

For Engineering Excellence

ENGINEERING INDEX 2022

F O R U G A N D A

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EXECUTIVE SUMMARY

The engineering sector is considered one of the most relevant sectors, and a vehicle for economic and social development of a country. Studies have found a positive correlation between the engineering strength and the economic development of a country. The Economic intelligence Unit (EIU) working closely with the Royal Academy of Engineers developed the “Engineering Index 2019”, a measure of the engineering strength of a country. The index measures a country’s ability to conduct key engineering activities in a safe and innovative way. The index uses several indicators, grouped into six categories to create a numerical value. The study to create the index highlighted the lack of disaggregated data across the world and this limited accurate estimation of this value. More so, certain countries (including Uganda) were omitted in the study and therefore their index values were not developed.

This study therefore developed the “Engineering index for Uganda 2022” for each of the six (6) categories; Engineering knowledge, Engineering labor force, Engineering industry, Civil infrastructure, Digital infrastructure, and Safety standards. Development of index followed the same methodology developed by the EIU. Deliberate efforts were made to fill up data gaps using internationally established data sources. For categories for which data could not be found in international sources, in country data from relevant public institutions/agencies was used as the equivalent. For those indicators for which data was completely unavailable. the estimation approach used by the same EIU method was used to generate index scores.

Uganda index values are 1.1, n/a, 9.2, 6.1, 12.2, and 63.6 on Engineering knowledge, Engineering labor force, Engineering industry, Civil infrastructure, Digital infrastructure and Safety standards respectively. Compared to the global averages, Uganda is scores below average on all the index categories except digital infrastructure. Uganda’s competitiveness on digital infrastructure can be linked to the large private sector investors from the large telecommunication companies. The study also highlighted pain-points for data acquisition for index development and proposes action items to guide on the future Index development process.

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1.0 INTRODUCTION

1.1. What is the Engineering Index?

The Engineering Index (here in after referred to as an Index) is a tool that provides an understanding of the factors that determine overall engineering capability across countries (Center for Economic and Business research, 2016). The Economic Intelligence Unit (EIU) worked in collaboration with the Royal Academy of Engineering and Lloyd's Register to develop the Engineering Index 2019. The Index assessed 99 countries (representative of the low-, middle- and high-income economies) based on six categories. These categories include Engineering knowledge, Engineering labor force, Engineering industry, Civil infrastructure, Digital infrastructure, and Safety standards in engineering (Royal Academy of Engineering, 2020). We give the description of each of these categories in the appendix (Table 4). Across the six categories, the Index's 23 indicators are designed to capture metrics against which countries can measure their performance and paint a picture of their overall engineering capability. The index measures a country's ability to conduct key engineering activities in a safe and innovative way.

1.2. Why is it important?

The field of engineering has become broad and is constantly evolving. Therefore, the scope of work and sectors in which engineering skills are needed has tremendously expanded. Part of this skill demand is driven by the growth of the digital economy. Today, engineers develop solutions that support human well-being, drive economic innovation, and enhance safety. The evolving landscape of engineering presents a need for a corresponding change in engineering capabilities.

The Uganda National Development Plan (NDP III) emphasizes a science driven economy with research and Innovation under development strategy #15 (National Planning Authority, 2020). Engineers are at the forefront of innovation, and therefore pivotal in realization of NDP III. The index provides a mechanism for Uganda and other countries to continuously assess and forecast sectoral growth. This provides an opportunity to identify underperforming sectors, and a guide to designing targeted policies/programs that enhance domestic engineering capability.

1.3. Study Objective

This study objective was to develop Uganda's Index for 2022. The study specifically aimed at establishing data sources for Index development, highlighting missing data in the sources, and developing recommendations to improve the future index development process.

