



## TESTING THE DISTRIBUTIONAL DIVERGENCE IN THE PILLARS OF REGIONAL DEVELOPMENT IN MOROCCO

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### ABSTRACT

*This article examines the distributional divergence of the pillars of regional development in Morocco using a new hierarchical clustering algorithm from the unsupervised machine learning literature. The study utilizes a unique dataset of regional indicators to identify the major clusters of development and differences in regional performance in terms of economic transformation, social inclusion, and environmental sustainability. Results from the hierarchical clustering algorithm show that the Moroccan regions are highly differentiated and the clusters identified do not necessarily coincide with the traditional administrative divisions. This suggests that the policies implemented in Morocco have not been effective in achieving balanced development across all regions. The findings of this study provide important insights into the challenges of regional development in Morocco and the potential of using machine learning algorithms to better identify and address regional disparities.*

**Keywords:** Regional development, Hierarchical clustering algorithm, Machine learning, Distributional divergence, Regional disparities.

**JEL Codes:** O43, C45, C52.

### 1. INTRODUCTION

The distributional divergence in the pillars of regional development has been widely discussed in recent years. This divergence is the result of disparities between different regions in terms of the effectiveness of development strategies, the availability of resources to support development, and the level of economic and social progress achieved. Numerous studies have been conducted to uncover the reasons for the divergence in regional development, which include unequal access to resources, lack of investment in infrastructure and human capital, and lack of effective governance and institutional

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#### Makale Geçmişi/Article History

Başvuru Tarihi / Date of Application : 23 Mayıs / May 2023

Düzeltilme Tarihi / Revision Date : 14 Şubat / February 2024

Kabul Tarihi / Acceptance Date : 15 Mart / March 2024

frameworks (Cheshire and Magrini, 2000; Monastiriotis, 2011; Martin and Sunley, 1998; Iammarino, 2018; Monastiriotis, 2014; Bakucs and Fertő, 2019; Buchholz et al., 2020). Additionally, the different cultural, political, and economic contexts in which regional development is pursued have been identified as potential sources of divergence (Dawkins, 2003; MacCallum, 2009; Pike et al., 2007).

It is important to note that the distributional divergence in regional development is not a static phenomenon; it is affected by numerous factors, including changes in the global economy, technological advances, and the emergence of new markets (Storper, 1997; Nijkamp, 2009; Baldwin and Martin, 2004). Therefore, it is essential to continually monitor the distributional divergence in regional development to inform effective policies that can reduce the disparities between regions (Martin and Sunley, 1996).

Morocco has long been a leader in the development of its regions, but there is a growing divergence in the approaches taken to regional development across the country. While many areas have made significant progress in recent years, others have been left behind due to a lack of investment, infrastructure, and resources. This has created a “two-speed” regional development landscape in Morocco, with some regions experiencing greater growth and prosperity than others.

The main pillars of regional development in Morocco are infrastructure, education, and economic diversification (Becheikh, 2021; De Haas, 2009; Eddelani et al., 2019). In terms of infrastructure, there has been a significant investment in roads, railways, ports, energy production, and distribution networks. This has allowed for increased access to services and markets in the country and has helped boost economic development.

In terms of education, Morocco has made great strides in improving access to quality education in its regions. This has been achieved through increased funding and support for primary and secondary schools and universities. This has allowed more citizens to attend school and contributed to the economy’s growth.

Finally, the government has sought to diversify the country’s economy by developing special economic zones and encouraging the growth of industries such as tourism, agriculture, and manufacturing. This has helped to create jobs and stimulate the local economy in certain regions.

Despite these efforts, there remains a wide divergence in the level of development across the regions. This is largely due to a lack of resources and investment in some regions and the unequal distribution of wealth across the country. As a result, some regions have been able to benefit from investment and infrastructure while others have been left behind. This has created a two-speed regional development landscape in Morocco, with some regions experiencing greater growth and prosperity than others.

In this regard, this article aims to test whether there is an increasing degree of distributional divergence in the pillars of regional development in Morocco, within the framework of the distribution dynamics of the econometric literature of economic growth. It utilizes a new algorithm of hierarchical clustering from the unsupervised machine learning literature. It also examines the role of public sector policies in influencing the distributional outcomes of economic development and the challenges posed by this unequal distribution. Finally, the article provides policy recommendations to address the growing disparities in regional development in Morocco.

This article provides a unique and novel approach to understanding the distributive divergence of the pillars of regional development in Morocco. Specifically, this article utilizes a hierarchical clustering algorithm from the unsupervised machine learning literature to identify and distinguish clusters of regions with different development profiles. This approach differs from traditional methods of regional development analysis. Furthermore, this study produces detailed insights into the complex dynamics of regional divergence in Morocco, providing important implications for policymakers. Consequently, this study provides a valuable contribution to the existing literature on regional development in Morocco and may serve as a useful reference for other studies in the region.

This study is composed of five sections. The first section outlines the introduction to the study. This is followed by a second section examining related literature. The subsequent sections describe the data set of the research, define the variables, and outline the methodology. Finally, the fifth section presents and explains the results of the study.

## **2. LITERATURE REVIEW**

The concept of regional development has long been studied in the context of economic, social, and political considerations (Palekiene et al., 2015). In recent years, however, the focus has shifted to include the notion of distributional divergence. This concept suggests that the distribution of economic, social, and political resources among different regions and countries is not equal, which can lead to disparities in regional development. The literature review examines the literature that deals with the concept of distributional divergence in the pillars of regional development (Munga and Mæstad 2009; Pan-Long, 1995; Jacobson et al., 2005; Gyimah-Brempong and de Gyimah-Brempong, 2006).

