



GLOBAL HUNGER CLUSTERING USING SPATIAL TEMPORAL DBSCAN

Sustainable Development Goals

Goal 2: **Zero Hunger**



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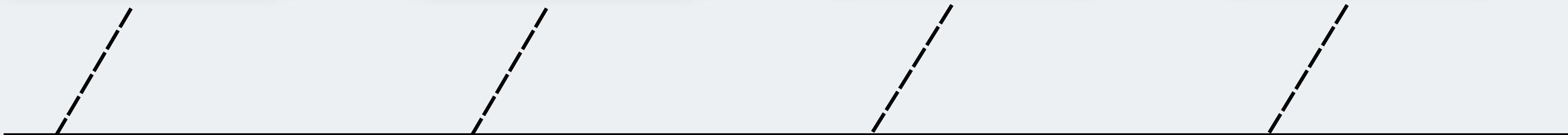
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Background and Issues



Global Hunger Situation

More than 2 billion people are affected by hidden hunger (WHO, 2006). Worldwide, around 800 million people are chronically hungry (FAO, 2017).

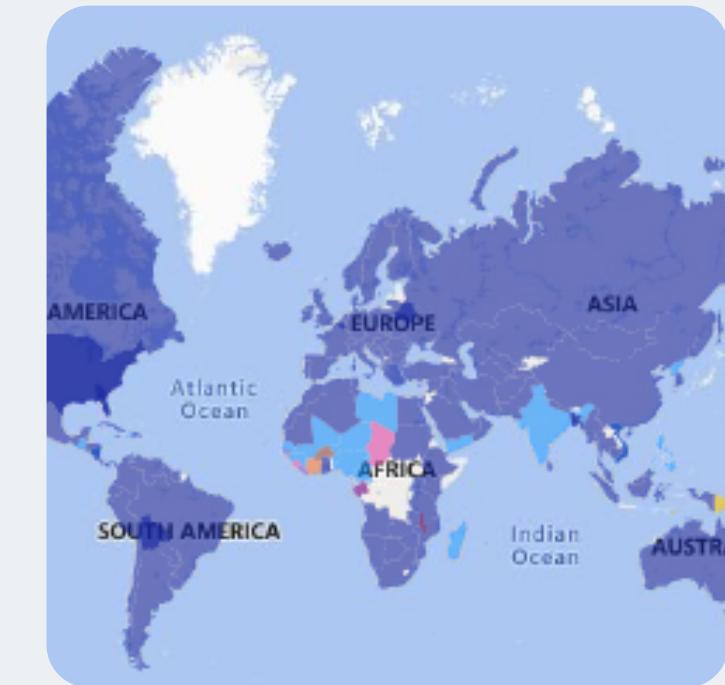


Ending Hunger in the SDGs

Ending hunger in all its forms in the SDGs remains a global challenge.



Problem



Solution

We will provide regional clusters that are able to describe the hunger conditions of a country over time, along with the main causes of hunger.



Objectives



1

Implement Spatio Temporal Density-Based Spatial Clustering of Applications with Noise (**ST-DBSCAN**) clustering algorithm to **clusterize countries** globally based on hunger indicators.

2

Find the best clustering based on **Silhouette Coefficient** and minimum number of **noises**.

3

Generate clear **insight** into the causes of hunger and provide **recommendations**.



Data Collection

Undernourishment, Child
Stunting, Women's
Anemia, and Child
Mortality data are collected
to illustrate global hunger
levels

Data Preprocessing

Merge data and
handling missing values

Exploratory Data Analysis

Using heatmaps and
boxplot.

Cluster Analysis

Using Spatial Temporal
DBSCAN.

Insight and Recommendation

Provide recommendations
to relevant authorities on
addressing global hunger

Analysis Stage

Next





Data

The data used is **secondary data of panel type** obtained from the UN Statistics Division ([UNStats](#)) and the Inter-Agency Group for Child Mortality Estimation ([UN IGME](#)). The data consists of a combination of **cross-sections which are shown on observations of countries in the world**, and **time series which are shown on observations from 2012 to 2019**.

Cross-sections		Time Series		Variables			
GeoAreaName	Region	TimePeriod	Undernourishment	Stunting	Mortality	Anemia	
Afghanistan	Southern Asia	2012	21.0	44.3	80.269673	37.5	
Albania	Southern Europe	2012	4.5	16.4	11.213958	21.6	
Algeria	Northern Africa	2012	3.1	12.1	26.494217	32.9	
Angola	Middle Africa	2012	13.3	31.8	104.875269	45.9	
Argentina	South America	2012	3.3	7.1	13.342989	12.7	
...	
Venezuela (Bolivarian Republic of)	South America	2019	23.4	10.5	24.229726	24.2	
Viet Nam	South-eastern Asia	2019	5.5	21.0	21.063481	20.6	
Yemen	Western Asia	2019	38.9	37.6	61.595028	61.5	
Zambia	Eastern Africa	2019	29.2	33.2	62.585328	31.5	
Zimbabwe	Eastern Africa	2019	38.9	23.1	52.665884	28.9	



Variables

Undernourishment

The percentage of a population with insufficient caloric intake to meet their daily energy

Child Stunting

Proportion of children below the age of five who experience impaired growth, indicated by a low height-for-age ratio.



Women's Anemia

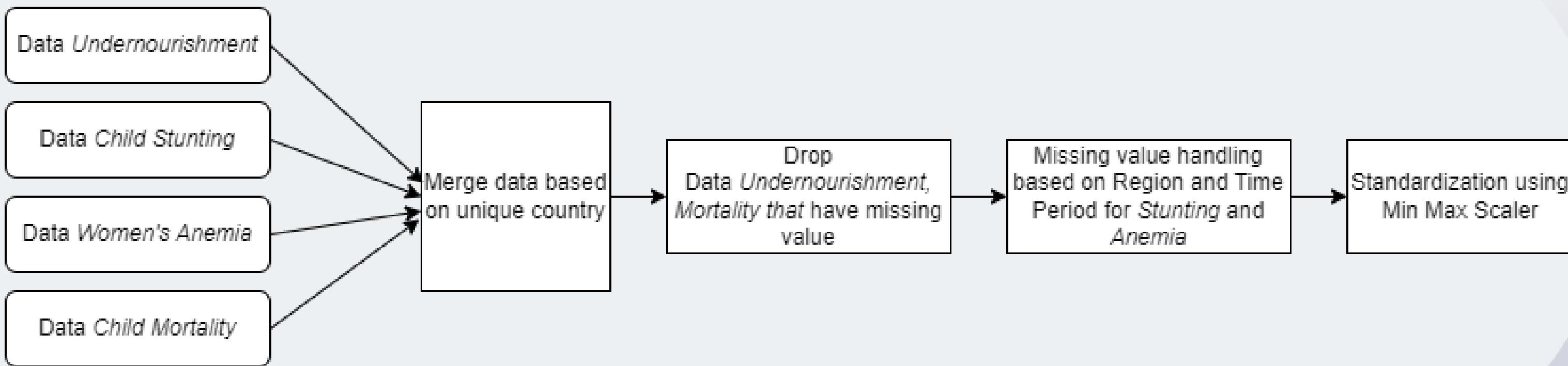
The percentage of women experiencing iron deficiency, which, if experienced during pregnancy, can adversely affect the baby's growth.

