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Research quality framework for universities and research institutions

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Abstract: The objective of this study was to develop a framework to perform research quality assessment of universities and research institutions operating in Mauritius. The methodology involved the use of both exploratory and descriptive research designs. The assessment of the national research status and review of literature on research quality frameworks (RQF) led to the identification of four main research quality dimensions and 16 new indicators relevant for Mauritius. The main contribution of the study is the development of a standard RQF with 42 indicators to assess research quality for Mauritian universities and research institutions. In addition to the RQF, a software for institutional research quality assessment and for associated policy decision making was developed. The use of the RQF was found to be a vital tool of national importance, for use by research institutions and higher education institutions (HEIs) in making strategic choices while pursuing their research agenda.

Keywords: research quality; research quality framework; research assessment; bibliometrics; universities; research institutions.

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1 Introduction

Human advancement is closely associated to the result of research in the form of novel technologies, products and services, and processes and techniques, among others, which aim at improving the quality of life. Aagaard-Hansen and Svedin (2009), and Carew and Wickson (2010) opined that the assessment of research quality is fundamental to make sure that research continues receiving support and funding, and to make researchers realise the significance of high-quality research. In this context, several national frameworks have been developed around the world for assessing the quality of research and eventually its impact on society. However, Pinar and Horne (2022) pointed out that there have been many criticisms on several aspects of already existing frameworks. These include the significant costs involved in the preparation and evaluation of research quality; the lack of objectivity in the assessment exercise; and the lack of transparency in making judgements for the allocation of research funds to supposedly quality-related research. Internationally, there is no accepted or standardised method for evaluating research quality. This is mainly due to different nations or institutions having different intents for evaluating the quality of their research works. In the case of Mauritian universities and research institutions, there is no standard framework to assess the quality of research being undertaken at national level or by researchers as a result of public funding received. The traditional method of research assessment is the peer-review mechanism whereby research plans or scientific results are scrutinised by scientific colleagues. However, Pinar and Unlu (2020) disclosed that peer-review is often performed either by narrow specialists who are unable to compare different projects, or by people with broad scientific qualifications, but without the specific insight required to evaluate the ingenuity of results generated within a scientific field. As such, the use of the peer-review mechanism as a sole means of assessing research projects involves serious shortcomings given that such a method is subjective and may provide for a certain degree of biasness on the part of the reviewers.

An important matter which needs urgent attention is the annual ranking of Mauritius which has remained constantly low over the years in comparison to other economies. It is to be noted that one of the factors that contribute to the low GII ranking is the country's low level of overall research performance which is derived from an assessment of the country's capacity for delivering high level research outputs leading to important knowledge creation. As such, this influences the country's GII ranking by directly impacting the level of innovation. In the Mauritian context, the main institutions with the highest number of research publications are a consortium of the local universities and research institutions. Therefore, it becomes increasingly crucial for these institutions to ensure high-quality research which can correctly position them at national and

international levels and improve their reputation thus making them more attractive to prospective researchers and national and international funding agencies. The RQF will be useful in demonstrating their performance to research funding agencies and hence guide them in the funding allocation decisions for research given that currently, there is no such established mechanism locally. The development and implementation of the framework will also help Mauritian universities and research institutions to integrate more into the global research community thus facilitating the exchange of knowledge and innovation and promoting collaborations with other universities and research institutions globally thereby ensuring their visibility. Moreover, an RQF can establish and maintain high standards of the quality of research and ensure that research outputs are robust, reliable and internationally competitive. This will eventually lead to an improved ranking of the country. The implementation of a carefully designed RQF will also support continuous improvement by identifying areas for enhancement and will lead to an enhanced research impact by ensuring that the findings are relevant, significant and applicable to real-life problems thereby contributing to societal and economic developments with a view to improving quality of life.

Furthermore, the development of the RFQ aligns to the requirements of several sustainable development goals (SDGs). It contributes to SDG 4 by promoting high standards in research thus enhancing the quality of education offered by universities. In relation to SDG 9, a robust RQF would ensure research production that can contribute to technological advancements and industrial growth as a driver of innovation and infrastructure development. As for SDG 17, the use of a RFQ promotes collaboration between universities, industries and governments thereby fostering partnerships that have an impact. These 3 SDGs collectively emphasise the importance of high-quality research in fostering education, innovation and partnerships necessary for sustainable development. Hence, the principal objective of this study was to develop a standard research quality framework (RQF) that can be adapted and implemented by any university/research institution to assess research quality. The study also aimed at developing a novel dynamic tool that would automate the assessment process.

The upcoming sections include a literature review of the different RQF implemented at international level. Their specific purpose and diverse indicators/metrics used for the assessment have been provided together with important gaps which this study addresses. The methodology provides an overview of the overall methods adopted for the successful completion of the study and details of the different steps used. This led to the development of a novel RQF through a detailed analysis of existing frameworks and addressing their shortcomings. The novel RQF was tested and refined through FGDs and in-depth interviews with stakeholders. Finally, a software was developed for automating the use of the RQF at institution level and recommendations were made for its effective use.

2 Literature review

Hansson and Monsted (2008) revealed that, over time, the conditions of conducting research have changed given that much emphasis is laid on the usefulness of specific research to the society. Belcher et al. (2015) disclosed that researchers want their research to reach a large number of people with a view to contributing more effectively towards bringing constructive changes in society. As most researchers argue, nowadays, it is

required not only to demonstrate the relevance but also the applicability of research right from the beginning. Irvin and Arhar (2003) claimed that though there is a consensus regarding the need for research of high quality, yet there is differing mindsets on what constitutes quality research. Langfeldt et al. (2019) highlighted that the notion of research quality is contextual and they vary between fields of research which are poorly understood. Oberg (2008) and Huutoniemi (2010) also stated that there is no consensus on a precise definition of quality research. According to Belcher et al. (2015), researchers and scientists are stressed about value additions in existing research. As such, they constantly look for guidance in a bid to produce high-quality research. Therefore, there is a strong need for appropriate principles, guidelines, criteria, or even benchmarks to be able not only to design a research activity, but also to evaluate its potential, progress, and accomplishments.

This era is witnessing an urgent call on behalf of researchers, practitioners, funding agencies and Governments for establishing a standard framework for the proper assessment of the quality of research being conducted. Smith et al. (2011) and Dougherty et al. (2016) highlighted that the assessment of research has been a long tradition which has been increasingly used to assess the quality of research produced by Higher Education Institutions (HEIs). However, Hicks et al. (2015) stressed that research assessments are now more dependent on certain metrics as compared to the dependency on the peer-review mechanism. Pinar and Unlu (2020) stressed that a certain degree of bias was observed during the research assessment exercises using the peer-review mechanism as the sole method of assessment. The idea of making a national assessment has been very controversial given the complexities involved in conducting such assessments involving the economic, social, and cultural aspects of research. Charmaz and Thornberg (2021) and Firdissa (2023) reiterated that notwithstanding the constraints, it is essential for researchers to have relevant quality benchmarks and practical guiding criteria to establish the quality of research being produced and published. Moreover, Pinar and Horne (2022) stressed that performance-based research funding systems have been used to a great extent around the world to allocate research funds and having a proper mechanism in the form of a dedicated assessment tool could aid to identify quality research for proper allocation of grants in the future.

An overview of the diverse mechanisms established for assessing research quality by 18 different countries with the highest number of publications has been provided in Tables 1 to 5. The details of the diverse frameworks pertaining to five regions namely Europe, Asia, North America, Australia, and Africa have been presented respectively. The specific purpose they serve, and the diverse tools/indicators used to evaluate the quality of research have also been highlighted.

Many countries have not yet realised the importance of assessing the quality of their research given that only 18 countries across the globe were found to have implemented a mechanism for assessment of research quality. The assessment frameworks were completely different given the fact that the evaluation culture differed considerably from country to country. As presented by Stark (2011), research performed in different domains of society gets evaluated by different kinds of evaluation mechanisms given that each assessment is context specific. The assessment using metrics is performed mostly in the fields of natural and life sciences. However, as per Colander and Hunt (2019), the social sciences are the most important among all areas of study because they allow to investigate what determines the human condition and how to improve it from different perspectives.

