Narrowing the digital gap as an essential factor for the development of E-Government in the Arab countries: An classificatory study using the hierarchical cluster analysis technique during the year 2022

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Abstract:

This study aims to classify 18 Arab countries according to the indicators of the digital gap during the year 2022, and to achieve this goal, six main indicators of the digital gap in the Arab countries were relied upon, represented in each of the digital gap for technological progress, the digital gap for physical capacity, the digital gap for technological achievement, The digital gap for telecommunications infrastructure, the digital gap for digital government services, and the digital gap for human capital. The study concluded that the Arab countries can be classified in terms of the size of the digital gap in them into three categories, the category of Arab countries that have a small digital gap, the category of Arab countries that have a medium digital gap, in addition to the category of Arab countries that have a large digital gap. It also pointed out that narrowing the digital gap is an essential factor for the development of E-Government in the Arab countries by providing equal opportunities for all individuals and institutions to access and benefit from E-Government services. (Police Times new roman 10, interligne simple)

Keywords : E-Government; Digital Gap; Arab Countries; Hierarchical Cluster Analysis Technique.

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I. Introduction

The world is currently experiencing rapid advancements in the field of information and communication technologies, as well as a significant transformation in digitization and digital technology. This era has been termed the digital transformation era, which primarily aims to use digital technology to change and improve people's lives in various sectors such as education, commerce, and health. Additionally, this digital transformation also contributes to achieving sustainable development and enhancing social and economic equality. As a result of this rapid digital transformation occurring worldwide, a digital divide has emerged among countries. This divide is not just a gap in resources but also a technological digital gap.

The digital divide is a global problem that affects many countries, whether they are developing or even advanced countries. It is a term that reflects the disparity in access to and use of digital technology, leading to significant disparities in opportunities and advantages available to individuals and communities. Moreover, the digital divide can have negative repercussions on economic growth and social development. Narrowing and reducing the digital divide has many positive benefits, including the development of e-government. This concept, which has garnered significant attention from countries and governments, relies on the use of information and communication technologies and digital transformation to provide government services. Its main aim is to improve the efficiency of government work and facilitate the provision of government services faster and more effectively.

Narrowing the digital divide is considered one of the most important factors for the development of e-government and providing equal opportunities for all individuals and institutions to access and benefit from digital government services.

The question of the study:

Given the importance of the digital divide in the development of e-government in Arab countries, the main problem statement of this study is as follows:

How can hierarchical cluster analysis be used to classify Arab countries based on digital divide indicators?

This main problem statement encompasses several sub-questions:

− What are the main indicators that allow us to classify Arab countries according to digital divide indicators?
− What is the classification of Arab countries based on digital divide indicators?
− Is narrowing the digital divide a key factor in the development of e-government in Arab countries?

Hypothesis:

From the main problem statement and the aforementioned sub-questions, we can derive the following hypotheses:

− Among the main indicators that allow us to classify Arab countries according to digital divide indicators are technological advancement, telecommunications infrastructure, and e-government services indicators.
− Arab countries can be classified into several categories due to disparities in material, knowledge, and even technological capabilities.
− Narrowing the digital divide ensures greater and wider use of e-government services, thus promoting the development of e-government.

In another context, this study aims to classify Arab countries according to digital divide indicators using hierarchical cluster analysis. This is done to provide accurate

and useful information for Arab countries to work on narrowing the digital divide and developing e-government.

Furthermore, in our endeavor to address the problem statement and ensure the validity of the proposed hypotheses, we have relied on the descriptive analytical approach to analyze and classify Arab countries according to digital divide indicators.

II. Conceptual Framework of the Study:

In the first part of our study, we will address various theoretical concepts related to digital transformation, e-government, and the digital divide.

1. Conceptual Framework of Digital Transformation:

Before delving into the key concepts related to e-government and the digital divide, we will first define the conceptual framework of digital transformation. We will discuss the concept of digital transformation, its benefits, and the motives behind it.

