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Towards a Circular Economy in The Arab Region: Development of Transformation Measurement Index

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Abstract

Globally, a circular economy (CE) is being promoted as a policy to achieve economic, environmental, and social sustainability. A significant reason for this is the increasing recognition of CE indices as effective tools in preventing resource waste and reducing negative environmental impacts. The aim of this study, therefore, is to establish a regional index based on globally recognized CE indicators that can be used to measure countries' transition toward circular economies implementation. Among the main components of the index are economic, business, environmental, governance, infrastructure, and social indicators. A bottom-up approach is utilized to develop the index structure, with four levels: items, sub-indicators, main indicators, and finally the index. In order to calculate the index, a structured statistical methodology is developed in four stages, including the normalization of items, the geometric mean of sub-indicators, the weighted geometric mean of main indicators, as well as the index calculation itself. In light of the index developed by the study, policymakers and stakeholders in the CE can determine the countries' transmission level toward CE and adopt policies to develop CEs activities in the region, reducing waste in natural resources, achieving economic, environmental, and social sustainability, as well as enhancing the added value of Arab economies.

Introduction

Currently, the global economy operates on a linear model. This model exploits natural resources, processes them into products, and discards them, causing significant environmental damage, wasting natural resources, and destroying biodiversity (Sariatli, 2017). In turn, it negatively affects health and causes climate disasters such as global warming, floods, melting ice, rising ocean levels, and harms current and future generations' rights (Millar et al., 2019). Today, however, people are beginning to realize that continuing along the linear economic system path will result in higher risks and costs, whether on the economic, human, or environmental levels. In response to these risks and the high costs associated with them, governments and civil society have been exploring alternative solutions and pushing the transition toward a circular economy (CE). In a CE, natural resources are conserved by eliminating waste, reusing resources, sharing, repairing, renewing, re-manufacturing, and recycling materials through a closed loop system (Murray et al., 2017; Jorgensen & Pedersen, 2018; Babbitt et al., 2018; Hofmann, 2019; and Morseletto, 2020). Since the CE offers many advantages and has been endorsed by many governments, civil society organizations as well as economic institutions, we believe that its adoption in the Arab region will achieve a balance between economics, social, and environmental aspects.

In contrast to the linear economy, the CE follows a number of key philosophies, including the organization of reversible cycles, resource efficiency, systems thinking, thinking in the form of systems, giving priority to the future, and creating mutual benefits between parties (Hout, 2017). By adopting a CE system, mankind can preserve natural resources, increase its competitiveness, reduce dependence on raw materials, reduce costs, build supply security, reduce greenhouse gas emissions, reduce the environmental impact of resource extraction, and offer new investment opportunities (Ly, 2021). In addition, the CE is strongly connected to the Sustainable Development Goals (SDGs), as the United Nations General Assembly and UN Economic and Social Council in September 2018 established the following goals: 7, 8, 11, 12, 13, 14, and 15 as highly relevant objectives for achieving a CE (Schroeder et al., 2019; El Wali et al., 2021). As outlined in these goals, there is an emphasis on ensuring reliable, sustainable, and affordable modern energy services for all; Promoting sustained and inclusive economic growth; providing full employment and decent work for all; and promoting inclusive, safe, and sustainably resilient cities and human settlements. Further, ensure that climate change is addressed, and its impacts are minimized, that oceans, seas, and marine resources are conserved and sustainably used, that terrestrial ecosystems are protected, restored, and managed, and that desertification is defeated, and that land degradation and biodiversity loss are halted (Schroeder et al., 2019).

In general, CE is the cornerstone of modern economies, including the green economy, the sustainable economy, the biological economy, and the purposeful economy. This is in order to create a balance between economic activities and the protection of the environment and climate. In the Arab region, many effective CE initiatives have been implemented. As an example, there is a recycling company in Saudi Arabia's third industrial city, Riyadh. It is the first and biggest in the Middle East and North Africa, recycling 3 million tons of waste annually. Similarly, in the State of Qatar, there is a Waste Treatment Center in the Masa'ada area, which recycles household waste to generate electricity. A number of green sukuks have also been successfully launched in the region to support green finance and CE. These include one issued by Majid Al Futtaim worth USD 1.2 billion and another by Saudi Electricity

Company worth USD1.3 billion. Additionally, the Islamic Development Bank and Egypt issued green sukuks in the region in October and November 2021.

As of 2021, the UAE launched a nationwide CE policy and established a CE council consisting of federal, local, and private sector representatives. The council aims to implement the CE policy through national plans and legislation that encompass and monitor sustainability criteria using the following steps as a guide. Developing strategies, policies, and initiatives that integrate CE principles into national plans; facilitating the development of immature markets; and increasing the ability of international players to reach the market. In addition, according to the report by Omar Adel (2019) who stated that using the CE model in the UAE's cities could result in savings of up to 28 billion dollars (102.8 billion dirhams) over the period from 2020 to 2030, scattered across 7.2 billion dollars in the urban environment, $11 billion in transportation systems, and $9.8 billion in housing. Furthermore, the report indicates that Dubai has constructed the world's largest waste-to-energy plant that will make Dubai the most sustainable and smart city by treating 1,900 tons of household waste annually, while the gases resulting from the process will be treated in the most environmentally safe and efficient manner possible.

Additionally, the report stated that Dubai Industrial Park offers support to its partners in order to adopt sustainability and recycling strategies. For example, the factory operated by Unilever uses solar energy and water recycling technologies, reducing the environmental impact of logistics by 90%. Further, the report demonstrates that in the UAE, Emirates Global Aluminium supplies nearly all its production to cement factories. Cement factories use the dust generated in the smelting process as an alternative fuel. More so, in 2008, the Abu Dhabi government established a company, "Tadweer", responsible for the policies, strategies, and contractual systems to manage waste in the emirate. Meanwhile, in coordination with the Tadweer Center, the "TAQA" company started building a waste-to-energy plant to produce electricity for the needs of more than 20,000 homes in addition to organic fertilizers and other products, valued at more than 1.2 billion dollars. Similarly, in 2007, Sharjah Environment Company created the "Bee'ah" centre in the Emirate of Sharjah, which is the world's third largest of its kind. In addition to this, there are industrial facility that self-recycle industrial wastes as by-products.