The literature review concludes that distributional divergence can have an important effect on regional development, leading to increased inequality, slow economic growth, and inadequate social services. However, it can also provide opportunities for targeted investments and market-based approaches to reducing disparities. It is therefore important to understand the implications of

distributional divergence to better understand the dynamics of regional development (Bruno et al., 1996; Clark, 2011).

Recent studies have been conducted to investigate the divergence in regional development, examining the causes of disparities in levels of development between different regions and the effects of these differences. In this context, we find the study by Adeosun and Owolabi (2021). The purpose of this study is to explore gender inequality in Nigeria. Specifically, it seeks to identify the determinants and outcomes of gender inequality in the country and assess the impact these factors have on economic and social development. The research focuses on the economic and social factors that shape gender inequality in Nigeria and the implications this has for economic and social development. It also examines the role of government policies and other interventions in reducing gender inequality in the country. Ultimately, the study seeks to provide useful insights for policymakers and other stakeholders to effectively address gender inequality in Nigeria. Cörvers and Mayhew (2021) explored the origins of regional disparities and potential solutions. They looked into the influence of regional economies and policies on these inequalities, as well as the efficacy of policies designed to reduce them. They also examined the economic and social implications of regional disparities and their impact on economic development and poverty. Lastly, they studied the implications of regional disparities for policymakers. In the same perspective, Rosés and Wolf (2021) examined the long-term regional growth and inequality in Europe from 1900 to 2015. The authors analyzed the regional disparities in economic growth and inequality in Europe and the factors that have contributed to them. They also explored the implications of these disparities for economic policy and the future of European integration. They also considered the role of public policies, such as regional development policies, in influencing regional growth and inequality. Finally, the authors discussed the implications of their findings for economic policy and the future of European integration. Zhong et al., (2022) investigated the effects of urban expansion on the urban-rural income gap in China. Using a panel data set with provincial-level information on urban expansion and income inequality, they analyzed the effects of urban expansion on the income gap between urban and rural areas and found that urban expansion contributes to an increasing spatial difference in income. Furthermore, they found that the effects of urban expansion on the urban-rural income gap are more pronounced in provinces with higher levels of urbanization and industrialization. These findings provide valuable insight into how urban expansion can contribute to income inequality in China and have important implications for urban planning and policy in China. Qin et al. (2022) studied regional development and inequality in the Yangtze River Delta region of China, analyzing the spatiotemporal evolution of regional inequality from 1990 to 2018. The results showed that inequality had increased until recently when core regions experienced faster growth and increased upward mobility, and peripheral regions experienced increased upward mobility. The core-periphery structure

remains strong, and more attention needs to be given to peripheral regions to reduce spatial polarization. The findings will be useful for regional planning and policy-making.

Few studies have been conducted in Morocco to analyze the distributional divergence of regional development. To date, the only study of this type was conducted by Benkada and Belouchi (2022). In this context, they examined the financial discrepancies of Equalization and their impact on regional development in Morocco. The authors analyzed the current economic context in Morocco, the economic and financial disparities between the regions of the country, and the dynamics of the equalization policy in terms of financing and progress. The authors also examined the effectiveness of the equalization policy in terms of regional development and discussed the implications for the country's future public policies. They ended with policy recommendations to reduce financial discrepancies and stimulate regional development.

### **3. DATA SET**

Regional growth is usually seen as a balance between economic transformation, social inclusion, and environmental sustainability (Pike et al., 2007). To determine if there is a growing level of distributional variation in the pillars of regional development in Morocco, we will utilize data and variables that demonstrate economic transformation, social inclusion, and environmental sustainability.

Morocco has been undergoing an economic transformation in recent years, to achieve sustainable and inclusive economic growth. This transformation is a key pillar of regional development in the country, as it helps to create jobs, reduce poverty, and promote economic diversification. It also helps to improve the quality of life for citizens, by providing access to better education, healthcare, and infrastructure. The transformation is also helping to attract foreign investment, which is essential for the country's economic growth. Additionally, it is helping to reduce the country's dependence on foreign aid and to increase its competitiveness in the global market. Finally, the transformation is helping to create a more equitable distribution of wealth, which is essential for long-term economic stability (Badraoui and Dahan, 2011; Becheikh, 2021; Aggarwal, 2019).

Furthermore, social inclusion is an important pillar of regional development in Morocco, as it is crucial for improving the general well-being of citizens, strengthening communities, and eradicating poverty. It is particularly important in addressing regional disparities in the country, which are the result of inequality and unequal access to resources and opportunities. Social inclusion has the potential to increase citizen's participation in decision-making, improve access to quality education, create jobs, reduce discrimination and marginalization, and contribute to reducing regional disparities in terms of access to health care, reducing income inequalities, and promoting more balanced development in all

regions of the country. Ultimately, social inclusion is essential for sustainable development in Morocco (Montanari and Bergh, 2019; Moumen et al., 2019).

Moreover, environmental sustainability is an important factor for regional development in Morocco, as it helps protect the country's natural resources, facilitates economic growth, contributes to social well-being, and creates a healthier environment for its citizens. Morocco is taking positive steps to protect the environment, such as promoting renewable energy, expanding sustainable agricultural practices, and investing in green infrastructure. These efforts help reduce emissions, conserve water, and protect ecosystems. By taking these measures, Morocco sets an example for other countries in the region and the world, demonstrating the importance of sustainable development in the region (Tekken and Kropp, 2015; Sghaier et al., 2019).