Table 1 Overview of research quality frameworks in Europe

Country	Europe			
	Framework	Purpose		Method/indicators
European countries	EU framework programmes (FP1 – FP7) (Arnold, 2012)	1 To measure and monitor trends in research across countries	1	Peer-review mechanism
UK	Research assessment exercise (RAE) (Rowlinson et al. 2015) Research excellence framework (REF) (HEFCE, 2009)	2 To measure the impact of research activities	2	Bibliometrics
		Evaluate research in higher education institutions		Peer-review mechanism – a panel of experts for each of the 15 subject areas
		1 Evaluate research in higher education institutions	1	Peer-review mechanism
		2 Assess research impact in UK higher education sector	2	Bibliometrics – citation counts, H-index
Italy	VTR – Valutazione Triennale della Ricerca (Francescheta and Costantinib 2011) VQR – Valutazione della Qualità della Ricerca (Bertocchi et al. 2015)	Evaluate research activities conducted by universities and research institutions	1	Peer-review mechanism – panel of experts (qualitative method – converted into quantitative ratings)
			2	Bibliometrics – article citation rating; journal citation rating; journal impact factor; H-index
		Evaluate scientific publications of all Italian universities and research institutions	1	Peer-review mechanism
		Italian national agency for the evaluation of university and research institutes (ANVUR)	2	Bibliometrics – citations, impact factor, 5-year impact factor, impact per publication, article influence score, SCImago journal ranking, source normalised impact per paper, and H-index
Germany	German excellence initiative (Kuhlmann, 2003)	To strengthen university structures and promote Germany as a location for excellent research	3 layers of assessments:	
			1	Individual research performance – peer-review mechanism; bibliometrics
			2	Impact of research and innovation policy programmes – peer-review mechanism
			3	Performance of institutions

Source: Author's construction

Table 1 Overview of research quality frameworks in Europe (continued)

<i>Country</i>	<i>Europe</i>		
	<i>Framework</i>	<i>Purpose</i>	<i>Method/indicators</i>
Spain	Evaluation of scientific research quality (Carmona et al., 2005)	To evaluate quality of scientific research	1 Peer-review mechanism 2 Bibliometrics – citations, journal impact factor, H-index
The Netherlands	Evaluation of societal quality of research (Van-Der-Meulen and Rip, 2000)	To evaluate societal quality of research	Peer-review mechanism and site visits
Norway	Framework for ex-post evaluation (Meunier and Welde, 2017)	To assess the social benefits emerging from research	Quantitative and qualitative assessment using a number of evaluation criteria (Norwegian Concept Research Programme)
Sweden	Research quality assessment (Wigren-Kristoferson et al., 2011; Wegman et al., 2007)	Comparison of high-performing researchers	1 Quantitative techniques using questionnaires and qualitative analysis of interviews 2 Bibliometrics – citation index, impact factor, citation rate, collaboration index, number of scientific publications
France	Research quality assessment (Courtault et al. 2010)	To evaluate research	Bibliometrics – number of citations, h-index, g-index

Source: Author's construction

Table 2 Overview of research quality frameworks in Asia

Asia			Method/Indicators
Country	Framework	Purpose	
India	Evaluation of the state of research quality (Sethi and Panda, 2014; Gangan, 2016a, 2016b; Kostoff et al., 2007)	To measure productivity of research institutes, individual researchers and to record the growth of particular subjects	1 Bibliometrics – publication trends, impact factor, citation index, H-Index 2 Scientometrics – citation analysis, impact of publications, qualitative and quantitative methods 3 Citation study 4 Content analysis 5 Framework score (F-score) 6 Web applications
Mainland China	Research performance evaluation (Li et al., 2012)	To evaluate the performance of Chinese universities	Bibliometrics: 1 Research Productivity index (RPI) based on the number of published papers, total citation counts 2 Research quality index (RQI) based on citation per paper, H-index, normalised citation impact
Hong Kong	Research assessment exercise (RAE) (French et al., 2001; Reddy et al., 2016; Qin and Wang, 2005; Meng et al., 2006)	To assess research impact on development of the national economy	1 Bibliometrics – citable documents, number of citations, cites per documents, H-index, impact factor 2 Aggregated efficiency analysis (AEA) – peer-review, qualitative and quantitative assessment 3 Data envelopment analysis (DEA) – statistical and econometric methods
Indonesia	Research impact assessment (RIA) (CGIAR, 2006)	To evaluate the impact of policy-oriented research in agriculture	Elements of assessment: 1 Output 2 Diffusion 3 Outcome 4 Impact
Saudi Arabia	Institutional research evaluation model (IREM) (Mazen et al., 2016)	To provide a concise and clear concept for enabling quality assessment of R&D of an institution in quantitative terms	The above elements are assessed using a number of indicators Quality assessment indicators – impact factor, article influence score, citations per paper, publications in indexed journal Trend indicators – number of publications, study design, subject of research Data extraction – inclusion and exclusion criteria, search engine, data extraction technique Statistical analyses
Singapore	Quality assurance framework for universities (QAFU) (Vidovich, 2008)	To conduct self-assessment of institutions involved in research	Assessing research performance using self-selected performance indicators

Source: Author's construction

Table 3 Overview of research quality frameworks in North America

<i>North America</i>				
<i>Country</i>	<i>Framework</i>	<i>Purpose</i>	<i>Method/Indicators</i>	
USA	Research assessment exercise (RAE) (Diana et al., 2004; Michelson, 2006)	To evaluate the quality of research and their impact	1	Peer-review mechanism
			2	Bibliometric analysis – analysis of publication records of institutions, number of publications, quality of journals in which papers were published; citation impact of papers; percentage of papers co-authored with other institutions, citation index, patents
			3	Econometrics
			4	Benchmarking
Canada	Transdisciplinary research quality framework (RQF) (Aagaard-Hansen and Svedin, 2009; Belcher et al., 2015)	To assess research which cuts across disciplines	1	Evaluation dimensions: societal relevance; impact; integration
			2	Evaluation criteria: relevance; credibility; legitimacy; effectiveness
	Evaluation of research in the context of the National Cancer Institute of Canada (NCIC) (Campbell et al., 2010)	To assess cancer research	1	Evaluation-Phase I: process review – peer review (self-administered surveys and review panel)
			2	Evaluation-Phase II: bibliometric analysis – number of papers, average of relative citations (ARC)
			3	Evaluation-Phase III: case studies

Source: Author's construction

Table 4 Overview of research quality frameworks in Australia

<i>Australia</i>				
<i>Country</i>	<i>Framework</i>	<i>Purpose</i>	<i>Method/indicators</i>	
Australia	Research evaluation parameters (Franklin, 1988)	To conduct research evaluation	1	Peer-review mechanism
			2	Bibliometrics
	Research quality framework (RQF) (Haddow, 2007)	To assess the quality and impact of research	1	Peer-review mechanism – 13 expert panels each comprising 12 members
			2	Limited dependence on bibliometrics
	Excellence in research for Australia initiative (ERA) (Christopher, 2008)	To assess research excellence	More dependent on bibliometrics than peer-review	

Source: Author's construction

Table 5 Overview of research quality frameworks in Africa

Africa					
Country	Framework	Purpose	Method/indicators		
South Africa	Research evaluation rating system (Pienaar et al., 2000)	To evaluate performance of research journals	1	Peer-review mechanism	
			2	Bibliometrics – citation analysis	
	Strategic framework to assess research journals (Pouris and Pouris, 2015)		1	Questionnaire	
			2	Peer-review	
			3	Bibliometrics – journal impact factor	
			4	Eigenfactor	
			5	Internationalisation of editorial boards of the country's journals	

Source: Author's construction

One similarity is that most of the frameworks focused on assessing research quality either at university level or research institution level. In some cases, the assessment focused on both. Zacharewicz et al. (2019) highlighted that many of the frameworks made use of the peer-review method together with only a few bibliometric indicators. However, Aksnes et al. (2019) affirmed that bibliometric indicators have been increasingly applied in research assessment exercises in recent years as compared to initial days of assessment. Zacharewicz et al. (2019) asserted that for instance, the UK research excellence framework (REF), was one of the few assessment models that proposed to use both quantitative indicators and the peer-review mechanism for assessing the quality of research. However, Aksnes et al. (2019) highlighted that the panel of reviewers chose not to make use of these metrics. Pinar and Unlu (2020) stressed that the review panels preferred not to use bibliometric information given that there was no systematic procedure to incorporate the quantitative information into the assessment process. On the other hand, Zhang and Sivertsen (2020) highlighted that there has been a recent reform in the research assessment exercise in China, for instance, which moves the focus from conducting a purely quantitative assessment to a balanced blend of qualitative and quantitative research assessment. Moed (2020) stated that this model shifts from a complete dependence on web of Science indicators as the sole method of assessment to integrate the peer-review mechanism in the system. However, Aksnes and Sivertsen (2019) were of the view that this system would still need an integrated research information system and a national journal evaluation system. However, the real issue brought forward by Zhang and Sivertsen (2020) was the challenges involved in the implementation of the system. As such, the proposition of using any method of assessment is of no use until and unless a proper and context specific assessment mechanism is established and duly implemented to provide the necessary tools for assessment.