Child Mortality

The rate of children who die before reaching the age of five within a given population per 1000.

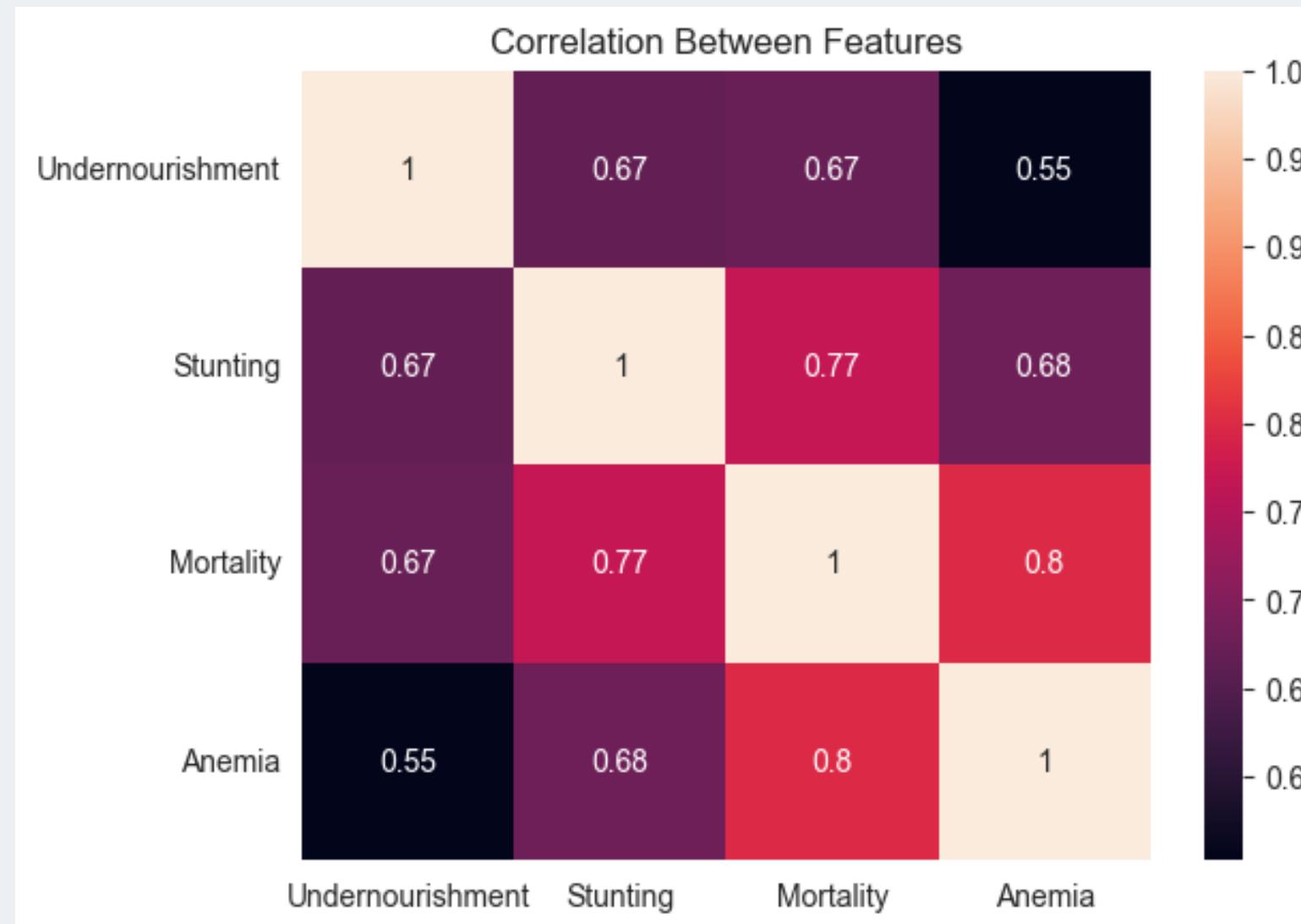


Data Preprocessing

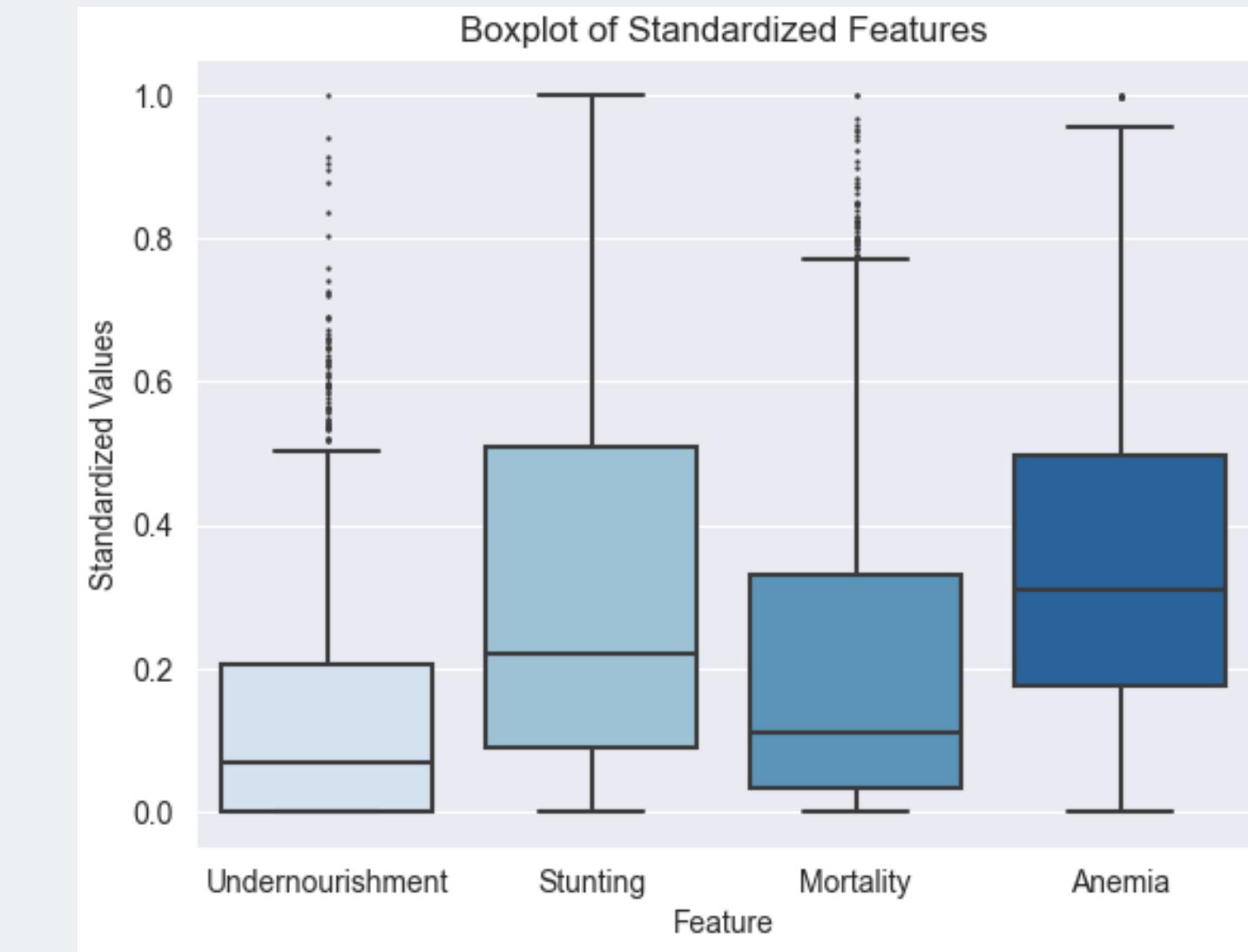




Exploratory Data Analysis



There are multicollinearities



There are outliers in *Undernourishment* and *Mortality*



Cluster Analysis

DBSCAN

- Requires 2 parameters:
 - Eps : distance parameter
 - MinPts : minimum number of objects within cluster

ST-DBSCAN

- DBSCAN algorithm with spatial and temporal adjustment
- Requires 3 parameters:
 - Eps1 : distance parameter related to spatial attributes
 - Eps2 : distance parameter related to temporal attributes
 - MinPts : minimum number of objects within cluster



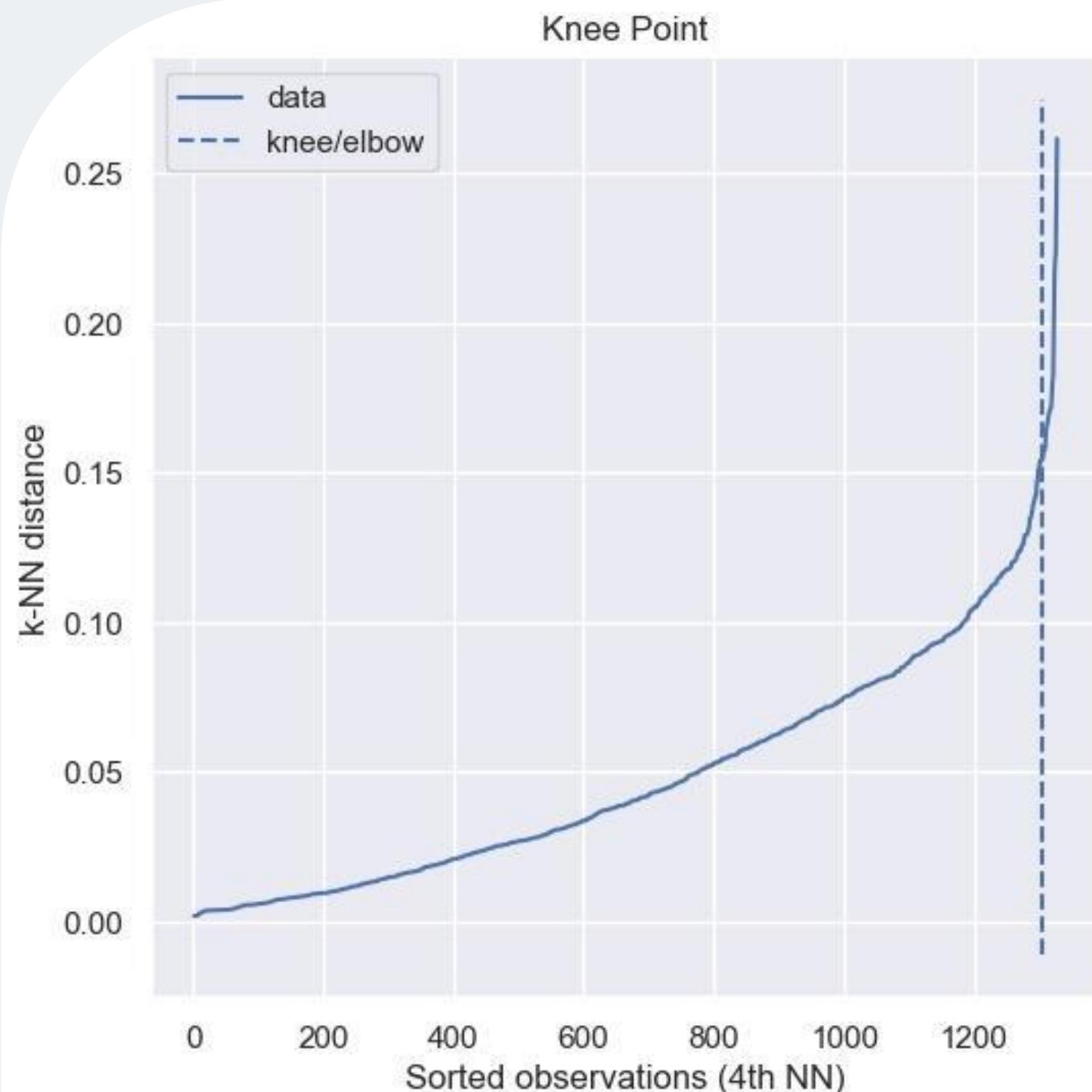
Hyperparameter Tuning



Using the **knee or elbow method**, which applies the k-Nearest Neighbors (k-NN) algorithm to determine the value of parameter `eps1` which is directly influenced by the minimum number of samples required for each cluster.

By doing so, it gave us the appropriate `eps1` value:

min_samples	eps1
0	0.115668
1	0.155948
2	0.154840
3	0.232029
4	0.316325
5	0.280195
6	0.317908
7	0.299722
8	0.317385
9	0.330370
10	0.433567
11	0.434798
12	0.334260





Hyperparameter Tuning RESULT



By varying the minimum sample size from 3 to 15, we obtained data for eps1 and the min_samples count. Additionally, for eps2, we explored a range from 1 to 7 (7 years span). Using the data, we constructed a recursive function to identify values for eps1, eps2, and min_samples that were able to optimize the silhouette score and have minimum noise compared to other parameter combinations.