To measure the three pillars of regional development in Morocco, synthetic indicators have been constructed to assess the effectiveness of each. These indicators are valuable in helping to determine the progress made in the region's development.

Economically, GDP per capita, unemployment rate, access to finance, and infrastructure are used to assess economic transformation. Social inclusion is evaluated using indicators such as poverty rate, youth education level, inequality, and access to public services. Finally, environmental sustainability is evaluated using indicators such as energy intensity, emissions intensity, and the share of renewable energy.

Table 1 lists the variables considered when calculating the three composition indicators for the three pillars of regional development in Morocco. These variables have been used to determine the extent of regional development in the country. The composition indicators are a measure of the various components necessary for successful regional development in Morocco.

Principal component analysis (PCA) is the most appropriate tool for calculating the synthetic indicator for each pillar of regional development at the level of the 12 regions in the Marc. This is because all variables involved in the calculation are quantitative, making PCA the most suitable technique. The advantages of using PCA to calculate a synthetic indicator include its ability to reduce the data set to its most important components, identify relationships between variables, and summarize a complex set of data (Marsal-Llacuna et al., 2015).

**Table 1. The Variables and Sources**

<b>Pillar</b>	<b>Variables</b>	<b>Database source</b>
Economic Transformation	GDP per capita	High Commission for the Plan of Morocco
	Unemployment rate	
	Regional road network	
	Electrification rate	
Social Inclusion	Poverty rate	National Observatory of Human Development   ONDH
	Net enrollment rate from 6 to 22 years old	
	The proportion of households in % Having electricity in the dwelling	
	The proportion of households in % Connected to the drinking water network	
Environmental Sustainability	The proportion of households in % Connected to the sewer network	Moroccan Agency for Energy Efficiency AMEE
	Energy intensity	
	CO2 emissions	
	The share of renewable energies	

The data for the three synthetic indicators reflecting economic transformation, social inclusion, and environmental sustainability in the twelve regions of Morocco were sourced from three separate databases. The High Commission for the Plan provided the data for the economic transformation indicator for 2019, while the variables used to construct the indicator of social inclusion were taken from the National Human Development Observatory for 2017. Finally, the variables used to construct the synthetic indicator of environmental sustainability were taken from the Moroccan Agency for Energy Efficiency for 2019.

Table 2 presents the sample of our research, which consists of the twelve regions of Morocco, as per the new territorial division declared as part of the Advanced Regionalization Project of 2011.

The figure below presents the map of the three pillars of regional development in Morocco. In the Dakhla-Oued Ed-Dahab region, the data indicates a negative economic transformation and environmental sustainability, implying a low economic activity and disregard for the environment. On the contrary, social inclusion is positive, signifying that local communities can be aided by support programs and services. In the Tanger-Tetouan-Al Hoceïma region, the data is indicative of a positive economic transformation and moderate environmental sustainability, demonstrating that the economy is expanding and environmental efforts are being made. However, social inclusion is negative, which could point to social disparities and difficulties for those of lower income. Finally, in the L'Oriental region, the data suggests a positive economic transformation and negative environmental sustainability, indicating that the economy is growing but environmental concerns are not being addressed. In addition, social inclusion is negative, which could indicate social inequalities and difficulties for low-income households.

**Table 2. Regions of Morocco**

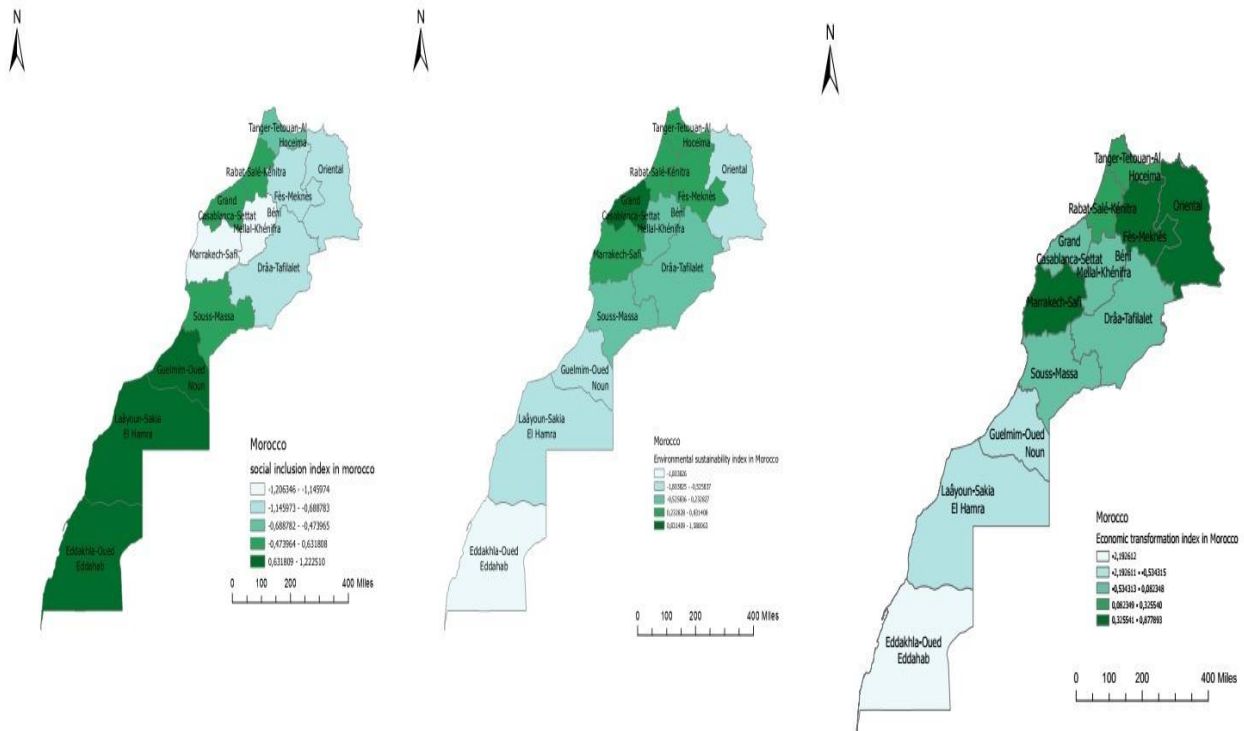
Map number	Regions
1	Tanger-Tetouan-Al Hoceima
2	L'oriental
3	Fès-Meknès
4	Rabat-Salé-Kénitra
5	Béni Mellal-Khénifra
6	Casablanca-Settat
7	Marrakech-Safi
8	Drâa-Tafilalet
9	Souss-Massa
10	Guelmim-Oued Noun
11	Laâyoune-Sakia El Hamra
12	Dakhla-Oued Ed-Dahab

