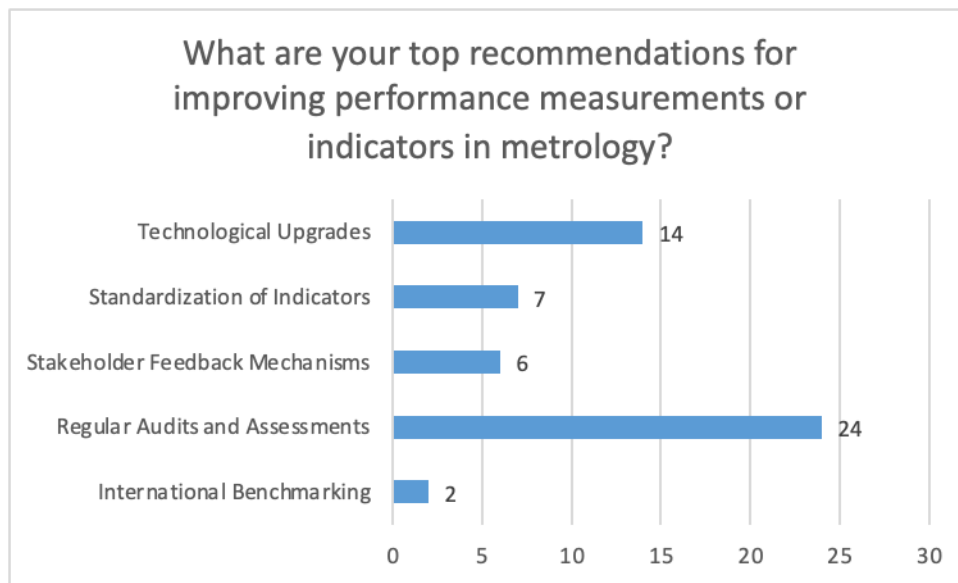
Technological Upgrades (14 Responses): 14 respondents emphasized the need for technological upgrades.

Standardization of Indicators (7 Responses): 7 respondents highlighted the importance of standardizing indicators.

Stakeholder Feedback Mechanisms (6 Responses): 6 respondents suggested incorporating stakeholder feedback mechanisms.

Regular Audits and Assessment (24 Responses): 24 respondents identified regular audits and assessments as a key strategy.

International Benchmarking (2 Responses): 2 respondents recommended international benchmarking.



Regular audits and assessments received the highest number of responses, indicating broad agreement on their importance. Implementing regular audits and assessments can provide ongoing evaluations of metrology performance, ensuring that standards are being met and identifying areas for improvement. This practice enhances accountability, transparency, and the overall effectiveness of the NQI.

Technological upgrades are also highly emphasized, reflecting the need for advanced tools and systems to improve measurement accuracy and efficiency. Investing in modern technology can enhance the precision and reliability of measurements, streamline processes, and support the development of more effective performance indicators. Up-to-date technology helps maintain the credibility and competitiveness of the metrology infrastructure.

Standardizing indicators is seen as a crucial step but is less prioritized compared to regular audits and technological upgrades. Standardizing performance indicators ensures consistency and comparability in measurements and assessments across different sectors and regions. This facilitates better benchmarking and more accurate evaluations of metrology practices.

While important, stakeholder feedback mechanisms received fewer responses, suggesting that they are considered a supplementary strategy. Incorporating feedback from stakeholders can provide valuable insights into the effectiveness and relevance of metrology practices. Engaging with users and industry players helps tailor performance measures to actual needs and challenges.

International benchmarking received the fewest responses, indicating it may be viewed as less critical compared to other strategies. Although less emphasized, international benchmarking can be useful for

comparing national metrology performance with global standards and practices. It provides a framework for evaluating and improving performance relative to international best practices.

Improving performance measurements and indicators in metrology requires a combination of strategies. Regular audits and assessments, along with technological upgrades, are prioritized actions that can significantly enhance the effectiveness of the NQI. Standardizing indicators, incorporating stakeholder feedback, and considering international benchmarking further support a comprehensive approach to performance measurement and management in OIC member countries.