The parameter values result are:

eps1 = 0.154840 , eps2 = 1, and min_samples = 5;

with **Silhouette score of 0.250921**



Clustering Result

Using the ST-DBSCAN analysis, a total of **8 clusters** were formed and **157 data points were detected as outliers**. The clustering result are as follows:

	GeoAreaName	Region	TimePeriod	Undernourishment	Stunting	Mortality	Anemia	Cluster
0	Afghanistan	Southern Asia	2012	21.0	44.3	80.269673	37.5	0
1	Albania	Southern Europe	2012	4.5	16.4	11.213958	21.6	0
2	Algeria	Northern Africa	2012	3.1	12.1	26.494217	32.9	0
3	Angola	Middle Africa	2012	13.3	31.8	104.875269	45.9	1
4	Argentina	South America	2012	3.3	7.1	13.342989	12.7	0
...
1323	Venezuela (Bolivarian Republic of)	South America	2019	23.4	10.5	24.229726	24.2	0
1324	Viet Nam	South-eastern Asia	2019	5.5	21.0	21.063481	20.6	0
1325	Yemen	Western Asia	2019	38.9	37.6	61.595028	61.5	-1
1326	Zambia	Eastern Africa	2019	29.2	33.2	62.585328	31.5	0
1327	Zimbabwe	Eastern Africa	2019	38.9	23.1	52.665884	28.9	0



Clustering Result

The variable means for each cluster are as follows

Cluster	Count	Undernourishment	Stunting	Mortality	Anemia
0	-1	157	24.515287	32.663694	68.050452
1	0	1058	6.710586	12.804849	20.706306
2	1	35	11.642857	30.465714	102.111453
3	2	22	14.827273	17.772727	53.915868
4	3	16	25.075000	34.118750	129.245230
5	4	7	30.371429	42.028571	95.814336
6	5	14	35.028571	30.235714	87.790951
7	6	12	24.608333	49.083333	53.844436
8	7	7	33.028571	40.942857	84.406029



Clustering Result

Based on the variable means, we can use GHI's threshold to classify values related to Undernourishment, Child Stunting, and Child Mortality. However, for women's anemia values, we will resort to WHO's threshold since GHI does not provide a categorization for this variable.

DATA UNDERLYING THE CALCULATION OF THE 2000, 2007, 2014, AND 2022 GLOBAL HUNGER INDEX SCORES

Guide to the colors shown in Appendix B

The colors shown in the table represent the following categories:

Green = Very low Orange = Low Yellow = Medium Red = High Maroon = Very high

They are based on thresholds for the different indicator values, as follows:

Category	Undernourishment	Child wasting	Child stunting	Child mortality
Very low	<5%	<2.5%	<2.5%	<1%
Low	5-<15%	2.5-<5%	2.5-<10%	1-<4%
Medium	15-<25%	5-<10%	10-<20%	4-<7%
High	25-<35%	10-<15%	20-<30%	7-<10%
Very high	≥35%	≥15%	≥30%	≥10%

Note: Threshold values for the prevalence of undernourishment are adapted from FAO (2015). Threshold values for child stunting and child wasting are from de Onis et al. (2019). Threshold values for child mortality are adapted from those shown in UN IGME (2021) but condensed to the five categories shown.

Table 2.3 **Classification of anaemia as a problem of public health significance**

Prevalence of anaemia (%)	Category of public health significance
≤4.9	No public health problem
5.0-19.9	Mild public health problem
20.0-39.9	Moderate public health problem
≥40.0	Severe public health problem

Source: adapted from reference (2)



22.54

Average of Anemia(%)

20.71

Average of Mortality(per 1000)

12.80

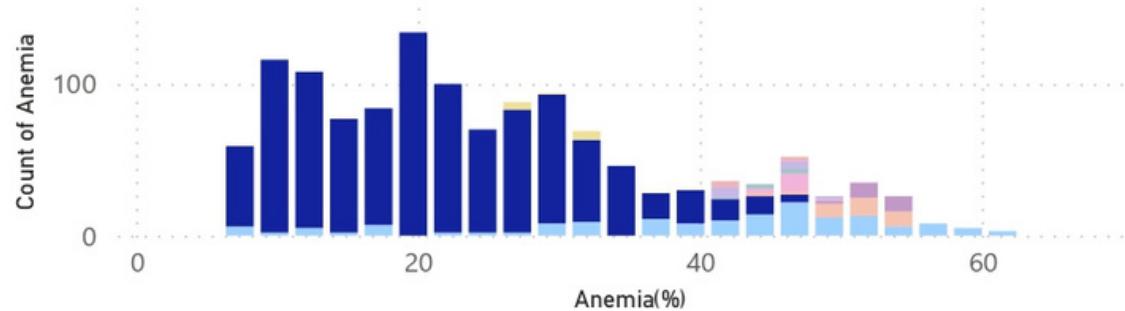
Average of Stunting(%)

6.71

Average of Undernourishment(%)