2.0 METHODOLOGY

The development of the Engineering Index for Uganda follows the metric developed by the Economist Intelligence Unit (EIU). The Index consists of six (6) categories and each of the six categories is made of indicators that vary in number. These categories include Engineering knowledge, Engineering labor force, Engineering industry, Civil infrastructure, Digital infrastructure, and Safety standards in engineering. To develop the index, First the categories and their indicators are weighted to represent their contribution to the Index value. Then, for each indicator, a score is obtained from publicly identified available databases. Because indicator scores from databases are provided in different units, they are normalized to a universal scale to allow aggregation and comparison. The normalized scores for each indicator are then aggregated to form an index score for Uganda under each of the six categories. Data acquisition for indicators, weighting, and normalization details are explained in the sections below.

2.1. Acquiring data for Index development

Hyperlinks to data sources for index development that are available to the public have been given in **Table 5**. The team made deliberate efforts to look for data on all the indicators from internationally recognized data sources. For categories for which data could not be found in international sources, In-country data from relevant public institutions/agencies was used as the equivalent. For those indicators for which data was completely unavailable, the estimation approach used by the same EIU method was used to generate index scores.

For indicator 3.1 and 6.1, an approximate value was calculated based on the estimation approach used by EIU. Because Uganda is ranked among low-income countries, we first clustered the countries (from the 99 countries) in the low-income category according to the World Bank classifications: We then calculated the average score for this indicator, and this was assumed as the average for Uganda.

2.2. Weighting

The role of weightings in an index is to reflect the importance attached to each category and/or indicator. Each category was given equal weights on scale of 100. Each indicator was also given a weight on the scale of 100 based on the number of indicators in the category. These weights have been given in **Table 5**.

2.3. Normalization

Indicator scores from respective data sources are presented in different measurement units (raw indicator data). Normalization rebases the raw indicator data to a common unit so that it can be aggregated. All indicators in this model are normalized to a 0-100 scale, where 100 indicates the best performance and 0 represents the worst

performance. Indicators are transformed on the basis of a min/max normalization, based on the formula below.

$$(x - \min(x)) / X = (/ (Max(x) - \min(x))) \times 100$$

Where Min(x) and Max(x) are respectively, the lowest and highest values in the 99 countries. The represents the highest/lowest rankings globally.

2.4. Synthesis/analysis

Developed Uganda engineering index was compared to the global and Sub-Saharan African average index scores. The global average values are the average scores of the 99 countries considered in the Engineering index 2019 report. The sub-Saharan African average is the average of the score for those countries included in the same report. The sub-Saharan African countries included, Singapore, Benin, Burundi, Madagascar, Ethiopia, Ghana, Mauritius, Mozambique, Nigeria, Rwanda, and South Africa. Uganda's ranking on the global scale and Sub-Saharan African region on each of the indicator categories is also given.

3.0 DEVELOPED ENGINEERING INDEX FOR UGANDA

3.1. Engineering Index

The 2022 Engineering Index for Uganda, based on the six (6) categories is summarized in **Table 1**, together with the global and sub-Saharan African average values. Uganda when measure on the global scale scores below average in all the Engineering Index indicator categories with index values of 1.1, n/a, 9.2, 6.2, 12.2 and 63.6 for knowledge, labor force, engineering industry, infrastructure, digital infrastructure and safety standards respectively. On the Sub-Saharan regional scale, except for digital infrastructure, Uganda performs below average. Uganda therefore competes favorably within the sub-Saharan region on digital infrastructure and ranks number 5 out of 11 countries included in the development index Table 2.

Table 1: Developed Uganda's Index 2022 for each indicator category.

Indicator Category	Uganda	Engineering Index	
		Global average	Sub-Saharan African Average
1) KNOWLEDGE	1.1	11.3	3.0
2) LABOUR FORCE*	N/A (missing data)	51.1	N/A
3) ENGINEERING INDUSTRY**	9.2	27.8	11.1
4) INFRASTRUCTURE	6.1	60.2	43.1
5) DIGITAL INFRASTRUCTURE	12.2	32.6	10.5
6) SAFETY STANDARDS***	63.6	85.1	77.3

* Sub-indicator 2.2 and 2.4 - Mean score in science performance among 15-year-olds and Mean score in Mathematics performance among 15-year-olds – no regional score data.