Even though, there are many successful initiatives that embrace the CE in the Arab region, however, in Arab countries, the CE faces many obstacles in the form of cultural, legislative and regulatory, marketing, and technological barriers (Kirchherr et al., 2018). In particular, CE principles need to be incorporated into all aspects of the product life cycle, from raw material provision to disposal. A circular economy still lacks industry-specific guidance. Regulation of this sector is still lacking international standards. In addition, there is still a lack of public awareness of the CE. Further, CEs and their applications do not yet have a legal framework in almost all countries in the region, as well as CE still require more investment as a new system. In addition, even though the Arab region offers a variety of natural resources, its strong economic growth path makes it vulnerable to some of the same challenges as other fast-growing economies. Urbanization and crude oil extraction represent one of the largest sources of waste and environmental pollution (Al Zoubi, 2020). Agricultural land and water supplies are also in short supply in the Arab region. Thus, traditional farming methods cannot increase food production and are heavily dependent on food imports. According to the UN Food and Agriculture Organization report, the Middle East and North Africa produce 250 kilograms of food waste per person, worth over USD 60 billion annually. In addition, recycling rates remain relatively low in the Arab region (Al Zoubi, 2020). Hence, this study aims to establish an "index" to estimate the level of dependence on the CE and the recycling rate in the Arab region in order to control waste in natural resources, reducing negative environmental impacts and boost Arab economies' added value going forward. In other word, this study is dedicated to establishing a regional index for measuring countries' progress toward CE implementation in the Arab world.

Literature Review

The CE concept is gaining popularity among governments, world organizations, regulators, academics, researchers, as well as the public. In many countries around the world, efforts have been made to develop strategies, models, and indicators in order to measure and evaluate CE transformation and adoption. Among them are China, Europe, the United States of America (USA), Belgium, the United Kingdom (UK), Australia, the Netherlands, India, Italy, Denmark, Japan, Spain, and South Korea (De Pascale et al., 2021). According to the current literature, indicators have been classified into three board levels, namely Micro, Meso, and Macro level (De Pascale et al., 2021). By incorporating macroeconomic indicators, we can harmonize trade, environmental, and economic policies on a national and international scale. While, using Meso indicators at a national level, one can identify not only material categories, but also industries and consumption patterns. Additionally, micro-level indicators offer details about specific business or local decision-making processes (Geng et al., 2012; Banaitė, 2016; and Morseletto, 2020).

A recent study by De Pascale et al., (2021), provides an overview of 61 CE indicators worldwide. The indicators were grouped into macro, meso, and micro categories, and on the basis of economic, environmental, and social sustainability dimensions, then on the basis of the 3R Core CE principles, namely Reduce, Reuse, and Recycle. In addition, it is evident from the literature that China has extensively applied and developed CE concepts at the macro and meso levels (Zhou et al., 2014). A few examples of macro level are Geng (2011), Jiang (2011), Faizi et al. (2018), Chun-rong and Jun (2011), Qing et al. (2011), Xiong et al. (2011), Geng et al. (2012), and Wu et al. (2014). It is proposed that seven macro-level indicators be used in China, which are multi-scale integrated analyses of societal metabolism; An evaluation index system for CE development level; An evaluation index for CE development; a system for evaluating CE development; the efficiency evaluation index for CE development; the Chinese National CE Evaluation Indicator System; the Super Efficiency DEA model. The proposed indicators reflect the sustainability dimensions of Environmental, Economic and Social and adhere to CE's core principle of Refuse, Rethink, and Reduce. An example of a meso level study in China is Geng et al. (2010), Tiejun (2010), Wen and Li (2010), Sałabun et al. (2019), Su et al. (2013), Geng et al. (2008), Su et al. (2013), Geng et al. (2012), Li (2011), Li and Su (2012), Wen and Meng (2015) and Zhao et al. (2017). A variety of indicators were developed, including Energy based indicators, Resource Productivity, MEP indicators system, NDCR evaluation indicator system, and Comprehensive evaluation index system. Indicators align with CE's core principles of Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, which include environmental, economic, and social sustainability factors.

Additionally, the CE concept and its indicators have only been discussed at micro to macro levels in the EUORP region, according to the literature review. Several micro-level studies have been conducted by Ellen MacArthur Foundation and Granta Design (2015), Di Maio and Rem (2015), Mohamed Sultan et al. (2017). Among these are the CE Index for recycling car materials that are consistent with CE's core principles of Reducing; the Material Circularity Indicator for products/materials that are consistent with CE's core principles of Refuse, Rethink, Reduce, and Reuse; and finally, a Recycling Desirability Index for materials that comply with CE's core principles of Reducing. Among the studies that have been published on the macro level within the EU region are Eurostat (2001), Haas et al. (2015), Smol et al. (2017), and Mayer et al. (2018). In addition, these studies cover guidance on Material Flow Analysis and Accounting, circularity indicators based on the MFA approach, regional eco-innovation indicators, and establishing tools for monitoring material flows that achieve the CE core principles of Refuse, Rethink, and Reduce at a macro level.