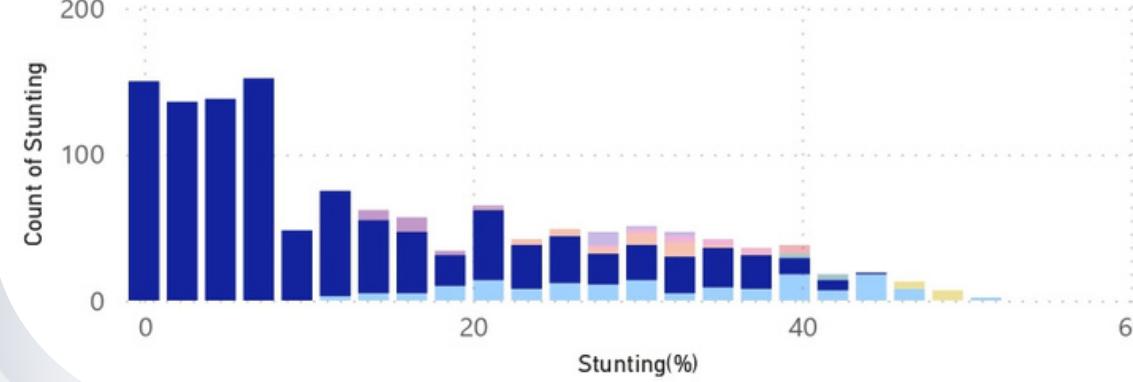
Anemia and Cluster

Cluster -1 0 1 2 3 4 5 6 7



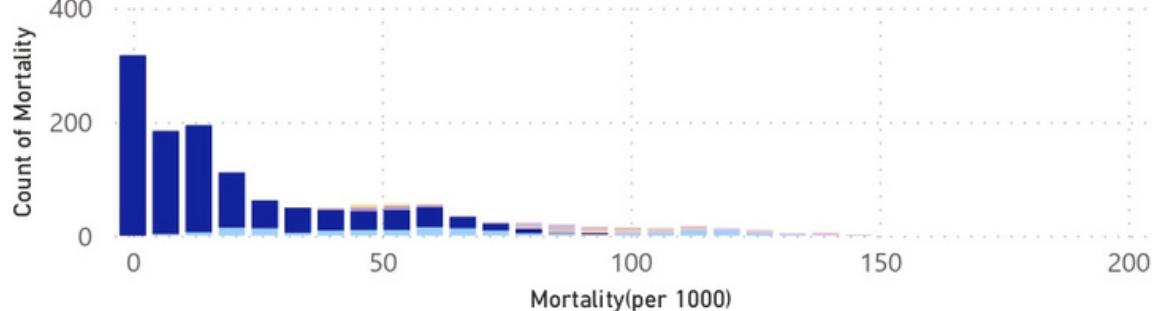
Stunting and Cluster

Cluster -1 0 1 2 3 4 5 6 7



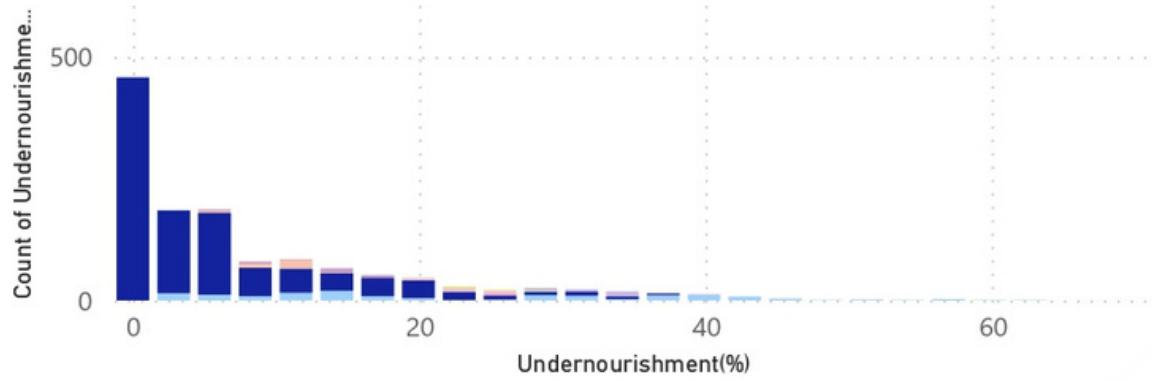
Mortality and Cluster

Cluster -1 0 1 2 3 4 5 6 7



Undernourishment and Cluster

Cluster -1 0 1 2 3 4 5 6 7



Cluster 0

Undernourishment : **Low**

Child Stunting : **Medium**

Child Mortality : **Low**

Women's Anemia : **Medium**



52.21

Average of Anemia(%)

102.11

Average of Mortality(per 1000)

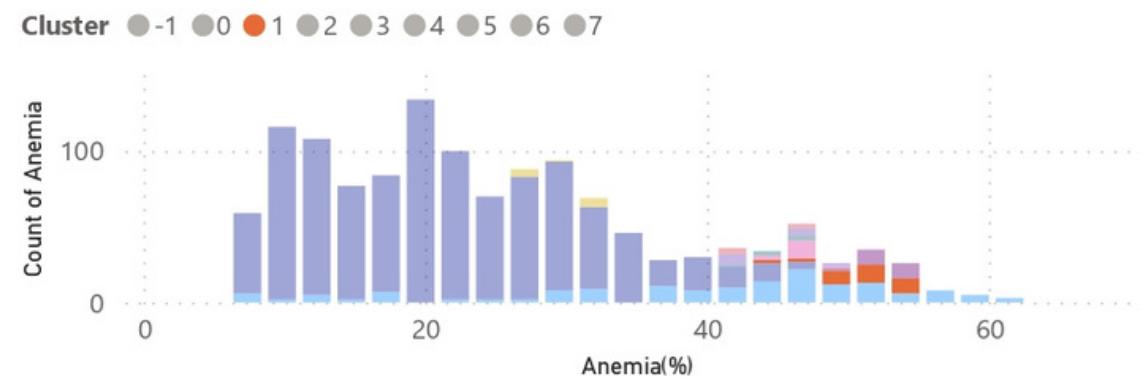
30.47

Average of Stunting(%)

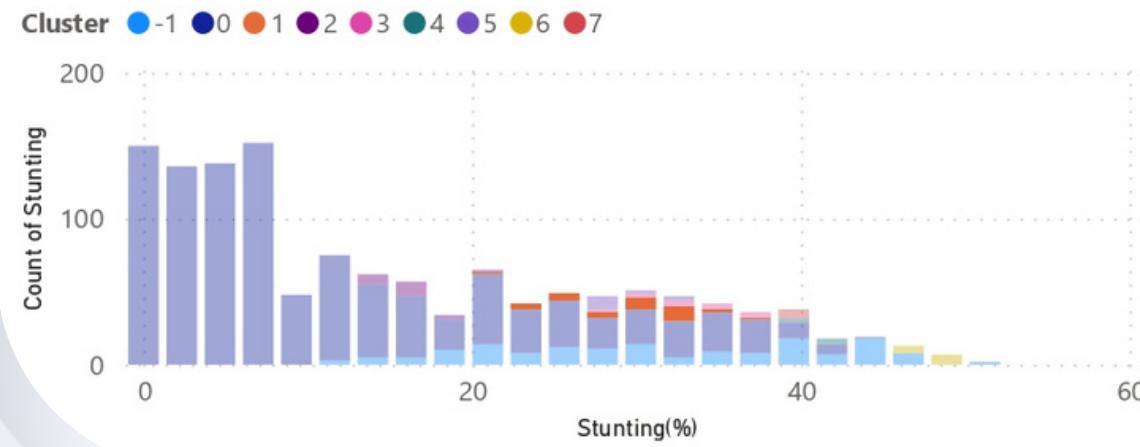
11.64

Average of Undernourishment(%)