**Figure 1. Map of three pillars of regional development in Morocco**

Map of social inclusion index in Morocco Factor Analysis

Map of Environmental sustainability index in Morocco Factor Analysis

Map of the economic transformation index in Morocco Factorial Analysis



#### 4. METHODOLOGY

This research examines the potential of a new hierarchical clustering algorithm from the literature on unsupervised machine learning to assess the distributive divergence of the pillars of regional development in Morocco. The hierarchical clustering algorithm is based on the principle that the data structure can be represented in a hierarchy, thus allowing for the identification of patterns and substructures in the data (Sherhod et al., 2014; Yau, 2016). Using this algorithm, the aim is to identify



any disparities in the development of the country's different regions, as well as to determine how these differences could be addressed. By understanding the differences in regional development, the research will provide valuable insight into the effectiveness of the Moroccan government's strategies and policies in the field of regional development. Furthermore, this type of analysis could also be used to inform future policy and programming decisions, as well as to direct resources toward the areas that need it most.

Hierarchical clustering is a popular unsupervised machine-learning technique used to group data points into clusters based on their similarity. It is a type of clustering algorithm that builds a hierarchy of clusters, with each cluster being a subset of the preceding one. Hierarchical clustering is used in a variety of applications, such as customer segmentation, image segmentation, and document clustering (Kassambara, 2017; Madhulatha, 2012).

Recently, a new hierarchical clustering algorithm has been proposed in the unsupervised machine learning literature. This algorithm, called the Hierarchical Agglomerative Clustering (HAC) algorithm, is based on the agglomerative clustering approach. The HAC algorithm is designed to be more efficient than traditional hierarchical clustering algorithms while still providing accurate results (Emmendorfer and de Paula Canuto, 2021).

Hierarchical Agglomerative Clustering (HAC) is a popular clustering algorithm used in data mining. It is an unsupervised machine learning algorithm that is used for detecting patterns in data. It is a bottom-up clustering algorithm that starts by treating each data point as its cluster and then iteratively merging these clusters until a user-defined stopping condition is satisfied (Maithri and Chandramouli, 2022).

The HAC algorithm works by first assigning each data point to its cluster. Then, it iteratively merges the most similar clusters until all data points are in the same cluster. The similarity between clusters is determined using a distance metric, such as the Euclidean distance. The algorithm then uses a heuristic to determine which clusters should be merged (Dash et al., 2003; Guha et al., 2003).

In conclusion, the Hierarchical Agglomerative Clustering algorithm is a promising new algorithm for unsupervised machine learning. It can achieve better accuracy than traditional hierarchical clustering algorithms while being more efficient. The algorithm has been evaluated on a variety of datasets, and the results show that it is a viable alternative to traditional hierarchical clustering algorithms.

## **5. RESULTS AND DISCUSSION**

This section presents the findings of an analysis of the distributional divergence in the pillars of regional development in Morocco. To conduct the analysis, a new unsupervised machine learning algorithm was used. The process of the classification analysis was completed, and the results were

interpreted by assessing the validity of the hierarchical analysis and the stability of the results. This was done by testing if the same results were produced across hierarchical groups and then measuring the distance.

The proximity matrix is used to illustrate the distances between different regions. This matrix is composed of rows and columns that represent these regions, and the data in the table depicts the calculated distance between them, in this case, the average distance. The matrix is triangular in shape, with the diagonal containing a zero value, indicating that the distance between a region and itself is 0, while the upper and lower parts of the matrix contain the same data.

A proximity matrix is a type of data structure used in data mining and machine learning to quantify the similarity between two data points. It is often used to measure the similarity between points in a dataset, such as geographical locations or data points derived from images. One common way to calculate the similarity between two data points is by using the Euclidean distance, which is the straight-line distance between two points in space. The proximity matrix can then be used to determine the most similar points in a dataset and to generate clusters of similar data points (de Castro and Von Zuben, 2002; Madhulatha, 2012).