In addition, another typical example of CE indicator developed in the United States of America were on a micro level is the Reuse Potential Indicator that is in line with CE core principles of refuse developed by Park and Chertow (2014) applied to resource waste and the Recycling Desirability Index developed by Mohamed Sultan et al. (2017) that applied for materials related to CE core principles of Reduce. At a macro level, a Eurostat study (2001) introduces and measures material flow analysis and accounting indicators that reflect the CE core principles of Refuse, Rethink, and Reduce. The research carried out by Huysman et al. (2015), Huysman et al. (2017), and Vanegas et al. (2018) has contributed to the development of CE indicators such as Recyclability Benefit Rate, CE Performance Indicator, and Ease of Disassembly Metric. Further, in the case of the United Kingdom, a study by Mohamed Sultan et al. (2017) and Huysman et al. (2017) developed indicators called Recycling Desirability Index and CE Performance Indicator to measure CE activities in electronic services sectors and post-industrial plastic waste treatment at the micro level. Several CE indicators have been developed at the micro level in the Netherlands, including Eco-cost Value Ratio and Value-based Resource Efficiency Indicator by Scheepens et al. (2016) and Di Maio et al. (2017). A number of CE indicators, including the Synthetic Economic Environmental and Recycling Desirability Index, have been developed at the micro level in Italy and India, respectively. Likewise, Bovea and Perez-Belis (2018) introduced Circularity Design Guidelines for CE development in Spain at micro level.

Moreover, Jacobsen (2008) proposes the "Kalundborg IS complex" as a measure of economic and environmental aspects of CE in Denmark, reflecting the CE core principles of refuse, rethink, and reduce. In South Korea, Park and Behera (2014) developed an indicator called “Eco-Efficiency Indicator” that reflects the four CE core principles of Refuse, Rethink, Reduce, and Reuse. Furthermore, Pagotto and Halog (2015) introduce an indicator for the Australian food industry called "Eco-Efficiency Performance", which reflects the CE principles core of Refuse and Rethink. In addition, Eurostat (2001) conducted a study in Japan to develop guidelines on Material Flow Analysis and Accounting to measure CE activities related to the core principles of reduce and reuse. Haupt et al. (2016) introduced an indicator of Switzerland's waste management system, namely "MFA of the Swiss waste management system", which reflects the CE core principles of Refuse, Rethink, and Reduce. Last but not least, “The Global Multiregional Waste-Input-Output Model” introduced by Tisserant et al. (2017) reflected the CE core principles of Refuse, Rethink, and Reduce at the global level.

To summarize, several studies have been conducted in order to determine and develop global CE indicators. A number of indicators have been established and gathered by researchers. On the basis of the CE core strategies called the 9R framework, the indicators can be categorized into three levels: micro, meso, and macro. These indicators are also classified by such research according to sustainability dimensions, including economic indicators, environmental indicators, and social indicators. It is important to note that there have been a number of studies carried out to develop indicators to measure CE activities, but there have been none that measure the level of country advancement toward CE adoption. To fill this gap, this study establishes a regional index to measure the Arab countries' economic transformation toward CEs.

Circular Economy Framework

In order to make the economy circular, various methods have been developed, known as 9R-strategies or framework. This includes Refuse**,** Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover. By employing these strategies of framework, we will be able to contribute to shifting the global economy toward sustainability (Kirchherr et.al., 2017 and Potting et al., 2017). Closing material loops sustainably has been made easier with the 9R framework. As the loop closes (lower R), external inputs require less, and so the strategy becomes more circular. In contrast, as R gets higher, the loop becomes less circular and less preferable.

A 9R-framework can be broken down into three loops: Shortest Loops, Medium Loops, and Long Loops. The R-framework's shortest loops are Refuse, Rethink, and Reduce (R0 - R2). As part of their strategy, they implement smart manufacturing, design for disassembly, and material passports, which reduce waste during the design phase. Further, there are five medium loops in the 9R-Framework: Reus, Repair, Refurbishing, Remanufacturing, and Repurposing. The purpose of these methods is to extend the lifespan of building materials. Among the loops in the R-framework, Recovery and Recycle (R8-R9) are the longest loops. These are methods used for transforming waste into products that are considered 'waste' by the industry, which require energy and technical equipment to add value.

Figure (1): The 9R Framework

Circular Economy

Higher Level of circularity = Fewer natural resources and less environmental pressures.

Linear Economy

		Strategies	
Shortest Loops	**R0**	**Refuse**	Make product redundant by abandoning its function or by offering the same function with a radically different product.
	R1	**Rethink**	Make product use more intensive (e.g. by sharing product).
	R2	**Reduce**	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials.
Medium Loops	**R3**	**Reuse**	Ruse by another consumer of discarded product which is still in good condition and fulfils its original function.
	R4	**Repair**	Repair and maintenance of defective product so it can be used with its original function.
	R5	**Refurbish**	Restore and old product and bring it up to date.
	R6	**Remanufacture**	Use parts of discarded product in a new product with the same function.
	R7	**Repurpose**	Use discarded product or its parts in a new product with a different function.
Long Loops	**R8**	**Recycle**	: Process materials to obtain the same (high grade) or lower (low growth) quality.
	R9	**Recover**	Incineration or material with energy

Source: Adapted from Potting et al. (2017)

Construction of CE index

In developing CE index, there are many aspects to consider, including its definition, objective, framework, methodology, and limitations.

Index Definition

The CE Index is an economic index designed to measure the Arab countries' degree of transformation from a linear economy system to a circular economy system. In this index, the country that scores the highest value has a better track record of achieving the CE transformation. It indicates that a country's economy can maximize resource efficiency by reducing waste, maintaining long-term value, reducing primary resources, and closing loops with products, parts, and materials within a framework that benefits society, protects the environment, and enhances economic sustainability.

Region's CE index objective

Establishing the CE index in the Arab region is intended to encourage, measure, and assess the transformation from linear economy to CE, which is expected to result in a number of advantages. Among them are the reduction of natural resource consumption, the sustainable extraction of natural resources, and the security of supply of natural resources, the reduction of waste, the reduction of emissions, the increase in natural capital, the reduction of costs, and the creation of more job opportunities.