Question 19. What should be the future priorities for enhancing the metrology pillar within the QI system in your country?

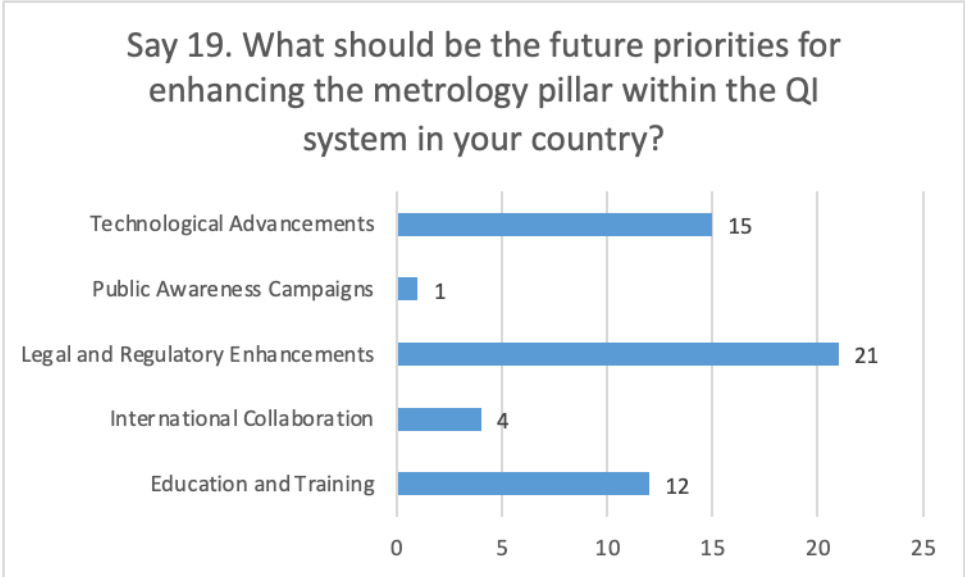
Technological Advancement (15 Responses): 15 respondents prioritized technological advancements.

Public Awareness Campaigns (1 Response): 1 respondent highlighted public awareness campaigns.

Legal and Regulatory Enhancement (21 Responses): 21 respondents emphasized legal and regulatory enhancements.

International Collaboration (4 Responses): 4 respondents identified international collaboration as a priority.

Education and Training (12 Responses): 12 respondents focused on education and training.



This is the most emphasized priority, suggesting that there is a significant need to strengthen the legal and regulatory frameworks governing metrology. Enhancing legal and regulatory frameworks ensures

that metrology practices are not only compliant with international standards, but are also robust enough to support effective trade practices. Strong regulations provide clarity, enforceability, and consistency in metrology practices, which are crucial for maintaining trade quality and confidence.

Technological advancement is the second most cited priority, indicating a recognition of the need to modernize and update metrology technology. Investing in new technologies can improve measurement accuracy, efficiency, and capabilities. Advanced technology supports the implementation of up-to-date metrology practices and can enhance the overall effectiveness of the NQI.

Education and training are also important, though less prioritized compared to legal and technological aspects. Focusing on education and training helps build a skilled workforce capable of implementing and maintaining high standards in metrology. It ensures that personnel are well-versed in current practices and technological advancements, contributing to more effective management of metrology systems.

International collaboration is less emphasized, but still noted as a priority. Engaging in international collaboration can facilitate knowledge exchange, standardization efforts, and alignment with global best practices. This can enhance the national metrology system by integrating international expertise and fostering cross-border cooperation.

Public awareness campaigns are mentioned the least. While public awareness is important for overall support and understanding of metrology, it is currently less prioritized compared to other strategic areas. However, increasing public awareness can contribute to broader support for metrology standards and practices.

To effectively manage the NQI for Trade in OIC member countries, priorities should focus on enhancing legal and regulatory frameworks, investing in technological advancements, and strengthening education and training. International collaboration should also be pursued to integrate global practices, while public awareness campaigns, though less emphasized, can further support the overall metrology system. Balancing these priorities will help build a robust and effective metrology pillar within the NQI.