1.1. Concept of Digital Transformation:

Digital transformation refers to using technology to support radical changes in institutional processes (Terry & Others, 2009, p. 11). It can also be defined as the process of companies transitioning to a business model that relies on digital technologies to innovate products and services, provide new revenue channels, and opportunities to enhance the value of their products (Rolami, 2022, p. 80). Similarly, digital transformation is an investment in thought and behavior change to bring about a radical transformation in the way work is done, by leveraging significant technological advancements to serve beneficiaries

faster and better. Digital transformation offers immense potential to build efficient, competitive, and sustainable communities by radically changing services for various stakeholders, including consumers, employees, and beneficiaries, while improving their experiences and productivity through a series of coordinated processes, accompanied by redefining the necessary procedures for activation, implementation, and monitoring (Iraqi Technology Experts Authority, 2020, p. 6).

1.2. Benefits of Digital Transformation:

Digital transformation offers numerous benefits, including but not limited to: (Iraqi Technology Experts Authority, 2020, p. 13)
  – Changing work models and enhancing thinking methods;
  – Achieving radical improvements in services provided to individuals in health, education, safety, and security fields, improving their experiences and productivity;
  – Enhancing efficiency, reducing expenditure, quickly and flexibly implementing new services;
  – Reshaping how people live, work, think, interact, and communicate, based on available technologies, with continuous planning and ongoing efforts to redefine practical assets;
  – Providing a strategy for creating higher competitive value, advanced work teams, and sustaining a culture of innovation;
  – Facilitating faster innovation to achieve desired results and move towards success;
  – Leveraging modern technologies to be more aware and flexible in work, capable of forecasting and planning for the future.

1.3. Motives Behind Digital Transformation:

The trend of countries towards digital transformation strategies since the beginning of the new millennium was not coincidental but rather a result of a combination of new factors that contributed to the emergence of the phenomenon of governmental strategies for digital transformation. The most important motives in this regard include: (Rolami, 2022, p. 81)

– Governments' recognition of the importance of the knowledge economy and the digitalization of public facilities and their ability to drive economic development and create a competitive advantage for countries compared to others;
– Considering digital transformation as one of the most effective administrative approaches that create a duality of "improving public service quality and rationalizing public spending";
– Changes in customer and citizen requirements towards accelerating the time to benefit from services, along with continuous changes in technologies and the quality of their utilization;
– The very high added value created by technology and innovation-based industries in the economy has led countries to adopt digital transformation as a means to accelerate economic growth rates.

2. Framework of the Digital Government:

After identifying the key concepts related to digital transformation, in this theoretical section of our study, we will outline the most important concepts related to digital government.

2.1. Concept of Digital Government:

Digital government is defined as an advanced knowledge in developing administrative knowledge, its application technologies, and professional skills. It enriches administrative thought with concepts related to electronic knowledge and information and communication technologies (Qidwan & Maamari, 2017, p. 50). According to the World Bank, it refers to the use of information technologies by government entities, such as the use of wide-area networks, the internet, and mobile computing, through the mutual relationships between citizens, institutions, government entities, and other stakeholders. This aims to achieve several objectives, including improving the provision of government services to citizens, enhancing interaction with the business sector and industry, improving accessibility levels, and achieving more efficient government management (Gustova, 2017, p. 4).

2.2. Advantages of Digital Government:

Digital government offers multiple advantages, including: (Al Rifai, 2009, p. 309)

– **Expedited processing:** Electronic transactions do not require the time needed for traditional methods (traditional government).
– **Increased precision:** Electronic services are more accurate and precise than manual processes in traditional government.
– **Cost reduction:** Electronic service delivery reduces the number of employees needed to work in administration compared to traditional government, as well as by streamlining procedures, work stages, and eliminating office tools used in service delivery.