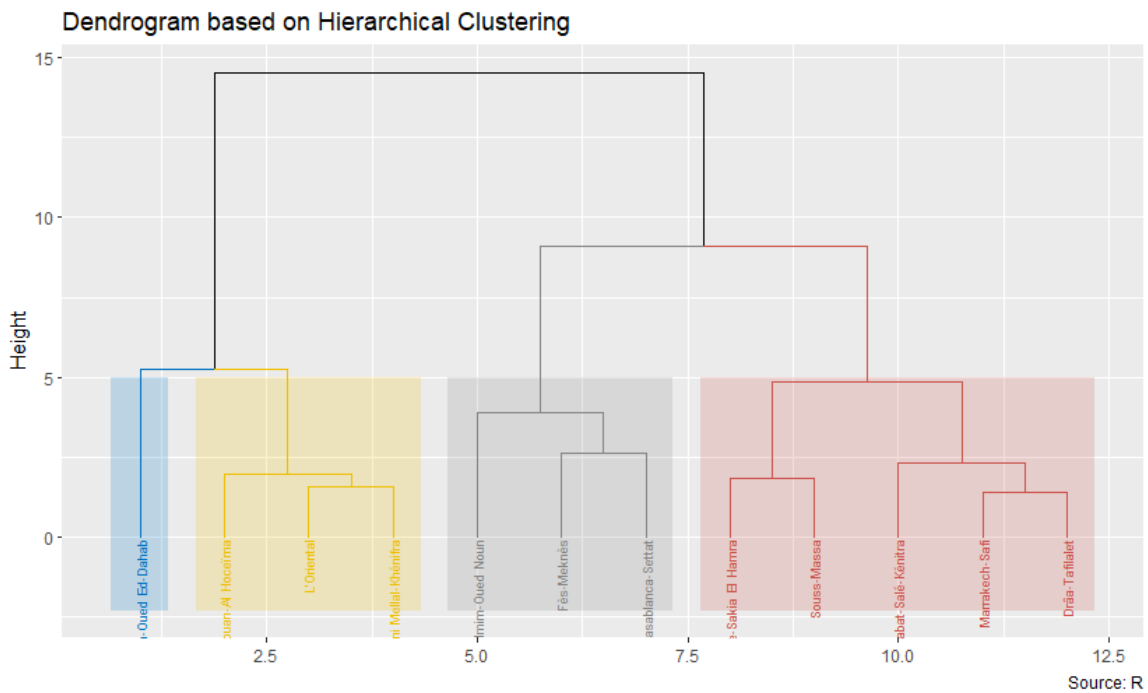
The table below presents the Euclidean distances between twelve regions in Morocco, providing a helpful visual of the relative proximity between them. From the table, it is clear that the regions are closely related, with most of them having a distance of four or less. The furthest apart regions are Dakhla-Oued Ed-Dahab and Marrakech-Safi, at a distance of 4.472. This indicates that the regions are relatively close together. The data presented in this table is beneficial for gaining a better understanding of the geography of Morocco and for making decisions related to regional development. This can help to identify potential problems and opportunities that need to be addressed to improve the region's development. The proximity matrix can also be used to identify the best strategies for regional development and to ensure that the region's resources are utilized most efficiently. In this way, the matrix of decisions has a major impact on the regional development of Morocco.

**Table 3. The proximity matrix**

Observation	Euclidean distance											
	1:Dakhla-Oued Ed-Dahab	2: Tanger-Tétouan-Al Hoceïma	3: L'Orientale	4: Béni Mellal-Khénifra	5: Rabat-Salé-Kénitra	6:Marrakech-Safi	7: Drâa-Tafilalet	8: Laâyoune-Sakia El Hamra	9: Souss-Massa	10: Fès-Meknès	11:Casablanca-Settat	12:Guelmim-Oued Noun
1:Dakhla-Oued Ed-Dahab	0,000	3,782	3,852	3,859	3,658	<b>4,472</b>	3,526	1,466	2,870	4,426	4,093	1,837
2: Tanger-Tétouan-Al Hoceïma	3,782	0,000	1,200	,751	,790	,856	,540	2,557	1,158	,655	1,581	2,412
3: L'Orientale	3,852	1,200	0,000	1,185	1,669	1,194	,987	2,794	1,373	1,360	2,652	2,451
4: Béni Mellal-Khénifra	3,859	,751	1,185	0,000	1,527	,733	,456	2,847	1,598	1,051	2,236	2,745
5: Rabat-Salé-Kénitra	3,658	,790	1,669	1,527	0,000	1,556	1,215	2,272	,990	1,102	1,016	2,116
6:Marrakech-Safi	<b>4,472</b>	,856	1,194	,733	1,556	0,000	,947	3,340	1,895	,592	2,224	3,155
7: Drâa-Tafilalet	3,526	,540	,987	,456	1,215	,947	0,000	2,444	1,143	1,059	2,045	2,307
8: Laâyoune-Sakia El Hamra	1,466	2,557	2,794	2,847	2,272	3,340	2,444	0,000	1,561	3,168	2,722	,606
9: Souss-Massa	2,870	1,158	1,373	1,598	,990	1,895	1,143	1,561	0,000	1,694	1,883	1,286
10: Fès-Meknès	4,426	,655	1,360	1,051	1,102	,592	1,059	3,168	1,694	0,000	1,713	2,976
11:Casablanca-Settat	4,093	1,581	2,652	2,236	1,016	2,224	2,045	2,722	1,883	1,713	0,000	2,725
12:Guelmim-Oued Noun	1,837	2,412	2,451	2,745	2,116	3,155	2,307	,606	1,286	2,976	2,725	0,000