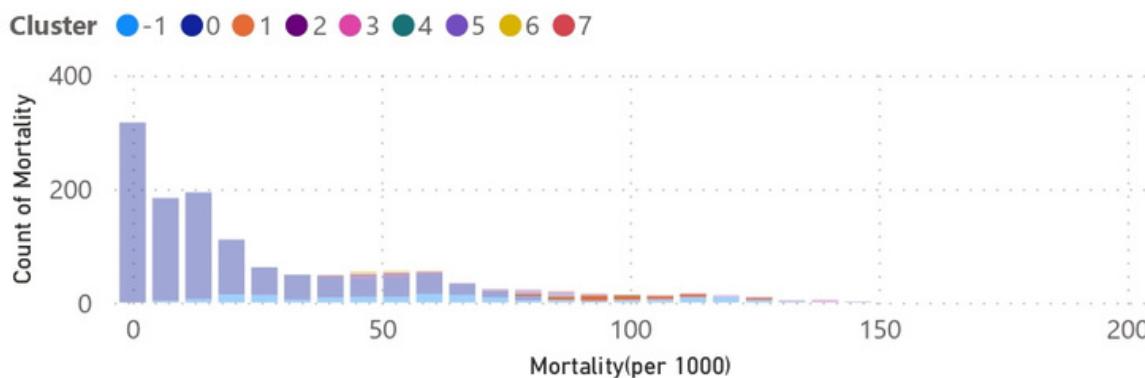
Anemia and Cluster



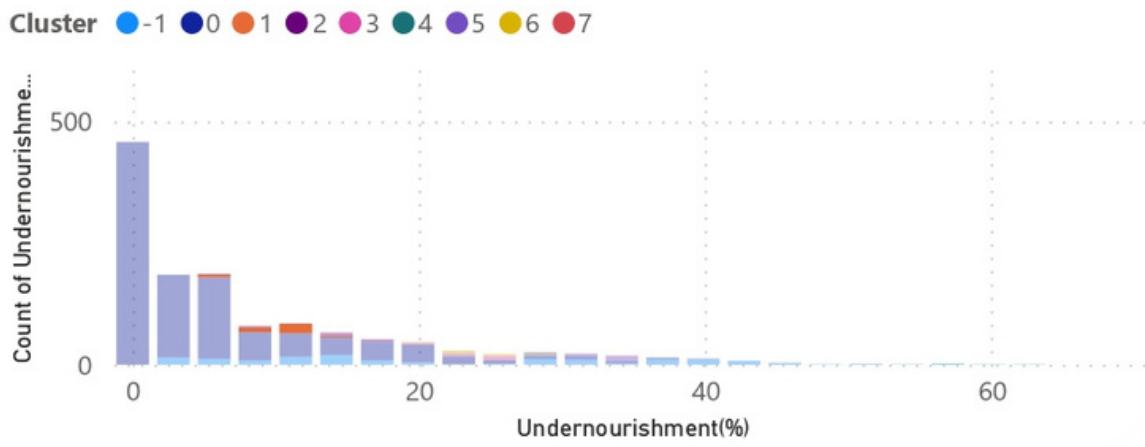
Stunting and Cluster



Mortality and Cluster



Undernourishment and Cluster



Cluster 1

Undernourishment : Low

Child Stunting : Very High

Child Mortality : Very High

Women's Anemia : Very High



53.83

Average of Anemia(%)

53.92

Average of Mortality(per 1000)

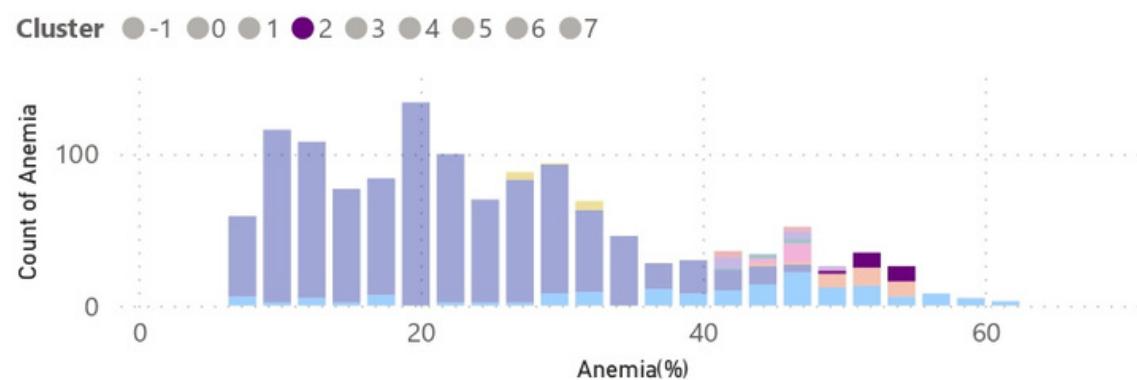
17.77

Average of Stunting(%)

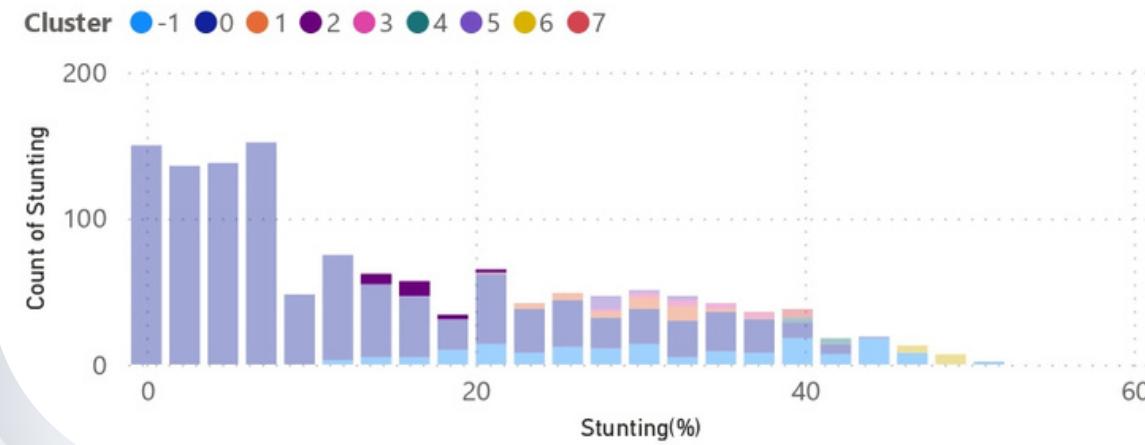
14.83

Average of Undernourishment(%)