– **Simplified procedures:** E-government eliminates bureaucracy and its negative consequences, such as wasted effort, time, and money, by simplifying and facilitating procedures through information networks, accomplishing work quickly and easily, saving time, effort, and reducing expenses.
– **Administrative transparency:** When transactions are completed electronically without direct contact between citizens and specialized employees, instances of bribery, manipulation, and forgery are reduced.

2.3. Objectives of Digital Government:

Among the most important objectives of digital government are: (Al Allaq, 2004, p. 32)

−Providing services better and faster to individuals and the business sector.

−Creating an encouraging investment climate and removing obstacles for local and foreign investors.

−Providing accurate and continuously updated information to citizens, businesses, and other government institutions.

−Enhancing the efficiency of the government apparatus, oversight, and monitoring methods.

−Saving money and time by streamlining traditional transactions, meaning there will be oversight over citizens and institutions.

−Activating the role of citizens in development.

−Increasing transparency and credibility in government transactions.

2.4. Components of Implementing Digital Government:

Digital government, like traditional government, requires providing several components that contribute to its realization

and push it towards success. Among these requirements are: (Al Mohtadi, 2011, p.59-60)

  – **Infrastructure for e-government service:** This includes establishing government websites on the internet, as well as classifying and organizing information to build comprehensive databases providing a comprehensive information system.
  – **Providing services to citizens via networks:** This involves creating service centers to deliver and activate services to citizens, as well as extensive advertising campaigns to raise awareness among citizens about the services provided. Additionally, citizen participation can be enhanced through systems protecting citizen services.
  – **Government e-procurement through networks:** This is an electronic system for government procurement using the internet.

3. Framework of the Digital Divide:

After defining the conceptual framework for both digital transformation and digital government, we will delineate in this part of the study the conceptual framework for the digital divide.

3.1. Concept of the Digital Divide:

The digital divide is the gap between advanced and developing countries in access to information and knowledge resources, and the ability to use and exploit them. This gap has technological and organizational reasons as well as the availability of infrastructure (Abdelhadi, 2008, p. 7).

The International Telecommunication Union (ITU) defines the digital divide as: "The difference between those who have and those who do not have access to information through communication means and technologies (landline and mobile phones, computers, and the internet). The divide may exist

between advanced and developing countries, within the same group of countries, or within a single country, such as between rural and urban areas, or among populations based on age, gender, income, and ethnicity" (ITU, 2010, p. 40).

3.2. Impacts of the Digital Divide:

The impacts of the digital divide are diverse, especially on the economic and social levels, including:
– Inability of developing economies to adapt to international agreements.
– Economic stagnation and inability to transition to a market economy or competitive economy.
– Lowering of educational levels and isolation of thought in developing countries.
– Decrease in technological awareness and communication with the world.
– Increase in economic and informational poverty.
– Rise of extremist thinking and breeding of hatred against advanced countries.
– Absence of modern channels for information exchange among decision-makers in developing countries.
– Lack of informational transparency in countries.
– Absence of human communication patterns between different civilizations, negatively affecting the widening of this gap and transforming it into a cultural gap.

3.3. Indicators for Measuring the Digital Divide:

Among the most important indicators used in measuring the digital divide are: (Ali & Hijazi, 2005, p.33-34)

3.3.1. The Tele-Density Indicator:

Developed by the International Telecommunication Union (ITU), it is measured by the number of fixed and mobile phones per 100 individuals, and the capacity of communication networks in terms of data flow rate.

3.3.2. Technical Progress Indicator:

Measured by the number of computers, internet users, ownership of electronic devices such as fax machines and phones, by individuals, groups, and institutions.

3.3.3. Technical Achievement Indicator:

Measured by the number of patents, technology usage licenses, whether imported or exported, the volume of high and medium technology exports as a proportion of total exports, in addition to average years of schooling attainment.

3.3.4. Network Readiness Indicator:

Measured by the level of information society infrastructure in the three main sectors: governmental, private, and national, the qualification of individuals and markets, and the responsiveness of legislative and regulatory environments to the qualitative leap of the information society.