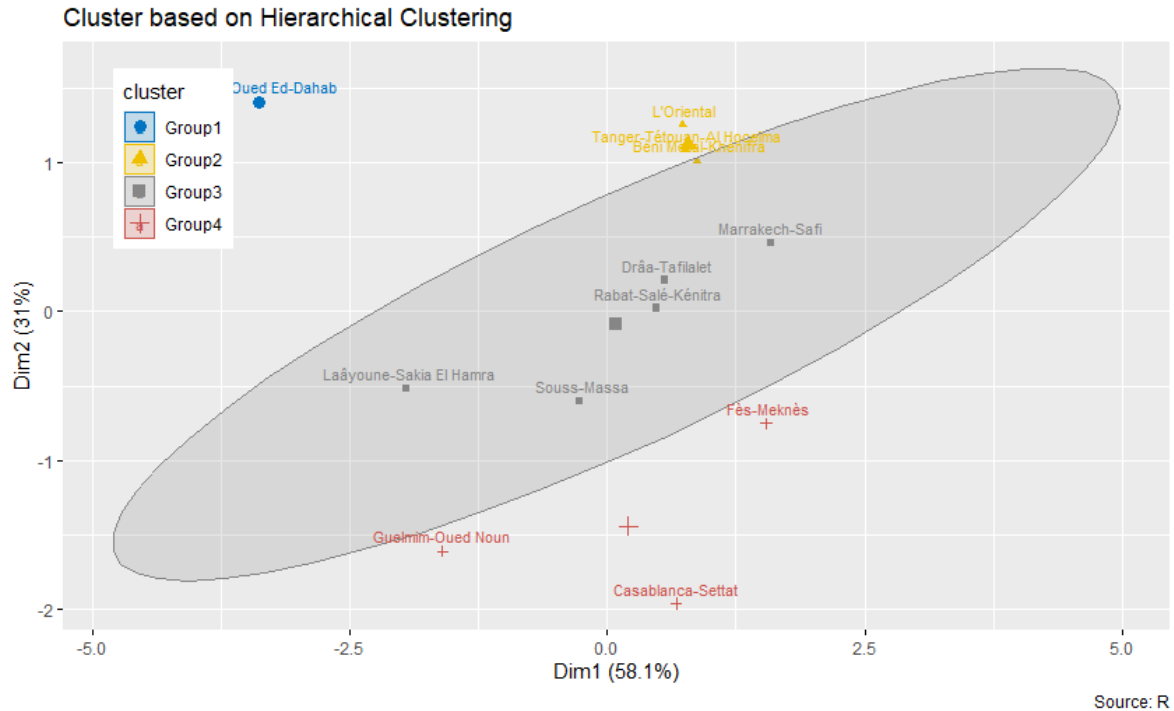
The use of dendrograms in hierarchical clustering algorithms is an important tool for understanding the distributive divergence of the pillars of regional development in Morocco. Dendrograms allow for the visual representation of the dissimilarity of the data, providing a clear view of the differences between the pillars of regional development in Morocco. Through this technique, it is possible to identify clusters of similar or dissimilar variables, as well as to identify outliers or clusters of unusual data points. This technique also allows for an analysis of the divergence of the data points across the various pillars of regional development in Morocco. By using a hierarchical clustering algorithm with a dendrogram, it is possible to gain a better understanding of the divergence of the pillars of regional development in Morocco and to identify areas of potential improvement or areas of disparity. The use of dendrograms in hierarchical clustering algorithms is a powerful tool for analyzing the distributive divergence of the pillars of regional development in Morocco.

**Figure 2. Dendrogram based on Hierarchical clustering**



The dendrogram would show the four different groups of regions based on their levels of development. Each group would be represented by a distinct branch of the dendrogram, with the most developed regions at the top and the least developed regions at the bottom. The branches would show the distance between the regions in terms of development, and the size of the branches would indicate the level of development. By looking at the dendrogram, one could easily identify which regions are more developed than others and what measures can be taken to improve the development of lagging regions.

**Figure 3. Cluster based on Hierarchical Clustering**



Clustering based on Hierarchical Clustering is an important tool for assessing the distributional divergence in the pillars of regional development in Morocco. It allows for the assessment of the degree of dissimilarity between regions and the identification of geographical clusters with similar socio-economic characteristics. This method is useful for identifying and characterizing spatial patterns of uneven development in the country, and for understanding the underlying causes of the disparities.

By using the hierarchical clustering methodology, it is possible to identify the various clusters of regions in Morocco and compare them in terms of key indicators such as economic performance, human development, and social capital. This comparison can help to identify regional disparities in the development of the country and to design appropriate policies. Clusters based on hierarchical clustering can also be used to identify areas for potential investment and to assess the impact of investments on regional development.

In addition, clustering based on hierarchical clustering can be used to identify opportunities for public-private partnerships. This can help the government to maximize the potential of the resources available in the country and to ensure that these resources are used efficiently. Furthermore, the methodology can be used to evaluate the effectiveness of interventions related to regional development and to assess the success of policies focusing on the socioeconomic development of particular regions.

Overall, cluster-based hierarchical clustering is an important tool for assessing the distributional divergence in the pillars of regional development in Morocco. It provides insight into the underlying

causes of disparities and can be used to identify areas of a potential investment, as well as to measure the impact of investments on regional development.