It has been observed that countries in the African continent were ignoring the benefits and purpose of having an RQF to assess research quality and hence, were not seen to have ventured in this direction. Though several African countries are now seen to be undertaking research, not only within the local context, but also in collaboration with international institutions, yet only South Africa provided evidence of having endeavoured to initiate the process of assessing research quality. Wang et al. (2017) acclaimed that

novel research is more likely to be picked out by the peer-review evaluation method which prevents it from not being internationally recognised and are as a result published in low impact factor journals. Decades ago, the assessment of research quality started through the peer-review method, and this is the main reason why many institutions, nations and research groups have mainly been using the peer-review method of assessment so far. However, one of the limitations which many authors including Lee et al. (2013) highlighted was that the opinions of experts may be subjective, and their judgement may involve a lack of knowledge on the subject under scrutiny. Another peer-review bias as pinpointed by Lee et al. (2013) and Garcia et al. (2015) relate to editors judging the article by the reputation of either the author or the affiliated institution.

Overall, it was observed that whatever the name of the framework, the methods and indicators used to assess research quality were more or less the same with variations in the indicators being used by different countries and institutions. Zacharewicz et al. (2019) affirmed that research performance is assessed using three methods in general namely assessment based on quantitative metrics (bibliometrics); assessment based on the expert peer-review mechanism; or assessment based on a hybrid system based on both bibliometrics and peer-review which allow for an informed peer-review exercise whereby reviewers can use bibliometric data to make a judgement. Each of the three methods has several indicators to assess the quality of research performance. However, they must be used as a proper mix to assess all aspects of research quality within a specific context. Nevertheless, Wooldridge and King (2019) strongly opined that the outcomes of some of the metrics correlate with the peer-review assessment exercise.

3 Gaps in literature

During the course of the study, the following gaps were identified in the literature:

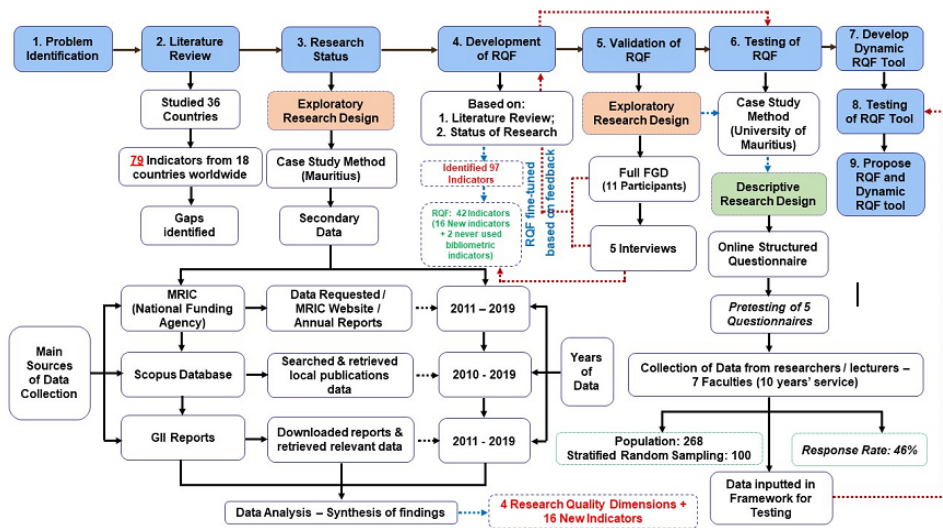
- Firstly, there is no consistent way to measure the quality of research in HEIs in general. Though most of the assessments are based on HEIs, yet there is no one standard or comprehensive framework to assess the quality of research within all universities of a particular country.
- Secondly, the use of the peer-review mechanism as the sole means of assessment method gives rise to subjectivity given that the opinions of experts can be biased. On the other hand, the use of bibliometric indicators as the only means to evaluate research would also not be appropriate. This practice impedes the conduct of a proper and accurate assessment thus producing unreliable or inappropriate assessment results which severely impacts the decision-making process.
- Thirdly, no framework was seen to be using a synthesis of all relevant bibliometric indicators within the university and research institution context for assessing research quality. The use of bibliometric indicators is limited to only a few selected indicators being used by nations to assess research quality. Using any bibliometric indicator in isolation or in limited numbers cannot ensure a proper assessment of research quality given that the selection of the few indicators might be subjective thus resulting into an incomplete assessment.

- Fourthly, existing RQFs do not focus on promoting innovation and the protection of knowledge created through intellectual property rights (IPRs). To date, only the European and American models were seen to have included patent applications and patent grants respectively as one of the indicators to assess the quality of research.
- Finally, the bibliometric community was seen to be discouraging the use of conventional bibliometric methods for evaluating research in the Social Sciences and Humanities (SSH). The reason being that the traditional bibliometrics focused a lot on the journal impact factor and H-Index which according to many authors were inadequate to correctly assess research quality in the SSH. However, this created confusion thus leading to a fundamental misconception that bibliometric indicators that are extensively used for evaluation in the natural and life sciences are not applicable in the SSH research areas.

The above important gaps have been duly considered and addressed in the proposed framework. The upcoming section details the research methodology that was adopted for this study.

4 Research methodology

In order to develop the RQF, a mixed method comprising of the exploratory and descriptive research designs was used as illustrated in Figure 1. The research process involved nine major steps including identification of the research problem; conducting of literature review and identifying relevant gaps; conducting a status of research in the Mauritian context; development of the RQF; validation of the RQF; testing of the RQF; development of the dynamic RQF tool; testing of the RQF tool; and finally proposing the RQF and the accompanying assessment tool for Mauritian universities and research institutions. Upon identification of the research problem, an extensive literature review was conducted to identify the diverse indicators being used by international frameworks to assess research quality following which a synthesis of the relevant indicators was made. As part of the exploratory research design, the study then used Mauritius as a case study to assess the research status of the country which was crucial to determine the applicability of relevant indicators in the Mauritian context. The RQF was developed based on the outcomes of the literature review and the Mauritian research status. The developed RQF was validated with major stakeholders using FGDs and interviews. The University of Mauritius (UoM) was used as a case study to test the effectiveness of the developed framework. For this part, the descriptive research design was used whereby an online questionnaire was designed to collect relevant data from university researchers and academics which was input into the framework for testing purposes. Once, the framework was tested, a dynamic RQF tool was developed in the Microsoft Spreadsheet software using advanced formulas and conditional formatting. The RQF tool was tested using the same dataset collected from the university prior to proposing the tool for implementation. The detailed step by step description of the methodological approach has been provided in the subsequent section.

Figure 1 Research strategy and methodology (see online version for colours)

Source: Author's construction

5 Major steps involved in the development, validation and testing of the RQF

5.1 Steps 1 and 2: Identification of research problem and indicators

Upon identification of the research problem (first step), the second step involved conducting an extensive review of existing literature to identify established mechanisms including specific indicators for the purpose of assessing research quality. In this respect, a total of 36 countries with the highest number of publications in 2018 were considered at regional and international levels. A total of 529 journal articles were considered out of which around 200 journal articles were relevant to the context of the study. On the international level, 25 countries from Europe, Asia, North America, South America and Australia were considered whereas 11 countries were considered from the African region. It is to be noted that out of the 36 research active countries, each having a significant number of publications, 18 countries, international and regional combined, were found to have evidence of the conduct of research quality assessments through some kind of mechanism or framework. The 18 countries have been presented in Tables 1 to 5. The literature review enabled a review of the existing techniques which led to the identification of 79 indicators, including bibliometric indicators, scientometric indicators, the peer-review mechanism, and other indicators, being used by different countries across the globe to assess the quality of research undertaken.