Proposed CE Index Framework

As shown in Figure 1, the proposed CE index in this study is established following the OECD inventory of CE indicators (OECD report, 2021), which contains five components, namely economic and business indicators, environmental indicators, governance indicators, infrastructure indicators, and social indicators. Each component (main indicator) contains many sub-indicators. Particularly, economy and business indicators include added value, business, economic efficiency, economic structure, gains and revenues, investments, productivity, and savings. an environmental indicator consists of efficiency, emissions, output material process, production and consumption, savings, and use. An indicator of governance includes awareness raising, capacity building, collaboration, education, finance, innovation, pilots, and experiments, monitoring and evaluation, public procurement, regulation, stakeholder engagement, and strategy and initiatives. An infrastructure and technology indicator includes indicators for areas, equipment, facilities, and products and services. Lastly, social indicators that include indicators related to jobs and human resources. The sub-indicators are measured using several items representing different sectors, such as resources, materials, water, food, energy, culture, education and knowledge, waste, textiles, built environment, public administration, agriculture, industry, mobility, tourism, land use, production, forest, reuse, repair, share (OECD report, 2021). Aa illustrated in Appendix (I), each sub-indicator is measured with several items from representing different sector.

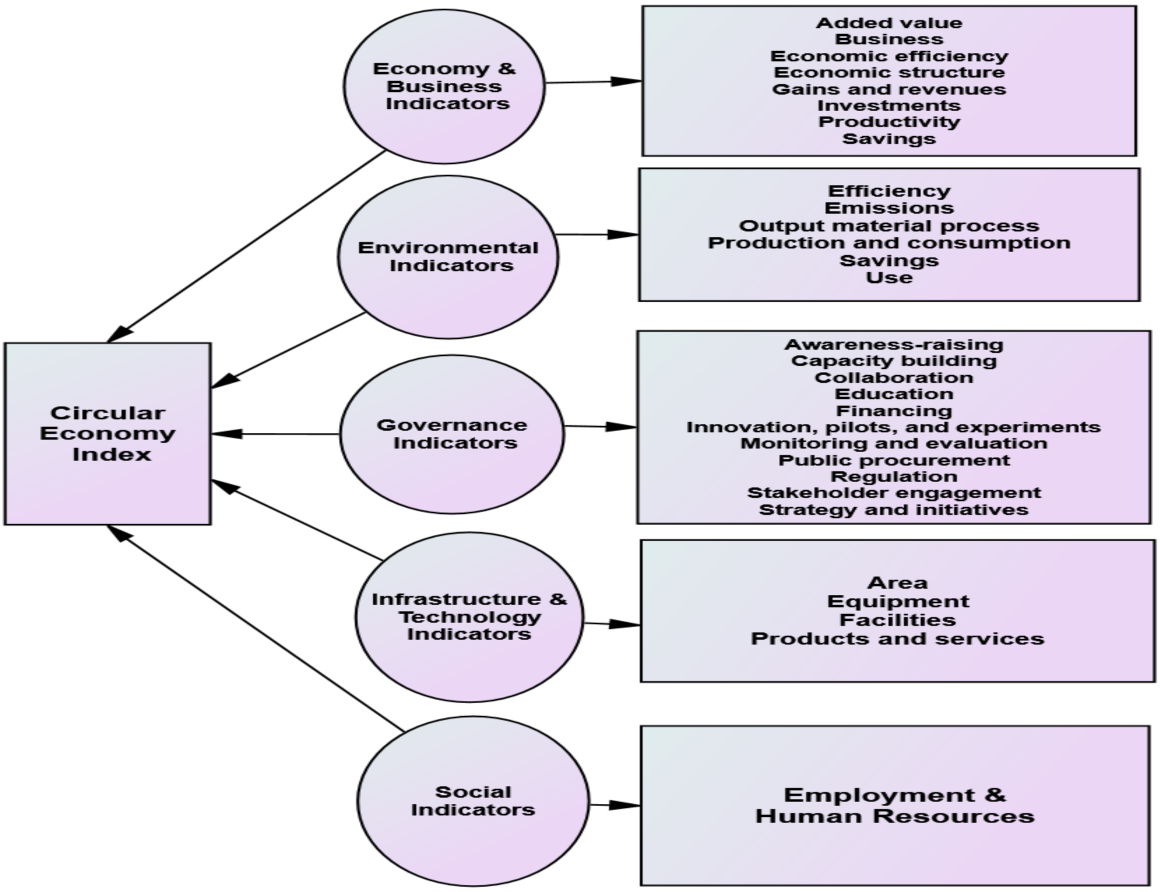

Figure (1): CE Index that draw from the OECD inventory indicators (OECD report, 2021).

Methodology

The CE index is considered a composite index. There are five main indicators included in the CE index, which include economic and business indicators, environmental indicators, governance indicators, infrastructure indicators, and social indicators. Every indicator contains several sub-indicators, each of which is measured by a different set of items and scales based on different sectors, and each sub-indicator displays heterogeneous data availability patterns, as illustrated in Appendix (I). Thus, the process of calculating the CE index consists of four stages.

First Stage: At this stage, the initial items are converted from their actual values to a range between (0 to 1) or (0 to 100%). As each item has a different measurement scale and unit of measurement, such as numbers, percentages, or amounts, etc. In order to ensure the consistency of all measurements of each item, the unit must be unified. To do so, the initial items must be standardized by converting them into minimum and maximum values. In this case, the range of possible values for the item is described: the minimum and maximum. Mathematically, this can be illustrated by the following equation that described by report on Global Human Capital 2017 of the World Economic Forum.

$$I_i = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

Where I_i refers to standardized value of the initial item, while X_{min} and X_{max} indicate the minimum and maximum value for initial item. X_i refers to the initial item at the base year.