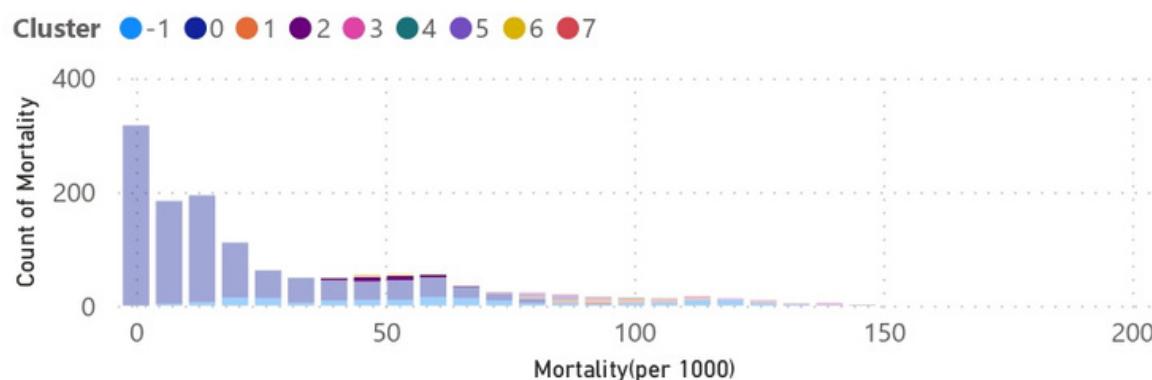
Anemia and Cluster



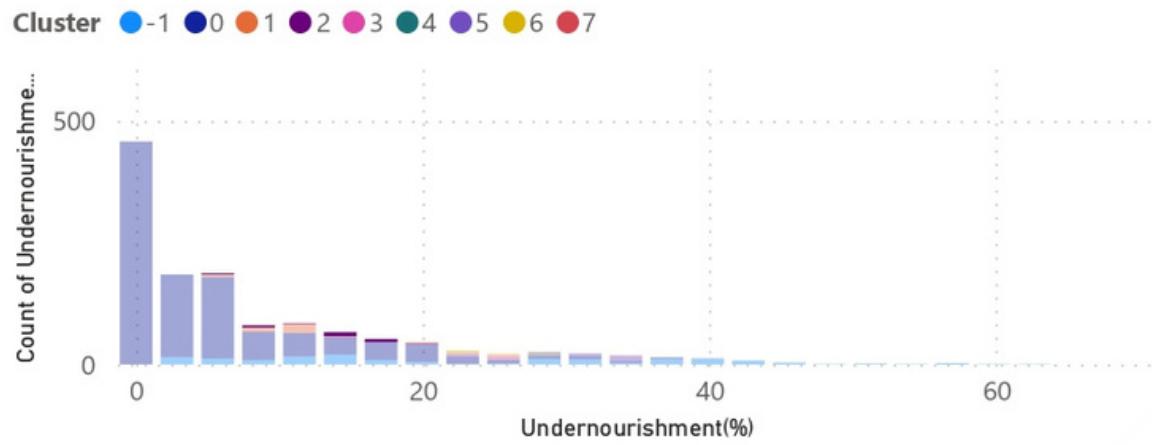
Stunting and Cluster



Mortality and Cluster



Undernourishment and Cluster



Cluster 2

Undernourishment : Low

Child Stunting : Medium

Child Mortality : Medium

Women's Anemia : Very High



47.63

Average of Anemia(%)

129.25

Average of Mortality(per 1000)

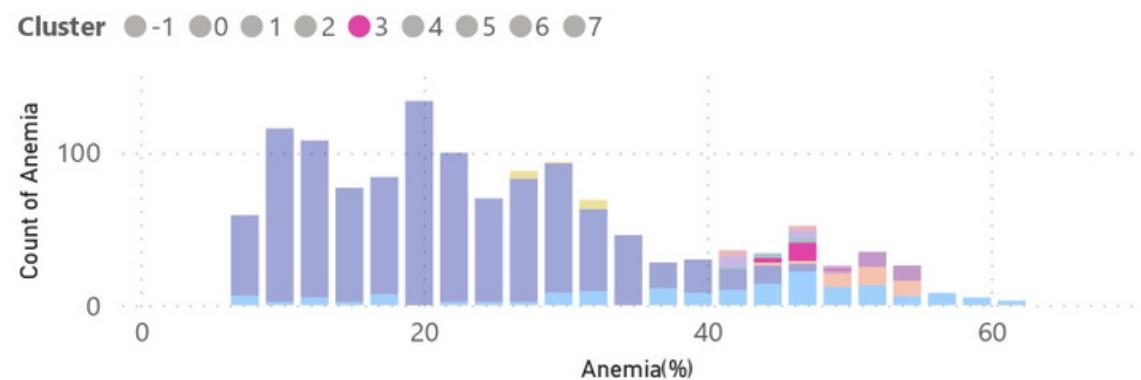
34.12

Average of Stunting(%)

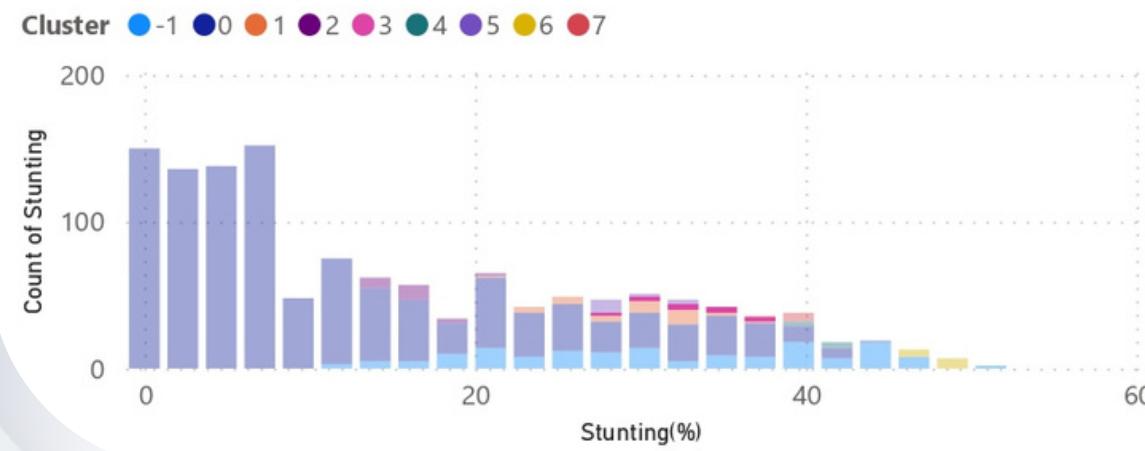
25.08

Average of Undernourishment(%)