5.2 Step 3: Case study method – research status of Mauritius

The third step involved using Mauritius as a case study for the purpose of collecting and analysing secondary data with a view to having a broader overview of the national status

of research. For this segment, a three-pronged methodological approach was embraced. Firstly, statistics related to successfully completed research projects funded by the Mauritius Research and Innovation Council (MRIC), the apex body to promote, coordinate and fund research and development (R&D) and innovation in the country, were compiled through an official request as well as from its official website and published annual reports. Secondly, statistics related to publications by Mauritian authors in peer-reviewed journals that were indexed in the Scopus database were considered. Thirdly, statistics pertaining to several research and innovation (R&I) indicators sourced from the World Intellectual Property Organisation (WIPO) and published in the global innovation index (GII) reports were used to gauge the research impact. A synthesis of the analysis from all three sources were made for the purpose of the research status assessment. Data for a 10-year period ranging from 2010/2011 to 2019 were used for the assessment. This excludes the covid-19 pandemic period. The case study helped in identifying four major research quality dimensions which formed the basis for developing the framework for universities.

5.3 Step 4: Development of research quality framework

The development of the RQF was the fourth step in the research process. The outcomes of the literature review and the research landscape of Mauritius played a major role in identifying the diverse indicators for inclusion in the contextualised framework. The RQF was principally developed based on the identified four research quality dimensions namely R&D; knowledge creation; knowledge diffusion; and knowledge impact, each encompassing a series of assessment indicators. In total, 97 indicators were identified which were carefully analysed in the local university context for inclusion in the developed RQF as follows: 79 indicators from the literature review; 16 new indicators from the assessment of the Mauritian research status; and two existing but never used bibliometrics proposed in the FGD. After conducting an extensive scrutiny of the 97 indicators, 45 indicators were carefully selected to be included in the developed RQF. The number of indicators were later reduced to 42 indicators based on recommendations from key participants of the FGD and interviews.

5.4 Step 5: Validation of developed RQF

5.4.1 Focus group discussion

The developed RQF was presented during a FGD to representatives of 11 institutions from Public HEIs (UoM, University of Technology, Mauritius, Universite des Mascareignes, MIE); private HEIs (Middlesex University, Polytechnics Mauritius Ltd); research institutions (MRIC, MSIRI); regulatory body (Higher Education Commission); public institutions involved in research (National Productivity and Competitiveness Council); and non-governmental organisation (Eco-Sud) involved in research. The FGD involved scrutiny and discussions on the framework, including the research quality dimensions, the different indicators and their specific parameters to be used for each indicator. The same set of questions were used for the FGD and interviews (Appendix 1).

5.4.2 *In-depth interviews*

In addition to the FGD, in-depth interviews were also conducted individually with 5 key resource persons from universities and research institutions namely the UoM; University of Technology, Mauritius (UTM); Mauritius Institute of Education (MIE); MRIC; and Mauritius Sugarcane Industry Research Institute (MSIRI). The constructive feedback received from both the FGD and interviews were taken into consideration and the developed framework was further fine-tuned.

5.5 *Step 6: Testing of developed RQF: case study method*

Upon refinement of the developed RQF, its effectiveness was tested. The UoM which is the leading research driven university in Mauritius was taken as a case study. Complete datasets related to a number of indicators were available through the Scopus database and other reliable sources namely The World Bank; Scimago Journal and Country Rank; Resurchify; and EigenFactor.org. However, given that the university does not record data related to these indicators, the use of the descriptive research design was used to gather crucial primary data for certain indicators from the university's research staff through an online survey. The compiled data were input into the developed RQF and calculations were performed manually to test the effectiveness of the RQF.

5.5.1 *Questionnaire design*

For the testing phase, an online structured questionnaire (Appendix 2) mainly comprising of closed-ended questions in the form of multiple-choice questions (MCQs) was devised to collect primary data that allowed for the testing of the different indicators and subsequently, the testing of the overall RQF. The questionnaire contained 14 different sections and 25 MCQs. Given that the objective of the data collection was principally to test the framework, data for a one-year period, that is, for year 2019, were collected for each of the specific indicators.

5.5.2 *Population size, sampling frame and technique*

The UoM had a population size of 268 researchers/lecturers with a student population of around 10,000 as of June 2022. The stratified random sampling technique was used whereby researchers with more than 10 years of service from each of the seven faculties were targeted for the administration of the questionnaire. The sampling size consisted of 100 potential respondents representing an average of 37% of the population. A breakdown of the population size, the sample size and the number of responses received are provided in Table 6.

5.5.3 *Data collection*

The link of the online questionnaire was forwarded individually to the 100 potential respondents by email and all responses received were automatically saved in an online database that was downloaded in an Excel format.

Table 6 Population size, sample size and responses received

<i>Faculties – University of Mauritius</i>	<i>Population size as at June 2022</i>	<i>Sample size (Respondents with more than 10 years of service)</i>	<i>Number of responses received</i>
Faculty of Agriculture (FoA)	19	7	4
Faculty of Engineering (FoE)	49	18	12
Faculty of Information Communication and Digital Technologies (FoICDT)	39	15	3
Faculty of Law and Management (FLM)	51	19	7
Faculty of Medicine and Health Sciences (FoMHS)	16	6	3
Faculty of Science (FoS)	38	15	7
Faculty of Social Sciences and Humanities (FoSSH)	56	20	10
<i>Total</i>	<i>268</i>	<i>100</i>	<i>46</i>

Source: Author's construction**Table 7** Synthesis of methods and indicators for assessing research quality worldwide

<i>Methods</i>	<i>Indicators</i>
Peer-review mechanism	
(Panel of experts)	Quantitative techniques (using questionnaires); qualitative techniques (using interviews and case studies) – converted into quantitative ratings
Bibliometrics	Number of publications/papers; type of publication; citable documents; citations per paper (CPP)cites per document; citation rate; total citation counts (number of citations); immediacy index (II) and Cited half-life index (CHL); citation analysis; citation index; average of relative citations (ARC); highly-cited publications (HICIT); author h-index; institutional H-index; journal H-index; author G-index; institutional G-Index; journal G-index; article citation rating (ACR); journal citation rating (JCR); impact factor/journal impact factor (JIF); activity index (AI) and relative impact factor (RIF); 5-year impact factor (IF); impact per publication (IPP); article influence score (AIS); publications in indexed journal; publications in refereed journal; publication trends; analysis of publication records of institutions; research productivity index (RPI); Research quality index (RQI); number of ESI fields (F); normalised citation impact (NCI); SCImago journal ranking (SJR); source normalised impact per paper; Eigenfactor; internationalisation of editorial boards of the country's journals; analysis of institutional publication records; citation impact of papers; percentage of papers co-authored with other institutions; number of patents; high-quality patent applications (PCTPAT); ranking of research publication outlets; world class Universities and Research Institutes (TOPINST)

Source: Author's construction

Table 7 Synthesis of methods and indicators for assessing research quality worldwide (continued)

<i>Methods</i>	<i>Indicators</i>
Scientometrics	Citation analysis; citation study; impact of scientific publications (using qualitative, quantitative, and computational methods); content analysis; framework score (F-Score); web applications (highly cited papers; publications in top journals; number of publications (P); and best paper rate (BPR)
Other methods/indicators	aggregated efficiency analysis (AEA) – including qualitative (peer-review) and quantitative (bibliometrics) methods; site visits; number of conferences; types of conferences; number of participants in conferences; number of policy makers present in conferences and influence on policy; number of press releases; number of press articles; changes in policies; reinforcement of existing policies; implementation of policy changes; changes in institutions; reduced poverty, improved food and nutrition security; sustained livelihoods of the poor; enhanced natural environment; study design; subject of research; statistical analyses – descriptive statistics, trend analysis using statistical tests and regression analysis; econometrics; benchmarking; research grants received; internationalisation of editorial boards of the country's journals

Source: Author's construction

5.5.4 Response rate

A total of 46 responses were obtained representing a response rate of 46%. All 46 responses provided relevant data which were duly considered. Given that the objective of the survey was not meant to have a sample which is representative of the population but rather to collect some data to test the effectiveness of the framework, the response rate was deemed largely sufficient.

5.6 Steps 7, 8 and 9: Development, testing and proposing the dynamic RQF tool

Finally, to ease the assessment exercise, a dynamic tool was developed in Microsoft Spreadsheet using advanced formulas including 'IF', 'AND' and 'OR' functions for the 42 indicators to automatically assess the performance of university research in terms of quality. The dynamic RQF tool simply requires to be fed with the appropriate data and the research quality performance is automatically generated and the corresponding rating for the institution is provided together with a colour coding. The tool was tested using data collected from the UoM and was finally proposed for implementation.