Furthermore, when adopting a standardization or normalization approach, it is very critical to know the direction of the initial item. Hence, not every increase in the index represents an improvement, and not every decline indicates a weakening. Thus, to have an accurate standardization measurement for the initial items, it is necessary to determine the trend direction of the item based on its performance, rather than its arithmetic hierarchy. As a result, initial items that are trending in the opposite direction are represented by the following formula:

$$I_i^* = 1 - I_i = 1 - \frac{X_i - X_{min}}{X_{max} - X_{min}} = \frac{X_{max} - X_i}{X_{max} - X_{min}}$$

Furthermore, to estimate the standardization values of extreme deviation initial items, you can use the following adjust logarithmic equation.

$$I_i^{**} = \frac{\ln\left(\frac{X_i + 1}{2}\right) * 100 - X_{min}}{X_{min} - X_{max}}$$

Second Stage: The second stage involves calculating the geometric mean of each item under each sub-indicator after calculating the standardized value for each item at the first stage:

<u>Calculation of G.M- individual item series:</u>

If $x_1, x_2, x_3, \ldots\ldots., x_n$ be n observations studied on sub-indicator (X), then the G.M of the observations is defined as:

$$\text{G.M} = (X_1\ X_2\ X_3 \dots\dots . . X_n)^{1/n}$$

Third Stage: After calculating the G.M values for each sub-indicator in the second stage, we applied the weighted geometric mean equation to estimate the value of the main indicators of the CE index.

Weighted Geometric Mean equation is given by:

$$\text{G.M} = \left(X_1^{\ w_1}\ X_2^{\ w_2}\ X_3^{\ w_3}\ \dots . \dots . . X_n^{w_n}\right)^{1/N}$$

Where $\mathrm{N} = \sum_{i=1}^{n} w_i$, i.e., total weight and w_i refers to weighted of each individual sub-indicator.

Fourth Stage: At this stage, we calculate the CE index using the weighted geometric mean, again incorporating all the main indicators.

Weighted Geometric Mean for CE Index is given by the following equation:

$$\text{G.M} = \left(X_1^{\ w_1}\ X_2^{\ w_2}\ X_3^{\ w_3}\ \dots . \dots . . X_n^{w_n}\right)^{1/N}$$

Where $\mathrm{N} = \sum_{i=1}^{n} w_i$, i.e., total weight, w_i refers to weighted of each individual main indicator.

Below is a diagram (2) that illustrates and summarizes the paradigm process of CE calculation, which includes the four stages discussed above:

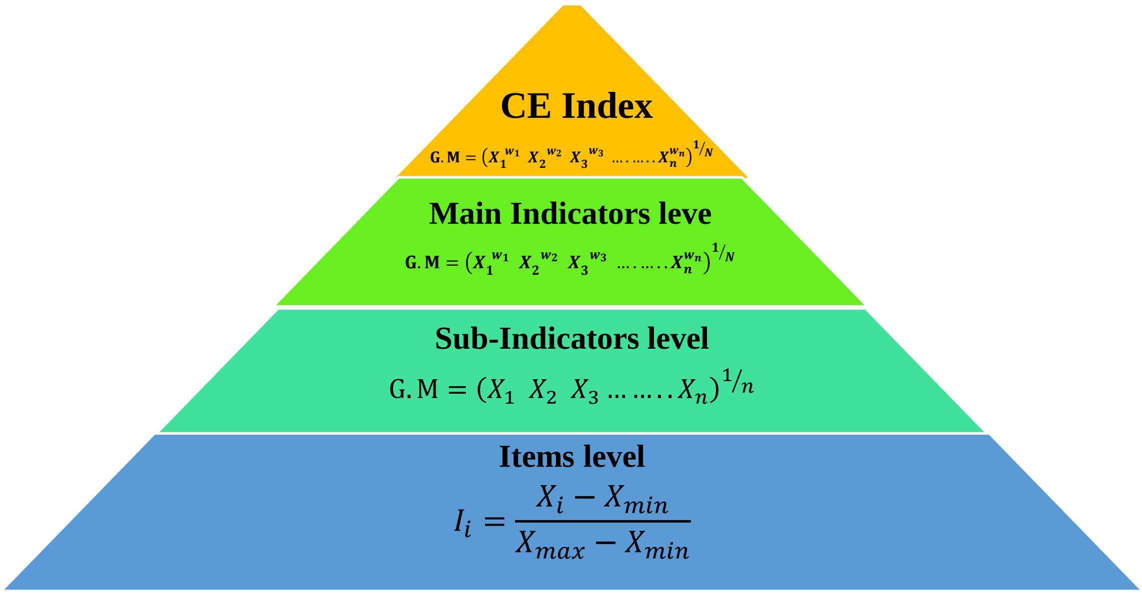

Figure (2): Paradigm of CE Index Stages Calculations.

Data Collection Process

To understand how well businesses in a country are pursuing the aims of a CE, governments need to have access to data that measures their CE activities. It, therefore, requires data on areas of a business that are not traditionally measured, such as the circularity of materials used in production and consumption, waste management, competitiveness, and innovation. Or, to put it another way, data on CE activities that reflect sustainability dimensions such as economic, business, environmental, governance, infrastructure, and social aspects. Data for these indicators can be obtained by creating surveys that include all the measurement items for each indicator and the sub-indicator, as shown in Appendix (I). The survey can be distributed to government statistics departments at the Arab countries' ministries of economy, environment, infrastructure, technology, education, and other national statistical offices. It can also be distributed to other Arab institutions, national or local authorities, as well as international organisations. The collected data will then be evaluated and analyzed using the recommended method in this study to calculate the CE index in the Arab region. This index can also be applied by each individual country to determine its level of CE transformation. A survey will be distributed to the target population of 22 Arab countries in the region as a part of the valuation of the region index.