The two figures demonstrate that the regions in Morocco are combined into four distinct clusters. Cluster 4 includes Fez-Meknes, Guelmim-Oued Noun, and Casablanca-Settat, as they are the closest in proximity. Cluster 3 consists of Rabat-Salé-Kénitra, Marrakech-Safi, Drâa-Tafilalet, Laâyoune-Sakia El Hamra, and Souss-Massa. Tangier-Tétouan -Al Hoceïma, L'Oriental, and Béni Mellal-Khénifra are clustered into cluster 2, while cluster 1 is exclusively occupied by Dakhla-Oued Ed-Dahab, marking the end of the clustering process.

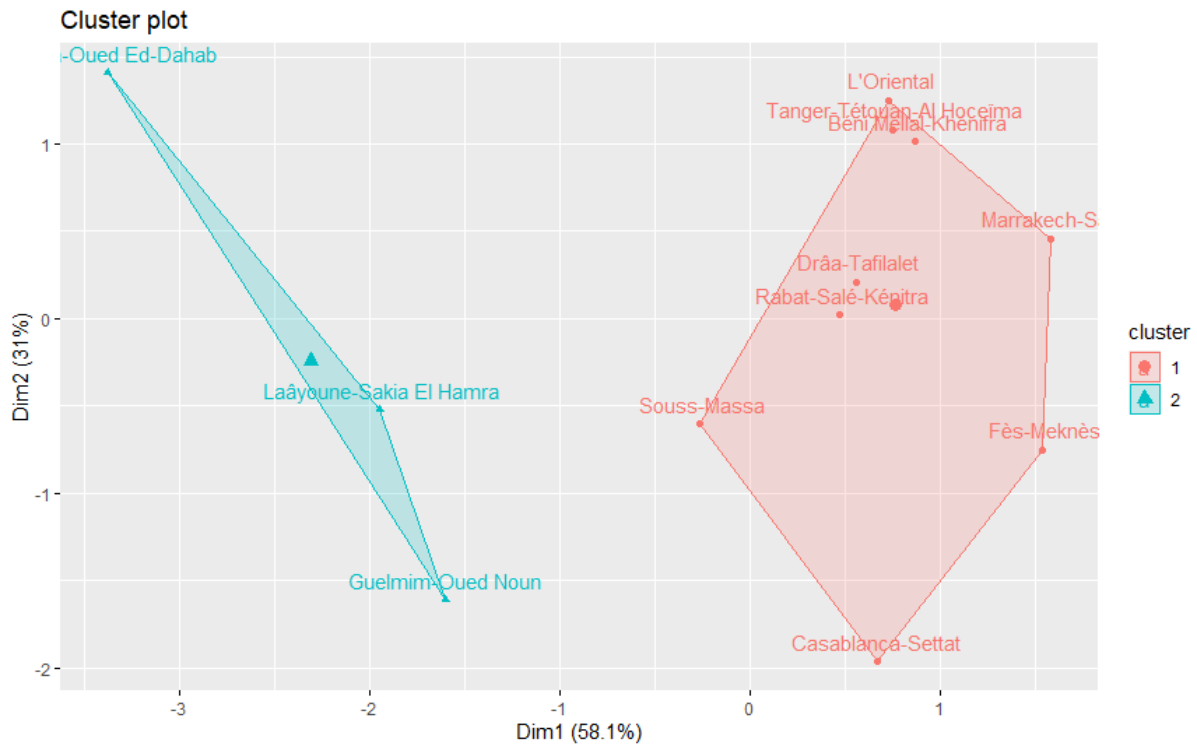
A cluster plot is an important tool for understanding the distributional divergence in the pillars of regional development in Morocco. It is used to visualize the differences in regional development in the country, such as economic performance, social inequality, and access to basic services. It is an effective way to identify regional disparities and can provide valuable insight into the current and future development of Morocco.

The cluster plot helps to illustrate the gap between the development of the different regions of Morocco. It enables the user to identify the regional differences in the distribution of economic performance, social inequality, and access to basic services. Through the use of the plot, users can identify which regions are lagging behind in terms of development and which regions are leading the way. This helps to identify potential areas for intervention, such as resource allocation or policy initiatives, in order to reduce the gap between the regions.

In addition, a cluster plot is a useful tool for assessing the impact of public policies on regional development. It can be used to measure the effectiveness of policies and identify areas where interventions may be necessary. For example, if a policy is implemented in one region but is hurting another, the cluster plot can show the discrepancy between the two regions and can be used to inform future decision-making.

Overall, the cluster plot is an important tool for understanding the distributional divergence in the pillars of regional development in Morocco. It can help to identify regional disparities and assess the impact of public policies on regional development. By providing valuable insight into the current and future development of Morocco, the cluster plot can be used to inform decision-making and guide interventions.