6 Results and analysis

6.1 Synthesis of indicators

A synthesis of the different methods and indicators adopted worldwide for the purpose of undertaking an assessment of research quality was made which provided a strong base to initiate the development of the RQF. The literature review revealed 79 indicators used as

different mixes across the globe which were classified principally under four main methods namely the peer-review mechanism (2 indicators); bibliometrics (44 indicators); scientometrics (9 indicators) and other methods/indicators (24 indicators).

The status of Mauritian research led to two important outcomes which proved to be beneficial in the development of the RQF. Firstly, it led to the identification of four main research quality dimensions which were used as a basis for the development of the RQF. Secondly, the outcome also helped in identifying 16 new indicators as presented in Table 8.

Table 8: Identified research quality dimensions and new indicators

<i>4 Research quality dimensions identified</i>		<i>16 New indicators identified</i>	
1	Research and development	1	Researchers, full-time equivalent (FTE)/mn pop
2	Knowledge creation	2	Gross expenditure on R&D, % of GDP
3	Knowledge diffusion	3	Private sector spending on R&D, % of GDP
4	Knowledge impact	4	Number of scientific scholarships
		5	Funding per scientific scholarship
		6	Number of peer-reviewed publications for which funding were received at regional/international level
		7	Annual funding received per peer-reviewed publication at regional/international level
		8	Number of research projects disseminated
		9	Number of PhD graduations
		10	Scientific and technical articles/bn PPP\$ GDP
		11	Publication by source type in peer-reviewed journals
		12	Commercial publishing
		13	Patent filings
		14	Patents by origin/bn PPP\$ GDP
		15	Copyright grants
		16	Industrial designs by origin/bn PPP\$ GDP

Source: Author's construction

The synthesis of the indicators captured a total of 97 indicators, including 2 indicators (CiteScore and % of journal publications cited) which came out from the FGD.

Following development of the first version of the RQF with a set of 45 indicators which was initially aimed for implementation at national level, a validation exercise was conducted using the exploratory research design in the form of one FGD and five in-depth interviews respectively involving key stakeholders. The upcoming section presents the analysis and results of the discussions held.

7 Analysis and discussions: focus group discussion and in-depth interviews

The FGD and interviews involved lengthy but fruitful discussions with relevant stakeholders whereby the author acted as the moderator and interviewer for the respective sessions. The moderator/interviewer made use of a set of six (6) questions (Appendix 1)

in the English language to systematically capture opinions and feedback from the participants. The representatives of the FGD involved important opinion leaders who were either at the decision-making level or advisory level with the authority or ability to influence policy decisions in the field of research performance assessment within their respective institutions. The participants comprised of high-level administrators including executive director; deputy director academic; project director; lead innovation, advocacy and entrepreneurship; and dean of faculty; as well as high-level scholars and researchers involving associate professor; coordinator, senior lecturer; senior researcher; and research officer of relevant institutions. The interviews involved researchers for the purpose of capturing their insights to obtain a global picture from different perspectives and comprised of professors, senior researcher, and research coordinator from 5 relevant institutions involving public HEIs and research institutions. The interviews were conducted to confirm the findings of the FGD. The qualitative method involved a thorough analysis of the discussions held during the FGD based on the following outlooks:

- relevance of the RQF in the Mauritian context
- ability of the different indicators to assess research quality
- applicability of the developed RQF at institutional or national level
- dimensions, indicators and parameters for inclusion in the RQF
- improvements on the developed RQF
- willingness to implement the developed RQF.

The discussions and results of the main aspects considered in the FGDs have been deliberated in this section.

7.1 Relevance/appropriateness of the framework

Participants agreed that there is a need for such a framework which is very relevant in the Mauritian context to assess research quality whereby the results would provide indication of not only the level of research quality but will also help in assessing the strengths and weaknesses in terms of research which impact on quality of life and innovation. This statement has been supported by the following quotes:

“The developed framework is something very important and of relevance.....
(P4)”

“We hope that this framework eventually would be applicable for Mauritius to make an assessment of the strengths and weaknesses in terms of research which impacts on innovation. (P3)”

7.2 Relevance of indicators in the Mauritian context

Participants commented that the proposed framework is quite innovative in the sense that they never came across such a framework which uses a synthesis of a broad but very relevant and precise set of indicators for the proper assessment of research quality. Participants emphasised that the framework includes novel indicators such as IPR in the form of patents, copyrights and industrial designs, as well as a set of 16 new indicators

never used before. The quote below provides evidence of the truthfulness of the above statement:

“.....and quite innovative framework indeed. I never saw such a framework which uses such a large set of very relevant and precise indicators..... It includes novel indicators not used in most of the existing frameworks or not used at all, for instance, patents, copyrights and industrial designs together with 16 newly identified indicators. This is a significant milestone achieved in the field. (P6)”

The participants affirmed that the development of the framework with such a complete set of indicators provides evidence of a major milestone which has been achieved in the field given that these relevant indicators have never been used together in any of the existing international frameworks.

7.3 Applicability of indicators within the local context

After duly scrutinising the framework, participants came up with a very critical conclusion that not all indicators proposed in the RQF would be applicable for the assessment of the quality of research as standard or universal indicators in all sectors of research within the Mauritian context. They argued that some indicators that would apply in a public university context, for instance, might not necessarily apply in the private sector setting. These arguments have been supported by the illustration of the following quotes:

“Some of the indicators may not apply because of the current situation..... (P7)”

“Any indicator which is not applicable in certain situations, how will you include that in your equation to work out the score? (P8)”

However, participants agreed that the proposed indicators fit perfectly for academic and research institutions. They highlighted that these indicators are very relevant in assessing research quality within these institutions given that many of the bibliometric indicators are international indicators that are used by researchers/groups of researchers worldwide as indicated by the following quote:

“Most of the indicators are known to us. They are international indicators that are used by researchers/group of researchers though in limited numbers (P6)”

7.4 Feasibility of using a standard framework for research quality assessment

Participants stressed that the idea of proposing a standard framework to assess the quality of research at National level was too ambitious as illustrated by the following quote:

“The testing of the framework at National level will be too ambitious in the first round. (P2)”.

The reason provided by participants was that the developed framework is completely new in the Mauritian context and implementing it on a national scale would involve many complexities and challenges given that different sectors including private sector organisations have different orientations in terms of outputs and deliverables.

7.5 Limiting the RQF to universities and research institutions

Based on the above discussions, participants strongly recommended to, in the first instance, limit the framework to universities and research institutions only instead of extending it at National level. It was also recommended to test the effectiveness of the framework at university level given that all the indicators included in the framework are applicable for the assessment of university research as per the following quote:

“Proposing an RQF at national level is a very challenging endeavour. In my opinion, you should first test the RQF with at least one (1) university or research institution to see the type of results it would generate and then, later on, perhaps extend it to the whole of Mauritius. (P1)”

The participants of the FGD highlighted that the implementation of the framework at university or research institution level could also prove to be a pilot test for determining the overall functionality of such a mechanism for implementation at National level at a later stage. One interesting aspect which came out was the flexibility of using these indicators for any time window as deemed appropriate and for any discipline/research. Hence, all discussions from hereon were directed towards the local university and research institution context.

7.6 Inclusion of new indicators

Participants proposed to include two new indicators namely ‘CiteScore’ and ‘% of Journal Publications Cited’. ‘CiteScore’ is the yearly average number of citations received by a journal to recent articles published in that journal. This was considered to be an important metric by participants given that this indicator allows the assessment of the quality of research outputs through comparison of academic journals within specific fields. The ‘% of journal publications cited’ represents the percentage of a journal’s publications being cited. The participants argued that this indicator provides an indication of the percentage of the publications published in a specific journal which are cited by authors. The higher the percentage, the higher number of publications from the journal are being cited. It was argued that these two indicators would blend perfectly with the mix of proposed indicators and would aid towards providing a better picture of the overall research performance of the university.