Table (2): List of CE Index's population target

No.	Country	Ministry	Department
1.	Algeria	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
2.	Bahrain	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
3.	Comoros	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
4.	Djibouti	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
5.	Egypt	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
6.	Iraq	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
7.	Jordan	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
8.	Kuwait	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
9.	Lebanon	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
10.	Libya	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
11.	Mauritania	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
12.	Morocco	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
13.	Oman	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
14.	Palestine	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
15.	Qatar	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
16.	Saudi Arabia	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
17.	Somalia	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
18.	Sudan	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
19.	Syria	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
20.	Tunisia	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
21.	the United Arab Emirates	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information
22.	Yemen	Economy, Environment, Infrastructure and Technology and Education	Statistics and Information

The CE Index's Limitations

Based on an assessment of the list of indicators, as shown in appendix (I), it is evident that the majority of existing indicators focus on the macro and meso-level measures of inter-economy and industry flow metrics. In the Arab region, CE strategies can only be monitored at macro and meso levels due to limited capabilities for measuring and obtaining data on the micro indicators. This since, neither the data from the country level to the business level is available, nor are the time and effort constraints from the business level to the industry level, or the country level, to be able to do this.

As illustrated in appendix (I), the existing items that measure the current sub and main indicators in the CE index rely mainly on quantitative parameters, like amounts, tons, numbers, and kilograms, which are numerical in nature. Social and behavioral indicators that look at the community's attitude toward the CE are less defined and appear in monitoring frameworks less frequently. By including social behavior items into the CE indicators, a comprehensive assessment of transformation to CE can be achieved.

Finally, there are not enough items at this level that measure all related indicators to provide a comprehensive picture of the country's transition to a CE. By including micro and business level items, a picture of the country's transition will be possible.

Conclusion

In this study, the goal was to develop an index that measures the degree of a country's transformation from a linear to CE. In establishing the CE index, many indicators and sub-indicators were adopted based on the available literature. There are five main indicators that make up the CE index: economic and business, environmental, governance, infrastructure, and social indicators. Each component is measured by a variety of sub indicators. Finally, each sub-indicator should be measured by several items. In order to calculate the proposed index, the four stages or levels are taken into account. In the first stage, study items were normalized because they measured on different scales, such as numbers, percentages, amounts, tons, kilograms, etc. A geometric mean method was used to calculate the normalized mean for all items under each indicator in the second stage, since different items belong to different sectors. To calculate the main indicators and the final index, weighted geometric means were used in the third and fourth stages of the study. Thus, by using the CE index, policymakers and countries in the region will be able to assess their progress towards CE transmission. Due to the lack of indicators for measuring micro-level activities within CE and community behavior toward circular economies, the index has such limitations. In future research, expanding the index to include indicators for measuring CE activities at the micro level and social behavior scopes will provide a comprehensive picture of the region's transition to the CE.

Recommendations and Policy Suggestions

Taking into account the Index developed by the study, policymakers, regulators, and CE stakeholders can consider adopting such policies in developing CE in the region.

- ✓ Regulatory laws and legislation are needed to establish and facilitate the implementations of CE and prevent natural resource waste in the region.

- ✓ Indicators for the CE should be developed on micro, meso, and macro levels, reflecting all aspects of our economy and lives.
- ✓ In order to achieve sustainable development and green economies in Arab countries, CE strategies need to be integrated into the governments' economic policies and frameworks. The process can be facilitated by drawing examples from international experience.
- ✓ Developing a monitoring framework for CE in the Arab region and establishing a CE stakeholder platform for exchange experience and related knowledge.
- ✓ Standards and methods for recycling content, recyclability, and repairability in the Arab region should be developed based on CE standards in developed countries.
- ✓ Creating policies and incentives that encourage the consumption of recyclable products and services in the region.
- ✓ Changing patterns of production and consumption and utilizing renewable energy consistent with climatic and environmental changes.
- ✓ Through media outreach and education, we can increase public awareness of the need to move toward a CE and environmentally friendly policies.
- ✓ A CE database should be built to determine how quickly the Arab region is transitioning from linear economies to CEs.

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Appendix (I): the CE indicators restricted from OECD inventory report 2021