** Sub-indicator 3.1 - Ratio of medium to large sized companies – regional average adopted.

*** Sub-indicator 6.1 - Fatal injuries per 100,000 in the engineering – regional average adopted

3.2. Uganda Index's global and regional ranking

In Table 2, Uganda's Index ranking on a Global and Sub-Saharan Africa region scale is presented. Among the 99 countries included in the index development, Uganda ranks at 95, 93, 86 and 89 for knowledge, engineering industry, digital infrastructure, and safety standards respectively. However, on categories such as Labor force and infrastructure, Uganda could not be ranked because her index values fall outside the values of the 99 countries. Within the sub-Saharan African region, out of the 11 sub-Saharan countries with developed indices, Uganda ranks number 11 in knowledge, number 8 in engineering industry and number 5 in digital infrastructure. Uganda's competitiveness in digital infrastructure can be traced to the large infrastructure investments that have been accomplished by the large telecommunication network.

Table 2: Uganda's Ranking globally and on the Sub-Saharan African continent.

Uganda's Ranking*		
Indicator Category	Sub-Saharan Africa (Among 11 countries)	Globally (Among 99 countries)
1) KNOWLEDGE	11	95
2) LABOUR FORCE	n/a (missing data)	u/r**
3) ENGINEERING INDUSTRY	8	93
4) INFRASTRUCTURE	6	93
5) DIGITAL INFRASTRUCTURE	5	86
6) SAFETY STANDARDS	6	90

*Country ranked 1 is best performing.

** u/r- Category is unranked because the index values for Uganda fall outside the values of the ranked countries among the 99.

4.0 CHALLENGES AND RECOMMENDATIONS IN DATA ACCESS FOR INDEX DEVELOPMENT

In Table 3, we summarize the challenges encountered during the Index development process. Recommendations for data formats that feed into developing the Index going forward are proposed. A detailed description of the required data format, potential sources and required actions to be initiated and championed by ERB are presented in **Table 6**.

Table 3: Challenges and Recommendations in data access for index development.

Challenges	Recommendation
Data is not readily available in Uganda for some indicators.	<ul style="list-style-type: none"> Responsible Agencies need to engage with international organizations dealing with these data surveys for future collaborations and explore inclusion in regular global annual surveys with Organization like UNESCO, ILO, OECD. Agencies need to explore working jointly in areas of research and policy. This will allow for universality in data collection in areas of research and policy. Agencies like UBTEB have already expressed interest in collaborating with UIPE/URB to drive policy and research agendas (See reply letter to data access request ref UBTEB/ES/095/2023). ERB needs to work with agencies that are custodians to the data to create awareness and prepare it in the format required to develop Uganda's Engineering Index.
Available collected data by some agencies lacks the details required for Index development.	
Data classification not Universal. For example, defining what qualifies to be an engineering/technical program. A case in point are some courses in the technical colleges that are classified as business programs, ie. Computer science, and computer engineering, and Boat Building Technology and Marine Mechanics.	
The scope of this study was limited to index development for the year 2022.	

5.0 CONCLUSION

This study developed the Engineering Index 2022 for Uganda. The developed index is missing values for the labor force category due to inaccessible data in country and region. The Index has provided a yardstick to assess Uganda's progress, regionally and globally, against the full set of factors/indicators that measure growth in the engineering sector.