3.3.5. Media Usage Indicator:

Developed by UNESCO, it is measured by the prevalence of mass media devices such as radios, televisions, newspapers, and magazines, the number of hours of listening and viewing,

reading rates, and paper consumption rates, as well as the degree of reliance of mass media on local sources compared to external sources like global news agencies and imported TV programs.

3.3.6. Information Intelligence Quotient :

One of the most difficult indicators to measure due to the novelty of the collective intelligence concept and the interactive dynamics between individuals and groups. It can be approximated by the number of virtual groups and discussion forums on the internet, the linkage elements between their sites, as well as other informational synergy phenomena such as collective development projects, scientific papers with multiple authors, scientific meetings, and the scope of information covered.

3.3.7. Standard number of Digital Access:

A new standard developed by the International Telecommunication Union based on several factors that affect a country's ability to access information and communication technologies, including infrastructure, material capacity, knowledge, and awareness in terms of information exchange capacity.

4. The Digital Divide in the Arab World:

While the digital divide is a global issue, it is more pronounced in the Arab world. Therefore, in this part of the study, we will discuss the causes of the digital divide and ways to mitigate it in the Arab world.

4.1. Causes of the Digital Divide in the Arab World:

The causes of the digital divide in the Arab world include the following: (Al-Najjar & Hussein, 2008, pp. 193-194)

4.1.1. Financial and Economic Factors:

Investment in information and communication technology requires highly developed infrastructure due to the advancement of the IT industry and communication means. This, in turn, requires significant financial and economic resources compatible with the requirements of the digital economy, which are not readily available in the Arab world. Additionally, there is a lack of a viable economic model for funding information infrastructure that can be emulated in other Arab countries.

4.1.2. Technical and Scientific Factors:

Referring to the absence of an Arab technological environment evidenced by the lack of Arab companies producing computers and software compared to foreign companies. Additionally, Arab spending on research and development in the field of IT is low.

4.1.3. Social Factors:

These factors include brain drain and capital flight from Arab countries, in addition to economic poverty leading to intellectual and cognitive poverty.

4.2. Ways to Mitigate the Digital Divide in the Arab World:

Several factors contribute to overcoming the digital divide, including: (Fouad, 2012, p. 29)
  – Evolution of curricula to focus on the technical aspect.

–   Teaching learners how to use and benefit from information technologies.
–   Technical training for workers.
–   Providing information and communication technology infrastructure to those in need, especially in rural areas.
–   Developing infrastructure (electricity grid, communication networks) to overcome the digital divide requires strong infrastructure.
–   Designing Arabic programs and search engines.
–   Arabization and adaptation of open-source software to serve the Arab environment.
–   Allocating part of the public budget to financially and morally encourage researchers and scientists to prevent brain drain.
–   Transparency in disseminating information in all sectors.
–   Cooperation among developing countries to overcome the gap.
–   Involving both the public and private sectors in developing the communication sector and human skills.
–   Enacting legislation and regulations that encourage investment and support the digital economy.
–   Establishing a dedicated authority to plan for building an information society.

III. Classification of Arab Countries According to Digital Divide Indicators Using Hierarchical Cluster Analysis:

Hierarchical cluster analysis is used in statistical analysis and data science to group similar objects or individuals based on common features among them. This involves several steps, starting with calculating distances between samples and transforming them into a distance matrix. Then comes the stage of identifying the most similar samples and grouping them into clusters, followed by recalculating distances between the new

clusters and grouping them into larger clusters. Finally, the previous steps are repeated until large and similar groups are reached. In general, hierarchical cluster analysis helps understand the similarity and difference between data clusters and facilitates decision-making based on this aggregated data.

1. Classificatory Study Introduction:

1.1. Study Methodology:

The study methodology relies on using the Hierarchical Cluster Analysis (HCA) method to classify Arab countries according to digital divide indicators, using the statistical software R.