**Figure 4. The cluster plot**

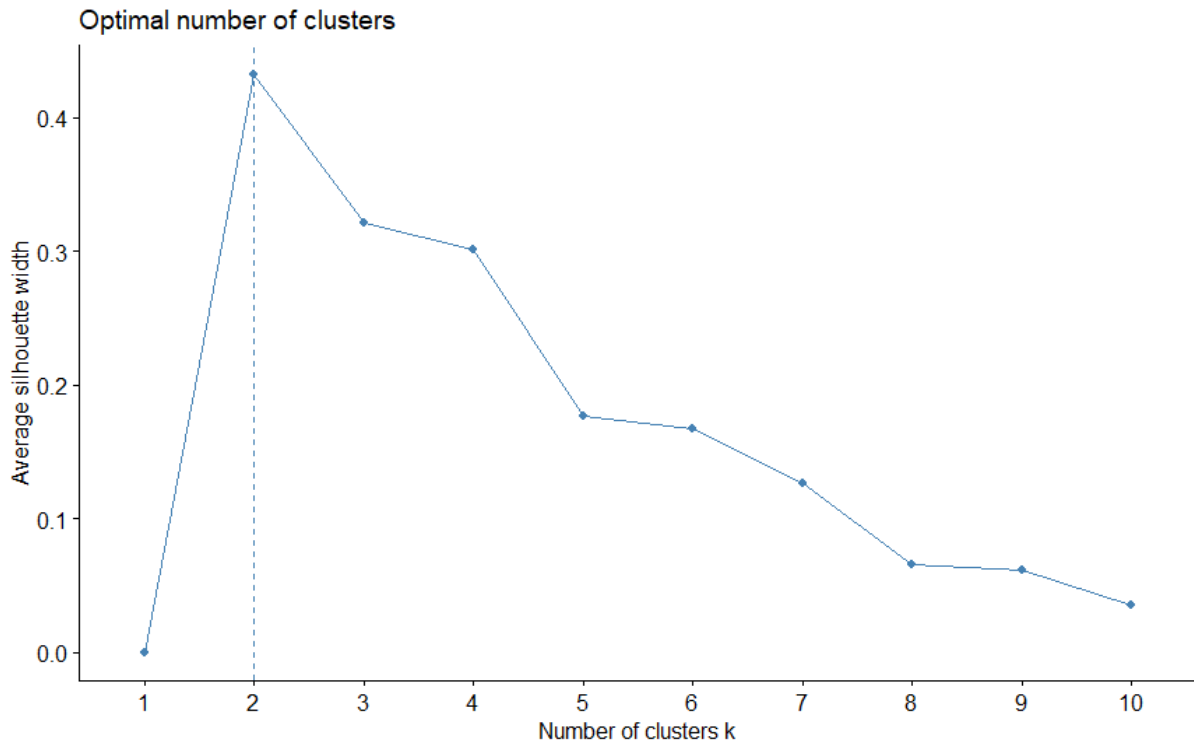


The cluster plot for the regions of Morocco offers valuable insight into the similarities and differences that exist between the various regions. In the first cluster, we can see that the regions of Guelmim-Oued Noun, Laayoune-Sakia El Hamra, and Dakhla-Oued Ed-Dahab share several similarities. These regions show a high degree of geographical proximity and shared history, as well as having experienced similar economic and social developments over the past few decades. The second cluster contains all the other regions of Morocco, which are more varied and distant from each other. The analysis of the cluster plot for the regions of Morocco can be used to identify common patterns and trends, informing policy decisions and development strategies. Additionally, understanding the unique characteristics of each region can help to improve the management of local resources and promote more equitable and sustainable development.

The optimal number of clusters is determined by examining the data and its structure. The optimal number of clusters will be the number that provides the most meaningful and accurate representation of the data. Determining the optimal number of clusters can be challenging, as there is no single "right" answer. It requires a deep understanding of the data and its structure, as well as the available clustering techniques. When determining the optimal number of clusters, it is important to consider the size of the dataset and the complexity of the data. If the dataset is large and complex, it may be difficult to identify meaningful clusters. Additionally, it is important to understand the purpose of the cluster analysis, as

the optimal number of clusters can vary depending on the purpose of the analysis. In conclusion, determining the optimal number of clusters is essential for obtaining meaningful insights from cluster analysis. It is a process that requires a deep understanding of the data and its structure, as well as the available clustering techniques. With the right understanding and approach, the optimal number of clusters can be determined and used to extract valuable insights from the data.

**Figure 5. The optimal number of clusters**



The plot indicates that the optimal number of clusters is two, as there are two distinct groupings of data points. The two clusters are easily distinguishable from one another, and all data points appear to belong to one of the two clusters. This suggests that two clusters would be the most efficient number to use for the analysis of data from Morocco.

## 6. CONCLUSION

This article has discussed the distributional divergence of the pillars of regional development in Morocco using a new hierarchical clustering algorithm from the unsupervised machine learning literature. The combination of this algorithm with a traditional clustering approach revealed a significant gap in the regional development levels, particularly in the north of Morocco. The study also highlighted a need for more effective measures to reduce this regional divergence. Therefore, it is recommended that policymakers in Morocco should consider the use of this new hierarchical clustering algorithm to better understand and address the regional disparities in development. This approach can enable them



to identify the causes of the divergence and come up with more targeted policies to reduce the gap. Furthermore, this algorithm can be used to monitor the effectiveness of such policies in the future.

In conclusion, the new hierarchical clustering algorithm from the unsupervised machine learning literature is an extremely useful tool for analyzing the distributional divergence of the pillars of regional development in Morocco. The results of the algorithm demonstrated the presence of significant disparities between the different regions in terms of economic transformation, social inclusion, and environmental sustainability. Moreover, it was also possible to identify sub-regions with similar characteristics and to pinpoint the most significant disparities. It is clear that this tool can be used to inform policymakers and help them to design more effective and equitable policies and interventions. To this end, it is crucial that further research is conducted to continue developing and refining the algorithm and to analyze other countries in order to the results. Finally, it is also important that policymakers use the results of this kind of analysis to inform their decisions and design more effective and equitable policies and interventions

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**Hakem Değerlendirmesi:** Dış bağımsız.

**Çıkar Çatışması:** Yazarlar çıkar çatışması bildirmemiştir.

**Finansal Destek:** Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

**Teşekkür:** -

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** The authors have no conflict of interest to declare.

**Grant Support:** The authors declared that this study has received no financial support.

**Acknowledgement:** -

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