7.7 Merging of indicators

Participants proposed to merge the indicator ‘journal impact factor’ and ‘5-year journal impact factor’ given that it provides the same measure of assessment with different time windows involving a timeframe of 2 years to 5 years respectively. The following quote illustrates this proposition:

“It is of no use having two indicators for the same metric simply because of two different timeframes. It would be wise to have a single indicator and let universities decide which one they want to use thus having a flexible approach.” (P9)”

7.8 *Renaming of indicators*

Participants also suggested to rename a few indicators namely patent filings (resident and abroad, including regional) and patent grants (Mauritian residents, non-residents and Mauritians abroad) to ‘patent filings’ and ‘patent grants’ respectively given that the focus has moved from proposing the RQF at national level to the university and research institution context. This makes evident the following quote:

“You need to reconsider the naming of the indicators Patent Filings and Patent Grants given that they are now being proposed for the university context. (P10)”

7.9 *Discarding of indicators*

The participants recommended the removal of the indicator ‘citations/citation counts’ due to the fact the RQF already contained the indicator ‘total citation counts’ which would mean a duplication of the indicators. Participants proposed to remove the indicator ‘citation index’ given that it is very difficult to establish which later documents cite which earlier publications, and this would have complicated matters in the assessment process thereby possibly resulting in a failed attempt to assess this indicator. Given that Mauritius still has a long way to go in terms of the number of publications produced, participants recommended that the indicator ‘highly cited publications/papers’ be removed from the RQF. One participant emphasised that:

“We still have a very long way to go for our publications to be counted in the top 1% publications. (P9)”.

The indicator ‘publication output by subject area’ was removed based on the following quote:

“This indicator will not help in any way in quantifying the assessment results and is therefore baseless to include such an indicator in the RQF which does not contribute to any results.” (P8).

7.10 *Discriminatory practice towards SSH and linguistics*

Participants opined that the field of SSH and linguistics were being undermined in already existing frameworks. Though, the participants affirmed that the developed RQF and its related indicators are very relevant yet, they made a number of criticisms of existing frameworks which were taken on board to improve the developed framework as highlighted in the following quotes:

“There may be a discriminatory set of practice baked into the very nature of the notion of impact factor. One is discipline-related, with certain disciplines such as STEM being more prestigious and visible than others including social studies, humanities and linguistics as well. (P4)”

“..... impact factor may limit the diffusion of high-quality research and does not necessarily foster a conducive atmosphere for research and creates a sort of gap between young but good researchers and the more experienced ones who are already in the system. (P4)

The participants stated that there might be a discriminatory practice which exists when using the indicator ‘impact factor’ which according to certain authors are not applicable in other fields of sciences. Participants strongly recommended considering the inclusion of the social dimension in the framework. Participants were of the view that the framework should be fair towards all aspects of assessments and should in no way favour any type of research or discipline in particular and that all disciplines should be given their due importance. They also argued that publications in any language should be taken on board while making quality assessments given that Mauritian scholars are either bilingual or multilingual. Many of the participants argued that the framework should nevertheless consider impact factor as a very important indicator which is equally applicable to the SSH and Linguistics and that it is a mere misconception that it is not applicable to the SSH and Linguistic fields.

7.11 Adoption of RQF at university and research institution level

Participants affirmed that the framework can be used not only for assessing research quality but the results will allow for a proper benchmarking of research performance at institutional and eventually at national/international levels. The following participants expressed their willingness to implement the framework within their institutions given that the results obtained will provide indications on corrective actions to be taken where applicable.

“..... we would wish to implement such a system to have at least an internal assessment of the university’s research works. (P2)”

“..... but we do not have such a well-defined, well designed, comprehensive and coherent framework which summarily takes all relevant aspects into consideration. This is indeed something that we are looking forward to. ((P4)”

“Indeed, a very comprehensive framework and is something which was long awaited. (P5)”

“..... I do not see why we should not embrace such a framework within our institutions. (P7)”

“Yes, indeed, we would like to have such a complete framework for a systematic and thorough assessment of our research works. (P8)”

7.12 Development of a dynamic tool for assessment

It was argued that having a standard framework for universities and research institutions is desirable and this framework has all the abilities to make a complete assessment. Hence, respondents strongly suggested to consider the development of a dynamic tool which could ease the exercise of research quality assessment by simply inputting the necessary data.

8 Fine-tuning of the developed RQF

The findings of the interviews supported the results of the FGD and hence, the RQF was refined based on the constructive feedback received to better fit the local university and research institution context:

- To limit and re-orient the framework for implementation at university and research institution levels.
- To consider research publications of all disciplines in the assessment exercise.
- To include publications in any language relevant to the Mauritian context in the assessment.
- To allow for a certain degree of flexibility for users of the framework to conduct an assessment for any time-period and for any discipline or type of research.
- To consider journals in the Scopus database which indexes only peer-reviewed publications with a view to excluding predatory publications.
- The scoring mechanism to be established in such a way to enable the final score to be translated into a percentage to determine the final results of the assessment.
- To conduct a case study with one of the universities to ascertain that data needed for the assessment exercise are either readily available or can be compiled.
- To review the list of indicators to include indicators that as a mix would best fit the university and research institution context.

9 Main dimensions and indicators of developed framework

As per Michael et al. (2016), the assessment of research quality requires different levels of focus given that it has a crucial role in the development and implementation of strategies and policies at institutional and national levels. The study led to the identification of four main research quality dimensions as presented in Table 8 under which the 42 selected indicators would fall. These broad dimensions and their related sets of indicators can be customised for any university and research institution, based on their specificities for assessing research quality. Each of the dimensions are interconnected given that R&D needs to be conducted to be able to create new knowledge and if the knowledge is not disseminated, it is unlikely to create any impact at all. Relevant indicators for each dimension were developed to allow a holistic assessment of the quality of research, from research initiation to impact. It should be noted that the four dimensions are equally used as innovation metrics by WIPO in its annual GII report for the purpose of assessing the relative performance of the national innovation systems of approximately 130 economies worldwide. The definition of each indicator has been provided in Table 9.

Table 9 Research quality assessment indicators

<i>A. Research and development (R&D)</i>		
<i>1. Research and development (R&D) Indicators</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 1	Researchers, full-time equivalent (FTE)/million pop	Researchers engaged in research and development (R&D) on a full-time equivalence, expressed as per million. (WIPO, 2019)
Indicator 2	Gross expenditure on R&D, % of GDP	Total domestic intramural expenditure on R&D during a given period as a percentage of GDP. (WIPO, 2019)
Indicator 3	Private sector spending on R&D, % of GDP	Spending on R&D by private sector during a given period as a percentage of GDP
<i>2. Scientific scholarships</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 4	Number of scientific scholarships per year	Number of peer-reviewed publications which were awarded sponsorship during a given period
Indicator 5	Funding per scientific scholarship	Average funding received per peer-reviewed publication during a given period
<i>3. Funding received (regional/international)</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 6	Number of peer-reviewed publications for which funding were received at regional/international level	Number of peer-reviewed publications which received sponsorship at regional/international level during a given period
Indicator 7	Annual funding received per peer-reviewed publication at regional/international level	Average annual funding received per peer-reviewed publication at regional/international level during a given period
<i>B. Knowledge creation</i>		
<i>1. Peer-review mechanism</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 1	Average rating received through peer-review mechanism	Average rating received by a panel of experts involved in evaluating and rating research projects
<i>C. Knowledge diffusion</i>		
<i>1. Dissemination indicators</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 1	Number of research projects disseminated	Dissemination of knowledge in terms of completed research works during a given period

Source: Author's construction

Table 9 Research quality assessment indicators (continued)

<i>C. Knowledge diffusion</i>		
<i>2. Participation in conferences/symposia/seminars</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 2	Number of participants in national conferences/symposia/seminars	Dissemination in terms of the number of participants reached during conferences/symposia/seminars at national level during a given period
Indicator 3	Number of participants in regional conferences/symposia/seminars	Dissemination in terms of the number of participants reached during conferences/symposia/seminars at regional level during a given period
Indicator 4	Number of participants in international conferences/symposia/seminars	Dissemination in terms of the number of participants reached during conferences/symposia/seminars at international level during a given period
Indicator 5	Total number of participants in conferences/symposia/seminars	Dissemination in terms of the number of participants reached during conferences/symposia/seminars at national, regional, and international level during a given period
<i>3. PhD graduations</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 3	Number of PhD graduations per year	Completed PhD studies during a given period
<i>D. Knowledge impact</i>		
<i>1. Bibliometric indicators</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 1	Scientific and technical articles/bn PPP\$ GDP	The number of scientific and technical journal articles (per billion PPP\$ GDP) produced by a country for a given period. (WIPO, 2019)
Indicator 2	Citable documents	A citable document is a publication, e.g., an article, a review or a proceedings paper that is considered to make a substantive contribution to the scholarly body of work in a particular research area and is most likely to be cited by other articles. (Clarivate Analytics, 2021)
Indicator 4	Total citation counts	The sum of the citation counts across all papers (Publish or Perish 4 User's Manual, 2016)
<i>D. Knowledge impact</i>		
<i>1. Bibliometric indicators</i>		
Indicator 4	Cites per document/publication/paper	The number of times or the frequency with which the published article is cited. It measures the performance or the impact of individual articles (Li and Ho, 2008)
Indicator 5	Article citation rating (ACR)	The number of citations per article per year taking into account the number of citations that the article received from other papers in the database (Francescheta and Costantini, 2011)