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Appendix

Table 4. Engineering Index Categories and Detailed descriptors

Indicator	Descriptors
1) KNOWLEDGE	A measure of a country's contribution to and advancement of knowledge in engineering and technology.
1.1) H index ranking (# of citations in engineering)	Measures a country's number of articles (h) that have received at least h citations in engineering disciplines.
1.2) R&D spending (% GDP)	UNESCO Institute for Statistics (UIS) data on research & development spending as a percentage of a country's GDP.
1.3) Number of universities in top 500 for engineering	Number of universities in the top 500 for engineering, by country according the Times Higher Education ranking.
1.4) Patent applications, residents	World Intellectual Property Organization's statistics on the total number of patent applications by residents for each country (most recent value).
2) LABOUR FORCE	Availability and diversity of engineers in the economy
2.1) Availability of scientists and engineers	World Economic Forum Executive Opinion Survey question; In your country, to what extent are scientists and engineers available?
2.2) Mean score in science performance among 15-year-olds	The Organization for Economic Cooperation and Development (OECD) Programme for International Student Assessment mean science scores for 15 year olds.
2.3) Female graduates in Engineering disciplines (tertiary education)	UNESCO Institute for Statistics (UIS) data on percentage of tertiary education graduates in engineering, manufacturing and construction programmes that are female.
2.4) Mean score in mathematics performance among 15-year-olds	The Organization for Economic Cooperation and Development (OECD) Programme for International Student Assessment mean Math scores for 15 year olds.
2.5) Graduates in Engineering disciplines (tertiary education)	UIS data on percentage of tertiary education graduates in engineering, manufacturing and construction programmes.

Indicator	Descriptors
3) ENGINEERING INDUSTRY	Strength and sophistication of the engineering industry.
3.1) Ratio of medium to large-sized engineering companies vs all of similar size	<p>Orbis data on medium to large-sized companies in engineering fields, as a percentage of all medium to large-sized companies in the country.</p> <p>Engineering fields include: Civil engineering, construction of other civil engineering projects (nec), engineering activities and related technical consultancy, research and experimental development on natural sciences and engineering.</p>
3.2) Engineering Exports	<p>Total dollar value of engineering exports #84 and #85 according to Trademap.org. Product: 84 Machinery, mechanical appliances, nuclear reactors, boilers; parts thereof.</p> <p>Product: 85 Electrical machinery and equipment and parts thereof; sound recorders and reproducers.</p>
3.3) Medium and high-tech Industry (% manufacturing value added)	United Nations Industrial Development Organization's (UNIDO) Competitive Industrial Performance (CIP) data on the proportion of medium and high-tech industry value added as a part of the total value added of the manufacturing industry by country.
3.4) Economic complexity index	The Observatory of Economic Complexity's Economic Complexity Index. Measures the relative knowledge intensity of an economy.
4) INFRASTRUCTURE	Ability of infrastructure to support and demonstrate domestic engineering activities.
4.1) Quality of infrastructure	The Economist Intelligence Unit's Business Rankings Index measures the quality or attractiveness of the business environment in 82 countries. The quality of infrastructure indicator is scored from 1 (very bad for business) to 5 (very good for business).
4.2) Extent and quality of road network	The Economist Intelligence Unit's Business Rankings Index measures the quality or attractiveness of the business environment in 82 countries. The quality of road network indicator is scored from 1 (very bad for business) to 5 (very good for business).