Indicators	Sub-indicators	Measurement	Unit	Year	References
Economic and Business indicators	Added value	added value of the circular economy	Amount	2019	Moraga et al., 2019
		Gross value added generated	Amount	2017	The OECD Inventory of CE indicators report 2021
		Economic value generated	NA	2018	The OECD Inventory of CE indicators report 2021
		Value added at factor cost (percentage of gross domestic product (GDP) at current prices)	%	2018	The OECD Inventory of CE indicators report 2021
	Business	Number of companies with certification based on life cycle or eco-design	number	2019	CETIM, 2019
		Increase in the number of enterprises and productivity	number	2018	The OECD Inventory of CE indicators report 2021
		Companies implementing products-a-service business models	number	2020	CETIM, 2020
		Strategy plan, projects and business activities involve in repair.	number	2021	Naranjo-Molina et al., (2021).
	Economic efficiency	Material intensity	Kg/EUR	2018	The OECD Inventory of CE indicators report 2021
		Domestic Material Consumption per capita	EUR/kg	2017	The OECD Inventory of CE indicators report 2021
		Generation of waste excluding major mineral wastes per GDP unit	Kg/Thous	2019	The OECD Inventory of CE indicators report 2021
		Economic growth of the circular economy	% of GDP	2019	Moraga et al., 2019
	Economic structure	GDP per Total Greenhouse Gas Emissions	PPP/kg CO2 equivalent	2018	The OECD Inventory of CE indicators report 2021
		Weight of the green economy in GDP	NA	2019	Green, P. (2019).
	Gains and revenues	Economic gains of the reduction of the digital impact in the local administration	NA	2018	The OECD Inventory of CE indicators report 2021
		Sales of organic products and local food products	NA	2019	The OECD Inventory of CE indicators report 2021
		Economic gains of the reduction of the digital impact in the local administration	NA	2018	The OECD Inventory of CE indicators report 2021
		donation and reselling scheme to the city	Amount	2018	The OECD Inventory of CE indicators report 2021
		Industry turnover in more circular products	Amount	2019	Jaurlaritza, E. (2019).
	Investments	Household spending on product repair and maintenance		2017	Magnier et al., (2017)
		Public expenditure on R&D related to EC	Amount	2019	Agenda (2019)
		Investment in R&D over the GD	% of GDP	2019	The OECD Inventory of CE indicators report 2021
		Amount invested in circular economy projects	total amount	2017	The OECD Inventory of CE indicators report 2021
	Productivity	Degree of productivity	NA	2018	The OECD Inventory of CE indicators report 2021
		Resource Productivity	EUR/kg	2017	The OECD Inventory of CE indicators report 2021
		Material Productivity	EUR GDP/kg DMC	2018	The OECD Inventory of CE indicators report 2021
		Material Productivity	total amount	2019	Moraga et al., 2019
	Savings	Cost savings	Amount	2019	Alhola et al., (2019)
		Waste reduction economic savings	Amount	2018	The OECD Inventory of CE indicators report 2021
		Money saved because of recovery and reuse of materials	Amount	2017	The OECD Inventory of CE indicators report 2021
		Savings made by not replacing items of clothing	Amount	2017	The OECD Inventory of CE indicators report 2021
Environmental Indicators	Efficiency	Amount of renewable electricity available to each household	NA	2018	Morley et al., (2018).
		Energy efficiency	NA	2017	The OECD Inventory of CE indicators report 2021
		Electricity from renewable sources (gross production)	GWh	2018	The OECD Inventory of CE indicators report 2021
		Energy intensity	TJ	2019	The OECD Inventory of CE indicators report 2021
	Emissions	CO2 emissions	Tonnes	2019	The OECD Inventory of CE indicators report 2021
		Greenhouse gas reduction	%	2019	The OECD Inventory of CE indicators report 2021
		CO2 emissions per capita	Tonnes/capita	2018	Morley et al., (2018).
		Greenhouse gas emissions per capita	NA	2015	The OECD Inventory of CE indicators report 2021

	Output material process	Materials recovered through reuse and recycling	Tonnes	2017	The OECD Inventory of CE indicators report 2021
		Percentage of recycled content used in materials	%	2018	The OECD Inventory of CE indicators report 2021
		Number of goods reused internally in the local administration	Number	2018	The OECD Inventory of CE indicators report 2021
		Repair and reuse of materials	Tonnes	2019	The OECD Inventory of CE indicators report 2021
		Recycling of biowaste per capita	Kg/capita	2019	The OECD Inventory of CE indicators report 2021
		Construction waste	NA	2017	The OECD Inventory of CE indicators report 2021
		Total amount of food waste generated per year	kg/inhabitant	2019	The OECD Inventory of CE indicators report 2021
		Waste production	Billion Kg	2018	The OECD Inventory of CE indicators report 2021
	Production and consumption	Gross electricity production	GWh	2018	The OECD Inventory of CE indicators report 2021
		Energy consumption (final)	toe/inhabitant	2018	The OECD Inventory of CE indicators report 2021
		Energy consumption (primary)	toe/inhabitant	2018	The OECD Inventory of CE indicators report 2021
		Consumption of fossil plastic in the food sector	Tonnes	2019	The OECD Inventory of CE indicators report 2021
		Consumption of secondary materials	Tonnes	2019	The OECD Inventory of CE indicators report 2021
		Material collected in a workshop for the reuse of building materials	Tonnes	2017	The OECD Inventory of CE indicators report 2021
		Water consumption	million m3	2019	The OECD Inventory of CE indicators report 2021
	Savings	Material savings	tons	2016	The OECD Inventory of CE indicators report 2021
		Drinking water savings	m3/year	2019	The OECD Inventory of CE indicators report 2021
	Use	Circular material use rate	%	2019	The OECD Inventory of CE indicators report 2021
		Direct resource use	Billion kg	2018	The OECD Inventory of CE indicators report 2021
		Tons of waste biomass used	Tonnes	2019	The OECD Inventory of CE indicators report 2021
Governance Indicators	Awareness-raising	Opening of a workshop for the reuse of building materials	YES/NO	2017	The OECD Inventory of CE indicators report 2021
		Publications on the circular economy	Number	2018	The OECD Inventory of CE indicators report 2021
		Awareness actions on search and innovation on the circular economy and their respective impact	Number	2017	The OECD Inventory of CE indicators report 2021
		Number of events held in collaboration with the social entrepreneurship community	Number	2017	The OECD Inventory of CE indicators report 2021
		Conferences about circular and responsible fashion	Number	2018	The OECD Inventory of CE indicators report 2021
	Capacity building	Guides developed on greater efficiency and material productivity for the built environment	Number	2017	The OECD Inventory of CE indicators report 2021
		Training courses in renewable energies	Number	2018	The OECD Inventory of CE indicators report 2021
		Training courses on the circular economy	Number	2018	The OECD Inventory of CE indicators report 2021
		People trained in the circular economy fields of activity	Number	2016	The OECD Inventory of CE indicators report 2021
		Number of conferences organized for training of municipal staf	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of start-ups supported by an innovation platform	Number	2017	The OECD Inventory of CE indicators report 2021
	Collaboration	No. of partnerships with municipalities/distribution	Number	2017	The OECD Inventory of CE indicators report 2021
		Collaborative projects implemented by the Galician network of Circular Economy	Number	2019	The OECD Inventory of CE indicators report 2021
		Number of meetings of the commission to develop alternatives to single-use plastic	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of workshops held to to link up supply and demand and boost the sharing economy	Number	2017	The OECD Inventory of CE indicators report 2021
	Education	Students trained in renewable energies	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of schools and universities that responded to the call for projects on the circular economy education	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of events organised in relation with pedagogical circular economy activities	Number	2018	The OECD Inventory of CE indicators report 2021
		Circular economy researchers	Number	2018	The OECD Inventory of CE indicators report 2021
	Financing	Financial assistance granted to companies related to the circular economy	Number	2016	The OECD Inventory of CE indicators report 2021