1.2. Sample and Study Period:

The study period includes the year 2022, and the study sample includes most Arab countries for which data was available, represented by eighteen (18) countries: Algeria, Tunisia, Morocco, Egypt, Libya, Jordan, Lebanon, Iraq, Mauritania, Syria, Saudi Arabia, United Arab Emirates, Bahrain, Qatar, Oman, Kuwait, Djibouti, and Comoros.

1.3. Data Sources:

Data on study variables were obtained from several international sources to collect the data used in this study, including:
- Arab Digital Economy Index Report, 2022.
- Worldwide Mobile Data Pricing Report, 2022.
- World Bank database (World Bank, 2023).

2. Digital Transformation and Digital Divide Indicators in Arab Countries:

In the hierarchical cluster analysis technique, we will rely on the main indicators of the digital divide obtained from the main indicators of digital transformation. Each digital divide indicator was calculated based on the following relationship:

Digital Divide Index = Total Digital Access - Digital Transformation Index

The percentage of total digital access is always 100 percent, from which:

Digital divide index = 100% - Digital transformation index

2.1.Indicators of Digital Transformation in Arab Countries:

The key indicators of digital transformation used in the study are as follows:
  – Technological Progress Index: Expressed as the percentage of individuals using the internet out of the total population.
  – Material Capacity Index: Represented by the average cost of the internet (average cost per 1 gigabyte in US dollars).
  – Technological Achievement Index: Expressed by the index of exports of information technology services as a percentage of total trade volume.
  – Telecommunications Infrastructure Index.
  – Digital Government Services Index.
  – Human Capital Index.

Table.1. illustrates the six main indicators of digital transformation for eighteen Arab countries in 2022.

Countries	Technological Achievement Index (%)	Affordability Index (1GB/1USD)	Technological Achievement Index (%)	Communications Infrastructure Index (%)	Digital Government Services Index (%)	Human Capital Index (%)
UAE	100	4,29	17,09	93,44	90,00	73,20
Bahrain	100	1,17	26,50	83,19	78,82	84,39
Qatar	100	6,87	0,30	82,33	65,88	66,98
Saudi Arabia	100	1,52	5,98	85,42	68,82	86,48
Kuwait	99,70	0,71	63,25	78,58	84,12	74,70
Oman	96,38	2,92	2,56	69,67	85,29	77,51
Morocco	88,13	0,69	28,21	58,00	52,35	61,52
Lebanon	86,59	3,00	17,95	41,23	41,76	65,67
Jordan	82,76	0,63	0,85	55,40	35,88	68,00
Tunisia	78,99	1,21	10,26	63,69	62,35	69,74
Egypt	72,06	0,93	10,26	46,83	57,06	61,92
Algeria	70,77	0,48	3,42	57,87	27,65	69,66
Djibouti	68,86	1,12	0,81	16,69	9,50	33,96
Mauritania	58,76	2,74	0,81	38,86	10,00	35,75
Libya	49,60	0,61	0,81	16,69	9,50	33,96
Iraq	48,92	0,68	0,81	16,69	9,50	33,96
Syria	35,78	8,57	0,81	16,69	9,50	33,96
Comoros	27,34	1,08	0,81	16,69	9,50	33,96

Source: Compiled by the researcher.

2.2.Digital Gap Indicators in Arab Countries:

Based on the digital transformation indicators and the following relationship:

Digital Gap Index = 100% - Digital Transformation Index

We have calculated all the main indicators of the digital gap for Arab countries, except for the Material Capacity Index, which directly represents the digital gap for each country. This is because the digital access to internet pricing is $0, thus the internet pricing for each Arab country reflects the digital gap in terms of full digital access to internet pricing. Consequently, we obtained the six main indicators of the digital gap for Arab countries, which are:

- – Digital Gap for Technological Progress.
- – Digital Gap for Material Capacity.
- – Digital Gap for Technological Achievement.
- – Digital Gap for Telecommunications Infrastructure.
- – Digital Gap for Digital Government Services.
- – Digital Gap for Human Capital. Table (2) illustrates the six main indicators of the digital gap for eighteen Arab countries in 2022.