Source: Author's construction

Table 9 Research quality assessment indicators (continued)

<i>D. Knowledge impact</i>		
<i>1. Bibliometric indicators</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 6	Author H-index	A compound measure of productivity and quality, as measured by the number of citations received by the published papers
Indicator 7	Journal H-index	The h-index is defined as the maximum value of h such that the given author/journal has published h papers that have each been cited at least h times. (Hirsch, 2005)
Indicator 8	Institutional H-index	The journal Hirsch-index (H) is an application of h-index at a Journal level, that is, taking into account a journal's publications
Indicator 9	G-Index	The institutional Hirsch-index (H) is an application of h-index on an institutional level, that is, taking into account an institution's publications (Li et al., 2012)
Indicator 10	Publication in indexed journal	The g-index is a variation of the h-index which uses cumulative citations instead of citations alone (Egghe, 2006)
Indicator 11	Publication in refereed journal	E.g., A g-index of 20 means that an academic has published at least 20 articles that combined have received at least 400 citations. (Publish or Perish 4 User's Manual, 2016)
Indicator 12	Journal citation rating (JCR)	Indexed journals (bibliographic database including the list of journals) are considered to be of higher scientific quality as compared to non-indexed journals. The publication of an article in the indexed journal increases its visibility and availability of the findings of the study to the global research community. (Balhara, 2012)
Indicator 13	CiteScore (CS)	Peer-reviewed (refereed or scholarly) journals – Articles are written by experts and are reviewed by several other experts in the field before the article is published in the journal in order to ensure the article's quality. (ASU, 2022)
		The number of citations per journal per year taking into account the number of citations that the journal received from other papers in the database.
		To evaluate the impact factor of the journal
		CiteScore (CS) of an academic journal is a measure reflecting the yearly average number of citations to recent articles published in that journal
		CiteScore is the number of citations received by a journal in one year to documents published in the three previous years, divided by the number of documents indexed in Scopus published in those same three years. (Wikipedia 2023; Libguides 2022)

Source: Author's construction

Table 9 Research quality assessment indicators (continued)

<i>D. Knowledge impact</i>		
<i>1. Bibliometric indicators</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 14	% of journal publications cited	The percentage of a journal's publications being cited
Indicator 15	Journal impact factor (JIF)/5-year journal impact factor (JIF)	The impact factor (IF) is a measure of the frequency with which the average article in a journal has been cited in a particular year. It is used to measure the importance or rank of a journal by calculating the times its articles are cited. (UCT Libraries, 2022)
Indicator 16	Eigenfactor ranking system	Average number of times articles from the journal, published in the past 2 (5) years, have been cited in the year of interest The Eigenfactor score is a rating of the total importance of a scientific journal. Journals are rated according to the number of incoming citations, with citations from highly ranked journals weighted to make a larger contribution to the Eigenfactor than those from poorly ranked journals. Eigenfactor score is calculated by eigenfactor.org. (Wikipedia, 2021a)
Indicator 17	Article influence score (AIS)	The Article Influence Score determines the average influence of a journal's articles over the first five years after publication. It is calculated by multiplying the Eigenfactor Score by 0.01 and dividing by the number of articles in the journal, normalised as a fraction of all articles in all publications. (Nature Portfolio, 2021)
Indicator 18	Journal ranking or SCImago (Scientific) Journal ranking (SJR)	A measure of the scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where the citations come from A journal's SJR indicator is a numeric value representing the average number of weighted citations received during a selected year per document published in that journal during the previous three years, as indexed by Scopus. Higher SJR indicator values are meant to indicate greater journal prestige. (Wikipedia, 2021b)
Indicator 19	Collaboration index (CI)	(Journal ranking system where it takes the shape of a pyramid with only a few journals at the top) Scientific journal ranking in terms of impact within a field (journals having a maximum CiteScore are ranked at the top) The average number of foreign authors who contributed to local articles. (Wegman et al., 2007)
<i>Source: Author's construction</i>		

Table 9 Research quality assessment indicators (continued)

<i>D. Knowledge impact</i>		
<i>1. Bibliometric indicators</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 20	Publication trends	The number of articles as a function of time, that is, the number of papers published over a certain period of time. (Kostoff, 2007)
Indicator 21	Publication by source type in peer-reviewed journals	Publications broken down into different categories, e.g., journals, conference proceedings, books, book series, trade publications, etc. over a certain period of time
Indicator 22	Impact per publication (IPP)	Average number of times articles from the journal, published in the past 3 years, have been cited in the year of interest, according to the Scopus database. (CWTS Journal Indicators, 2021)
<i>2. Publications with potential commercial applications</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 23	Commercial publishing	Publishing in which documents and other printed materials are produced on a for-profit basis for clients or for commercial sale, e.g., book publishing, etc. (Printwiki, 2021)
<i>3. Intellectual property rights (IPR)</i>		
<i>1. Patent rights</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 24	Patent filings (resident and abroad, including regional)	Patents filed by Mauritian residents and Mauritians residing abroad
Indicator 25	Patent grants (Mauritian residents, non-residents and Mauritian abroad)	A patent grant is basically the granting of a property right to an inventor for his invention or creation
Indicator 26	Patents by origin/bn PPP\$ GDP	An indicator to assess the number of patents that was granted by the country of origin every year. (WIPO, 2019)
<i>2. Copyrights</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 27	Copyrights granted per year	The exclusive and assignable legal right, given to the originator for a fixed number of years, to print, publish, perform, film, or record literary, artistic, or musical material. (NCI Library, 2021)
<i>3. Industrial design rights</i>		
<i>Item</i>	<i>Indicator</i>	<i>Definition</i>
Indicator 28	Industrial designs by origin/bn PPP\$ GDP	An indicator to assess the number of industrial designs that was granted by the country of origin every year Industrial design is a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life through innovative products, systems, services, and experiences (WDO, 2021)

Source: Author's construction

10 Research and development (R&D)

The first dimension which is 'R&D' is the input for the model given that research needs to be conducted for new knowledge to be created and added to the pool of knowledge. Until and unless research is conducted, new knowledge cannot be created. This dimension considers assessment indicators which promote research under R&D indicators; scientific scholarships and funding received at regional and international level. This dimension hosts a total of seven new indicators as shown in Figure 2 which do not appear in existing RQFs namely researchers, full-time equivalent (FTE)/mn pop; gross expenditure on R&D, % of GDP; private sector spending on R&D, % of GDP; number of scientific scholarships; funding per scientific scholarship; number of peer-reviewed publications for which funding were received at regional/international level; annual funding received per peer-reviewed publication at regional/international level.

10.1 Knowledge creation

The second dimension 'knowledge creation' is the process involving the peer-review mechanism and involves a single indicator 'average rating received by panel of experts', as presented in Figure 2, to conduct an evaluation of the knowledge that is created. This indicator involves a panel of experts for evaluating and rating research as compared to having recourse to the traditional method of involving only two or three reviewers in the process.

10.2 Knowledge diffusion

The third dimension which is 'knowledge diffusion' is yet another important aspect to create an impact. It is of utmost importance to disseminate knowledge which has been created as a result of research. As such, the six Indicators under this dimension relate to dissemination indicators; participation in conferences/symposia/seminars; and PhD graduations as shown in Figure 2. The number of research projects disseminated, and number of PhD graduations are new indicators which have been introduced under this dimension.