Indicator	Descriptors
4.3) Extent and quality of rail network	The Economist Intelligence Unit's Business Rankings Index measures the quality or attractiveness of the business environment in 82 countries. The quality of rail network indicator is scored from 1 (very bad for business) to 5 (very good for business).
4.4) Quality of port's infrastructure	The Economist Intelligence Unit's Business Rankings Index measures the quality or attractiveness of the business environment in 82 countries. The quality of ports indicator is scored from 1 (very bad for business) to 5 (very good for business).
4.5) Quality of air transport infrastructure	The Economist Intelligence Unit's Business Rankings Index measures the quality or attractiveness of the business environment in 82 countries. The quality of air transport indicator is scored from 1 (very bad for business) to 5 (very good for business).
5) DIGITAL INFRASTRUCTURE	Ability of digital infrastructure to support and demonstrate domestic engineering activities.
5.1) Digital Adoption Index	The DAI is a worldwide index that measures countries' digital adoption across three dimensions of the economy: people, government, and business.
5.2) Number of Servers	Netcraft and World Bank population estimates of the number of secure internet servers per 1 million people in a country.
5.3) Internet speed (Mbps)	Speedtest Global Index of mobile and fixed broadband speeds.
6) SAFETY STANDARDS	Safety in engineering intensive sectors.
6.1) Fatal injuries per 100,000 in engineering sectors	International Labor Organisation data on the number of fatal injuries per 100,000 in engineering related economic activities: Mining and Quarrying, Manufacturing, Electricity, Water Supply and Construction.
6.2) Safety outcomes	The UL Safety Index quantifies the relative state of safety for more than 180 nations. The Safety Outcomes driver is calculated as the mean of normalized indicators reflecting the Disability Adjusted Life Years per 100,000 people for causes associated with unintentional injury.

Table 5: Detailed computation of Indicator scores.

Indicator	Weight	Score	Normalized index values	Data Source
1) KNOWLEDGE	0.166667		1.1	
1.1) H index ranking (# of citations in engineering)	0.25	40	1.15	Scimago, https://www.scimagojr.com/countrysearch.php?country=UG&area=2200
1.2) R&D spending (% GDP)	0.25	0.14	3.19	Research and development expenditure (% of GDP) - Data (worldbank.org)
1.3) Number of universities in top 500 for engineering	0.25	0	0.00	https://www.timeshighereducation.com/world-university-rankings/2022/subject-ranking/engineering-and-it#!/page/0/length/25/name/University%20of%20georgia/sort_by/rank/sort_order/asc/cols/stats
1.4) Patent applications, residents	0.25	13	0.00	Patent applications, residents - Uganda Data (worldbank.org)
2) LABOUR FORCE	0.166667			
2.1) Availability of scientists and engineers	0.2	4.1	68.33	WEF_GCI_2017_2018_Profile_Uganda.pdf (weforum.org)
2.2) Mean score in science performance among 15-year-olds	0.2	n/a		
2.3) Percentage of Female graduates in engineering disciplines (tertiary education) (%)	0.2	20.3	44.36	Graduation data from all public and private institutions (both university and technical institutions) in Uganda with Engineering Programs

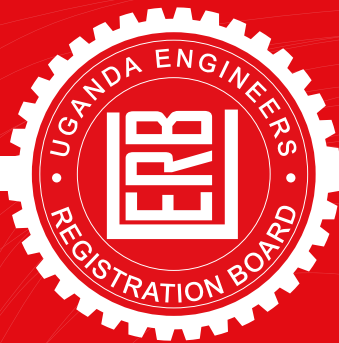
Indicator	Weight	Score	Normalized index values	Data Source
2.4) Mean score in mathematics performance among 15-year-olds	0.2	n/a		
2.5) Percentage of graduates in engineering disciplines (tertiary education) (%)	0.2	13.29	45.51	Graduation data from all public and private institutions (both university and technical institutions) in Uganda with Engineering Programs
3) ENGINEERING INDUSTRY	0.166667		9.24	
3.1) Ratio of medium to large-sized engineering companies vs all of similar size	0.25		19.25	Calculated as the average for low-income countries among the 99 countries
3.2) Engineering Exports	0.25	46625	0.00	Trade Map - List of products at 2 digits level exported by China in 2021
3.3) Medium and high-tech Industry (% manufacturing value added)	0.25	11	0.00	Medium and high-tech manufacturing value added (% manufacturing value added) - Uganda Data (world-bank.org)
3.4) Economic complexity index	0.25	-0.97	17.71	https://oec.world/en/profile/country/nga
4) INFRASTRUCTURE	0.166667		6.1	
4.1) Quality of infrastructure	0.2	3.3	50.00	TheGlobalCompetitivenessReport2017-2018.pdf (weforum.org)
4.2) Extent and quality of road network	0.2	3.4	70.83	TheGlobalCompetitivenessReport2017-2018.pdf (weforum.org)