Table.2. Main Indicators of the Digital Gap in Arab Countries in 2022.

| Countries	Digital Divide Index for Technological Advancement (%)	Digital Divide Index for Material Affordability (1GB/1USD)	Digital Divide Index for Technological Achievement (%)	Digital Divide Index for Telecommunications Infrastructure(%)	Digital Divide Index for Digital Government Services (%)	Digital Divide Index for Human Capital (%)
UAE	0	4,29	82,91	6,56	10,00	26,80
Bahrain	0	1,17	73,50	16,81	21,18	15,61
Qatar	0,00	6,87	99,70	17,67	34,12	33,02
Saudi Arabia	0,00	1,52	94,02	14,58	31,18	13,52
Kuwait	0,30	0,71	36,75	21,42	15,88	25,30
Oman	3,62	2,92	97,44	30,33	14,71	22,49
Morocco	11,87	0,69	71,79	42,00	47,65	38,48
Lebanon	13,41	3,00	82,05	58,77	58,24	34,33
Jordan	17,24	0,63	99,15	44,60	64,12	32,00
Tunisia	21,01	1,21	89,74	36,31	37,65	30,26
Egypt	27,94	0,93	89,74	53,17	42,94	38,08
Algeria	29,23	0,48	96,58	42,13	72,35	30,34
Djibouti	31,14	1,12	99,19	83,31	90,50	66,04
Mauritania	41,24	2,74	99,19	61,14	90,00	64,25
Libya	50,40	0,61	99,19	83,31	90,50	66,04
Iraq	51,08	0,68	99,19	83,31	90,50	66,04
Syria	64,22	8,57	99,19	83,31	90,50	66,04
Comoros	72,66	1,08	99,19	83,31	90,50	66,04

Source: Prepared by the researcher based on Table No 1.

3. Hierarchical Cluster Analysis Tree Structure:

As a first step, we will determine the optimal number of categories to consider in the tree structure of the hierarchical cluster analysis, and then proceed to define the structure of the tree chart. After relying on the statistical program R, we obtained Figure (1), where we notice the presence of three

homogeneous groups of Arab countries regarding digital gap indicators, indicating that the optimal number of categories is three classifications.

Fig.1. Classification of Arab countries into homogeneous groups regarding digital gap indicators.
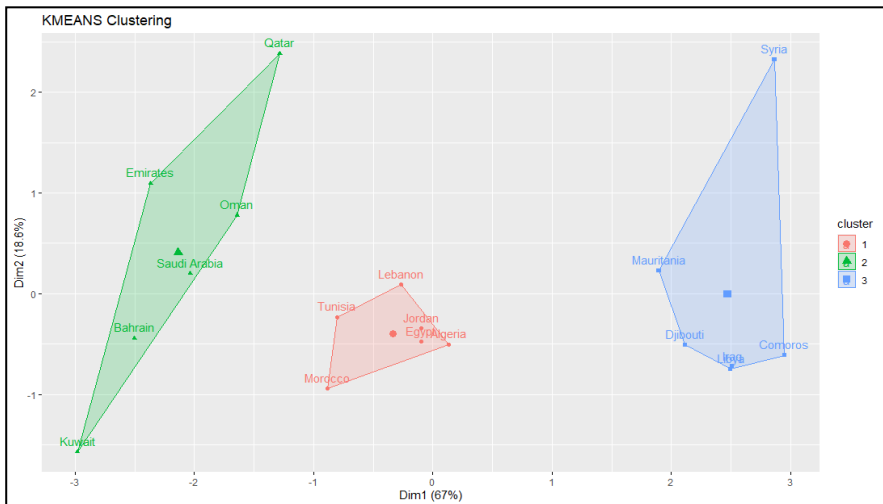
Source: Prepared by the researcher using the statistical software R

After determining the optimal number of categories, we will now present the tree structure of the hierarchical cluster analysis. By relying on the statistical program R, we obtained the following:

Figure.2. Tree structure of hierarchical cluster analysis.
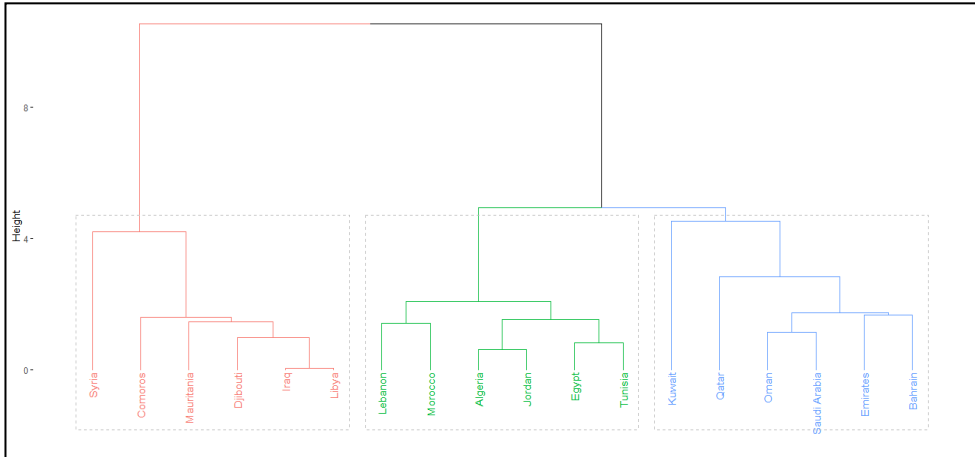
Source: Prepared by the researcher using the statistical software R

4. Results of the hierarchical cluster analysis for digital gap indicators in Arab countries:

Through the tree structure of hierarchical cluster analysis, we observe that it branches into two main clusters, each branching into two additional clusters, indicating the presence of three main clusters identified by three colors based on the optimal number of categories obtained earlier, as follows:

- The first main cluster on the right in blue comprises six Arab countries.
- The second main cluster on the right in green comprises six Arab countries.
- The third main cluster on the right in red comprises six Arab countries.

From this, we infer through the tree structure of hierarchical cluster analysis that Arab countries can be classified into three categories based on the degree of their digital gap:

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- **The first category consists of countries with a small digital gap**, including the United Arab Emirates, Saudi Arabia, Oman, Kuwait, Qatar, and Bahrain.

- **The second category consists of countries with a moderate digital gap**, including Egypt, Jordan, Tunisia, Lebanon, Morocco, and Algeria.

- **The third category consists of countries with a large digital gap**, including Libya, Syria, Djibouti, Iraq, Mauritania, and Comoros.

Furthermore, each pair of the following Arab countries has a homogeneous degree concerning the digital gap: the United Arab Emirates and Bahrain, Saudi Arabia and Oman, Egypt and Tunisia, Jordan and Algeria, Lebanon and Morocco, Iraq and Libya.

IV. Conclusion:

In this study, we relied on hierarchical cluster analysis to classify Arab countries according to key digital gap indicators, yielding several results, including:

- The most significant indicators allowing the classification of Arab countries based on digital gap indicators are six main indicators: technological advancement digital gap, material capacity digital gap, technological achievement digital gap, infrastructure digital gap, digital government services digital gap, and human capital digital gap.
- Arab countries can be classified into three categories based on the size of their digital gap: countries with a small digital gap, countries with a moderate digital gap, and countries with a large digital gap.

- Narrowing the digital gap is a fundamental factor for developing digital government in Arab countries by allowing a larger number of individuals and institutions to use digital government services, which is one of the most important factors for sustainable development.

Based on the above, the study proposes the following recommendations for Arab countries:

- Narrowing the digital gap requires improving digital infrastructure.
- Enhancing digital government services by providing integrated and user-friendly digital government services to citizens.
- More emphasis on scientific research and encouragement of innovation in the digital field.
- Making internet services available to everyone by facilitating its cost.

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