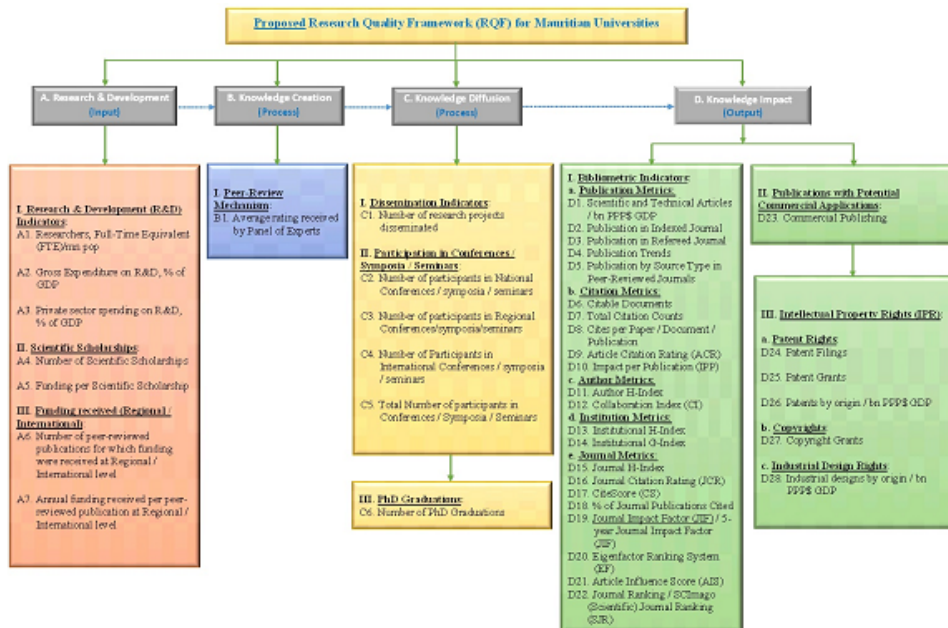
10.3 Knowledge impact

The fourth dimension 'knowledge impact' is considered as the output of the framework. Any research that is conducted needs to lead to the creation of new knowledge which in turn must be disseminated to have an impact. The assessment indicators under this dimension include a set of 22 bibliometric indicators having the ability to complement each other. The bibliometric indicators have been classified under five specific categories namely publication metrics (5 indicators); citation metrics (5 indicators); author metrics (2 indicators); institution metrics (2 indicators); and journal metrics (8 indicators). Two new bibliometric indicators namely scientific and technical articles/bn PPP\$ GDP and publication by source type in peer-reviewed journals and two existing bibliometrics never used as indicator before namely CiteScore and % of journal publications cited have been included in the framework. This dimension also includes one new indicator related to commercial publishing and four new indicators under IPR namely patent filings; patents by origin/bn PPP\$ GDP; copyright grants; and industrial designs by origin/bn PPP\$ GDP

which have not been used in any framework so far to assess knowledge impact. The diverse indicators have been shown in Figure 2.

Unlike national assessment mechanisms implemented by many countries worldwide, the RQF does not use any indicator in isolation or in smaller sets. It incorporates the peer-review mechanism together with a large set of selected bibliometric indicators and other novel indicators. The RQF presented in Figure 2 is flexible for adaptation and implementation within any university and research institution setting to suit their specific needs for any time period which allows for continuous assessment.

Figure 2 Research quality framework for universities and research institutions (see online version for colours)



Source: Author's construction

Table 10 Research quality performance rating

Rating (1 – 5)	Research quality performance
1	Very poor
2	Poor
3	Acceptable
4	Good
5	Very good

Source: Author's construction

11 Development of automatic RQF tool

The framework formed the basis for developing a dynamic RQF tool (Appendix 3) to be used to assess research quality. The tool consists of indicators under the four research quality dimensions and the overall research quality performance dashboard. The RQF tool has been developed in Microsoft Spreadsheet using advanced formulas and conditional formatting whereby each rating is represented by a specific colour showing the level of research quality performance as per Table 10.

12 Overall research quality performance dashboard

The overall research quality performance dashboard takes into consideration the different ratings obtained for each indicator and the performance level of the four research quality dimensions to generate the overall research quality performance of the university. It is to be noted that the four main dimensions are applicable in any research setting and the diverse indicators can be used by any university/research institution to assess research quality. The dashboard provides a snapshot of the breakdown of the ratings obtained and their respective research quality performance levels and eventually, the overall performance of the institution. Once the required data for the 42 indicators under each of the four research quality dimensions are input into the RQF tool, the system calculates the individual ratings and the overall performance of each quality dimension following which their regrouped performance levels are displayed on the overall research quality performance dashboard. The dashboard not only highlights good performance levels but also identifies specific areas where improvements are needed depending on the rating assigned and the colour coding with a view to improving the research quality performance level.

13 Recommendations

The case study of the UoM demonstrated the usefulness of the RQF in working out policy decisions for improvement at institutional level. This could entail policy decisions at national level on the implementation of the developed RQF for public and private universities and research institutions which could help in conducting an actual assessment of the quality of research being produced. Policies could also relate to conducting a continuous assessment of the research performance as compared to other models worldwide which conduct periodic assessments (Mazen et al., 2016). It is recommended that universities and research institutions create a platform in the form of a database where data related to the different parameters of the 42 indicators are recorded and updated from time to time for assessment purposes. Moreover, it is recommended for them to implement a research repository at institutional level which would consist of all research studies including peer-reviewed publications; non-peer-reviewed publications and unpublished documents. The repository should include research in all fields of science, including SSH and languages amongst other fields. The research repository should also include IPRs derived from research conducted including patent filings; patent grants; copyrights and industrial designs. This could prove to be beneficial in continuously monitoring the status of research and to some extent the impact that is

generated at institutional level as well as guarantee a continuous assessment of the quality of research (Wickson and Carew, 2014). The outcomes of the continuous assessment exercise could also be used to alert relevant authorities in case of low performance and corrective actions could be taken to redress the situation swiftly. Another policy could be to provide a proper environment for the conduct of the assessment of research quality at institutional level (Belcher et al., 2015). The RQF could also act as a guide in the long term for researchers to ensure that research being produced are of certain quality (Belcher et al., 2015). Such assessments are also useful to local and international funding bodies in the allocation of research funds to HEIs and research institutions.

14 Conclusions

The existence and use of an RQF is of utmost importance to any university/research institution given that good quality research is the crux of development and sustainable progress. The study successfully achieved its objective of designing and developing a novel standard framework together with a dynamic RQF tool which allows for an automatic assessment of the quality of research produced and published at the level of universities and research institutions. The validation exercise helped in fine tuning the framework to include a never used mix of 42 relevant indicators, including 16 novel indicators, based on four main research quality dimensions to assess the quality of research. Unlike other pre-existing assessment mechanisms, the RQF does not use any indicator in isolation or in smaller sets. It incorporated the peer-review mechanism together with carefully selected bibliometric indicators which have the potential to make a complete assessment of the quality of research. The framework was validated, tested, and used in a university setting, that is, the UoM, and in the process, the framework provided evidence of its suitability for assessment of research quality within universities/research institutions. The outcomes of this study in the form of the RQF and the dynamic RQF tool have the ability to provide the necessary base not only for local but also for international universities/research institutions to use the framework to assess their research quality performance.

The indicators of the framework are capable of assessing research in any fields of science including the SSH and linguistics. Moreover, the framework could serve as a useful instrument in the future not only to enhance the country's research performance thereby contributing to the nation's GII ranking but also for the proper allocation of research grants to quality research with the potential of having more impactful results. The assessment results using the framework would ensure that universities and research institutions with quality research are correctly positioned at national and international levels with a more enhanced reputation thus making them more attractive to potential funding bodies. This would also lead to an increased collaboration with foreign authors, institutions and authorities having similar interests in addition to identifying weak areas that require prompt actions for improvement. Moreover, the RQF would also contribute to SDG 4: quality education, SDG 9: industry, innovation and infrastructure; and SDG 17: partnerships for the goals. However, one limitation of the study is that the proposed framework is limited to universities and research institutions.

With every research conducted comes an opportunity for further research to delve upon. The fact that no similar RQF tool is currently available adds value to this piece of work and makes this study a base where further research could be conducted at national

or international level. The RQF would serve as a test case and based on the results obtained, could be further explored to include funding agencies and the private sector into the assessment exercise or to eventually extend it on a national scale. Another future study that could be investigated could be specifically assessing the impact of university research on society which is a real challenge whereby relevant research impact indicators could be studied for the development of a framework for research impact assessment. In a nutshell, this framework will enable any university and research institution wishing to assess their research quality to do so and based on the results obtained, to take appropriate measures for improving research performance through appropriate policy decisions.

Appendices/Supplementary materials are available on request by emailing the corresponding author.

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