Indicator	Weight	Score	Normalized index values	Data Source
4.3) Extent and quality of rail network	0.2	1.6	-73.68	TheGlobalCompetitivenessReport2017–2018.pdf (weforum.org)
4.4) Quality of port's infrastructure	0.2	2.6	-6.06	TheGlobalCompetitivenessReport2017–2018.pdf (weforum.org)
4.5) Quality of air transport infrastructure	0.2	3.1	-10.53	TheGlobalCompetitivenessReport2017–2018.pdf (weforum.org)
5) DIGITAL INFRASTRUCTURE	0.166667		12.2	
5.1) Digital Adoption Index	0.333333	0.34	23.20	Digital Adoption Index (worldbank.org)
5.2) Number of Servers	0.333333	35	0.01	Secure Internet servers (per 1 million people) - Uganda Data (worldbank.org)
5.3) Internet speed (Mbps)	0.333333	40.4	13.74	Speedtest Global Index – Internet Speed around the world – Speedtest Global Index
6) SAFETY STANDARDS	0.166667		63.6	
6.1) Fatal injuries per 100,000 in engineering sectors	0.5	139.8	129.94	Average of all Sub-Saharan African Countries included in the Index development
6.2) Safety outcomes	0.5	74.93	-2.78	https://www.researchgate.net/publication/307616691_205_The_UL_Safety_Index_quantifying_safety_around_the_world

Table 6: Reported discrepancies in data sources used and Proposed way-forward.

Indicator with missing Data	Required format	Data Format used	Action required by sector Agencies
Indicator 2.2 & 2.4: Mean score in science and Mathematics performance among 15-year-olds.	Mean score of science for 15- year-olds measured on standardized assessment)	Mean score for all science subjects that include Chemistry, Biology, and physics at UCE level	MoE and UNEB needs to work with OECD to conduct this assessment to 15-year-olds based on international standards through the Programme for International Student Assessment (PISA) assessment
	Mean score of Mathematics for 15-year-old measured on standardized assessment	Mean score in mathematics at UCE level	
Indicator 2.3: Female graduates in engineering disciplines (tertiary education)	Annual total number of female graduates in engineering programs in all universities	Annual Enrollment of females in all science and technology disciplines	National Council of Higher Education (NCHE). Needs to streamline data reporting from Higher institutions of learning on data format required
Indicator 2.5: Graduates in engineering disciplines (tertiary education).	Annual total number of graduates in engineering programs in all Universities	Annual Enrollment in all science and technology disciplines	National Council of Higher Education (NCHE). Needs to streamline data reporting from Higher institutions of learning on data format required
Indicator 3.1: Ratio of medium to large-sized engineering companies vs all of similar size	Number of large-sized companies in engineering fields.	Not reported in Uganda. Used and Estimate based on EIU approach	URSB and UIPE need to work together to collect this data on total number of companies including Civil engineering firms, construction of other civil engineering projects, engineering activities and related technical consultancy, classified either as medium, large, or small. Classification should be based on international standards
	Number of medium-sized companies in engineering fields	Not reported in Uganda. Used and Estimate based on EIU approach	

Indicator with missing Data	Required format	Data Format used	Action required by sector Agencies
Indicator 6.1: Fatal injuries per 100,000 in engineering sectors	Annual number of cases of fatal occupational injury in the Mining and Quarrying, Manufacturing, Electricity, Water Supply and Construction engineering firms	Not reported in Uganda. Used and Estimate based on EIU approach	Federation of Uganda Employees (FUE) and Ministry of gender labor, and social development (MoGLSD) should work with Labor Organization (ILO) to collect this data in standardized format.



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