		Budget amount assigned to calls for projects/living labs carried out/implemented and number of companies that have benefited from them.	Number	2016	The OECD Inventory of CE indicators report 2021
		Number and investment in circular-economy-related R&I projects	Number	2017	The OECD Inventory of CE indicators report 2021
		Budget of pilot public contracts in circular economy	Number	2016	The OECD Inventory of CE indicators report 2021
	Innovation, pilots, and experiments	Number of experimental projects on the building sector	Number	2017	The OECD Inventory of CE indicators report 2021
		Collected materials and objects in pilot projects within cultural facilities of the city	Tonnes	2018	The OECD Inventory of CE indicators report 2021
		Number of experimental projects initiated	Number	2017	The OECD Inventory of CE indicators report 2021
	Monitoring and evaluation	Products and construction techniques covered by life cycle analysis studies	Number	2019	The OECD Inventory of CE indicators report 2021
		Maps of local resources	Number	2018	The OECD Inventory of CE indicators report 2021
		Tracking the sale of maStudy of the establishment of waste disposal charges or other types of financial instrumentsterials from an Inclusive Recycling Program	YES/NO	2019	The OECD Inventory of CE indicators report 2021
		Life cycle and cost-benefit studies in waste management	Number	2019	The OECD Inventory of CE indicators report 2021
	Public procurement	Products/services covered by circularity criteria in the public procurement	Number	2017	The OECD Inventory of CE indicators report 2021
		Share of public procurement contracts that include environmental elements above the EU thresholds	%	2019	The OECD Inventory of CE indicators report 2021
		Public procurement contracts with a circular economy dimension	%	2017	The OECD Inventory of CE indicators report 2021
		Number of tender books with circular criteria (production and consumption)	Number	2017	The OECD Inventory of CE indicators report 2021
		Purchases of products that are reusable or include recycled material.	Amount	2019	The OECD Inventory of CE indicators report 2021
	Regulation	Number of circular policy advisers developing circular regulations and change 'linear' regulations	Number	2018	The OECD Inventory of CE indicators report 2021
		Policy process for new circular laws and regulations	NA	2018	The OECD Inventory of CE indicators report 2021
		Development of new laws and regulations that discourage linear practices	NA	2018	The OECD Inventory of CE indicators report 2021
		Legislative and normative incentives created	Number	2016	The OECD Inventory of CE indicators report 2021
	Stakeholder engagement	Number of economic actors mobilised for the development of territorial synergies between economic actors	Number	2017	The OECD Inventory of CE indicators report 2021
		Number of economic actors mobilised in an innovation platform for the circular economy	Number	2017	The OECD Inventory of CE indicators report 2021
		Network meetings for circular projects	Number	2018	The OECD Inventory of CE indicators report 2021
		Participants enrolled in the different programs for waste prevention	Number	2018	The OECD Inventory of CE indicators report 2021
	Strategy and initiatives	Projects incorporating smart design	Number	2017	The OECD Inventory of CE indicators report 2021
		Circular innovation projects	Number	2018	The OECD Inventory of CE indicators report 2021
		Circular economy vision documents	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of projects realised through a platform for the sharing economy	Number	2017	The OECD Inventory of CE indicators report 2021
Infrastructure and technology indicators	Area	Area of public space recovered for sustainable models	ha/year	2019	The OECD Inventory of CE indicators report 2021
		Number of recycling centres organised to supply repair actors	Number	2017	The OECD Inventory of CE indicators report 2021
		Number of reuse centres in the city	Number	2017	The OECD Inventory of CE indicators report 2021
		Number of collection points for reuse of materials	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of places devoted to repair	Number	2017	The OECD Inventory of CE indicators report 2021
	Equipment	Number of bento boxes distributed to reduce disposable packaging use	Number	2017	The OECD Inventory of CE indicators report 2021
		Number of waste collection devices installed	Number	2018	The OECD Inventory of CE indicators report 2021
		Change in the amount of bins allocated	NA	2018	The OECD Inventory of CE indicators report 2021
	Facilities	Seed banks (municipal)	Number	2018	The OECD Inventory of CE indicators report 2021
		Facilities with circular economy criteria	Number	2019	The OECD Inventory of CE indicators report 2021
		Sectors/facilities assessed as subject to IAC (Integrated Environmental Assessment	Number	2019	The OECD Inventory of CE indicators report 2021

		Empty houses	Number	2019	The OECD Inventory of CE indicators report 2021
	Products and services	New circular products	Number	2018	The OECD Inventory of CE indicators report 2021
		Share of circular products in total number of products	%	2018	The OECD Inventory of CE indicators report 2021
		Number of collection devices tested	Number	2018	The OECD Inventory of CE indicators report 2021
Social indicators	Jobs and human resources	Employment in the Circular Economy	Number	2017	Magnier et al., (2017)
		PhD and post-PhD grants and contracts in scientific employment	Number	2017	The OECD Inventory of CE indicators report 2021
		Direct jobs associated with the forest/wood sector	Number	2019	The OECD Inventory of CE indicators report 2021
		Number of green jobs created and secured	Number	2018	The OECD Inventory of CE indicators report 2021
		Number of jobs created by promoting circular consumption in the city	Number	2017	The OECD Inventory of CE indicators report 2021