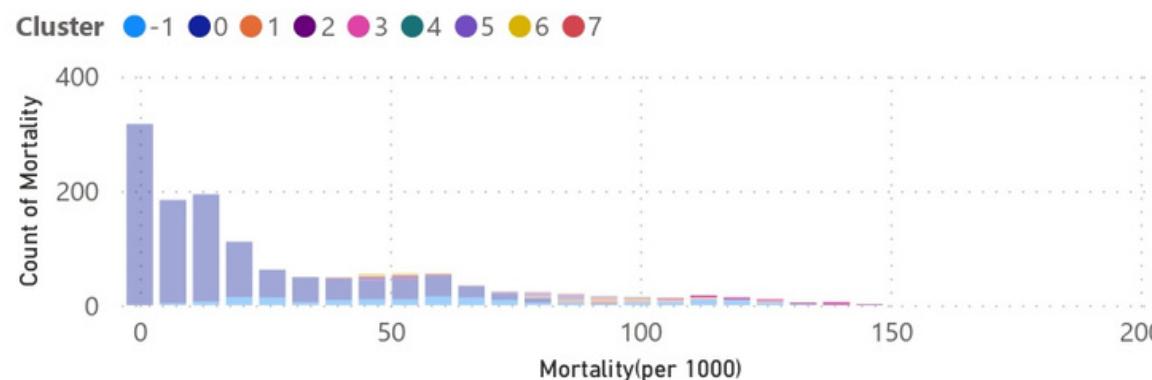
Anemia and Cluster



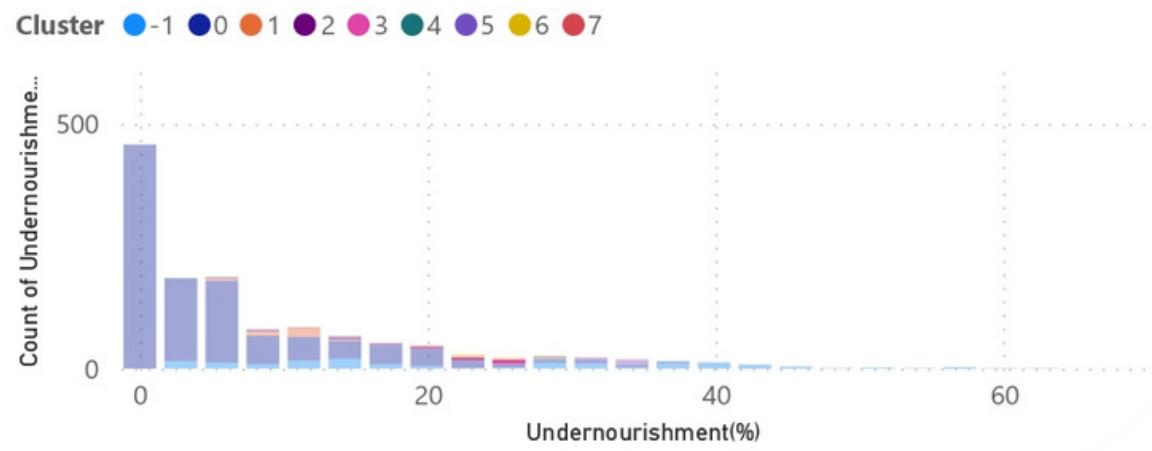
Stunting and Cluster



Mortality and Cluster



Undernourishment and Cluster



Cluster 3

Undernourishment : High

Child Stunting : Very High

Child Mortality : Very High

Women's Anemia : Very High



46.61

Average of Anemia(%)

95.81

Average of Mortality(per 1000)

42.03

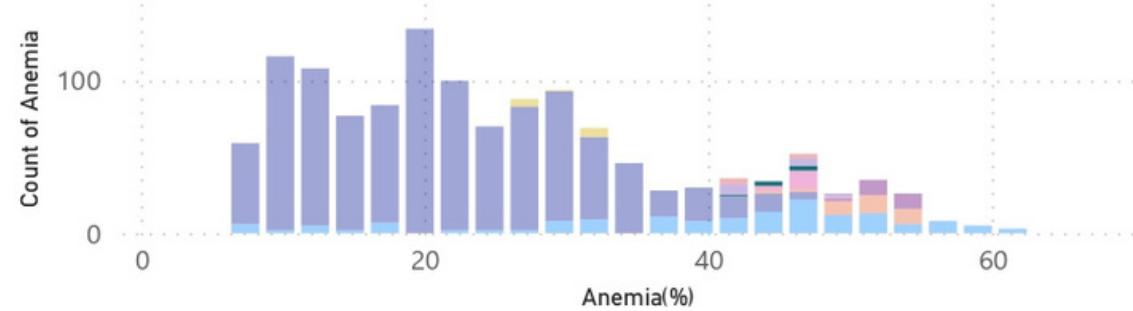
Average of Stunting(%)

30.37

Average of Undernourishment(%)

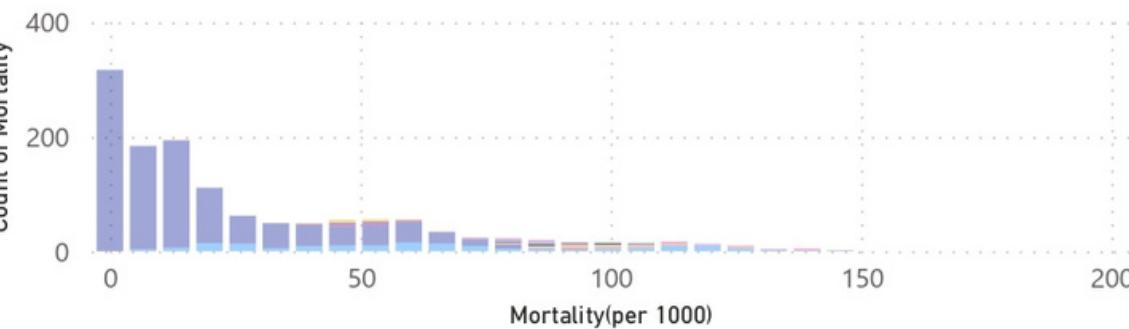
Anemia and Cluster

Cluster ● -1 ● 0 ● 1 ● 2 ● 3 ● 4 ● 5 ● 6 ● 7



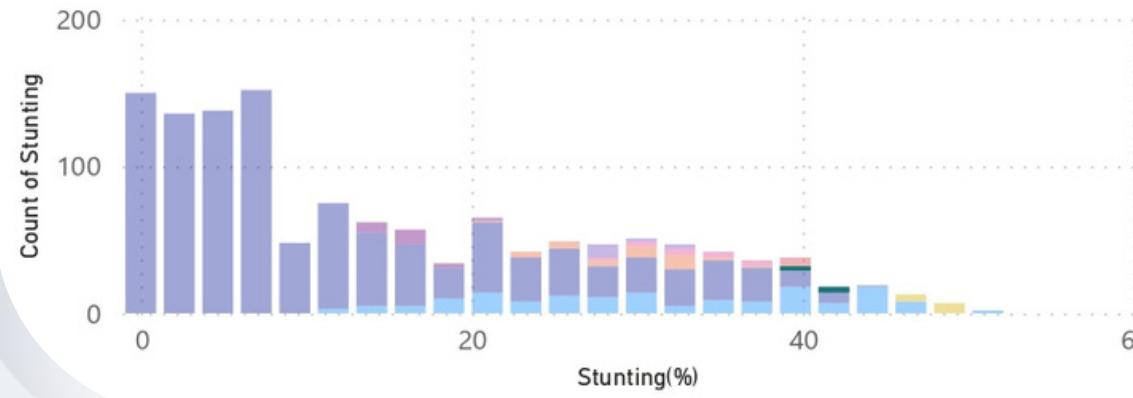
Mortality and Cluster

Cluster ● -1 ● 0 ● 1 ● 2 ● 3 ● 4 ● 5 ● 6 ● 7



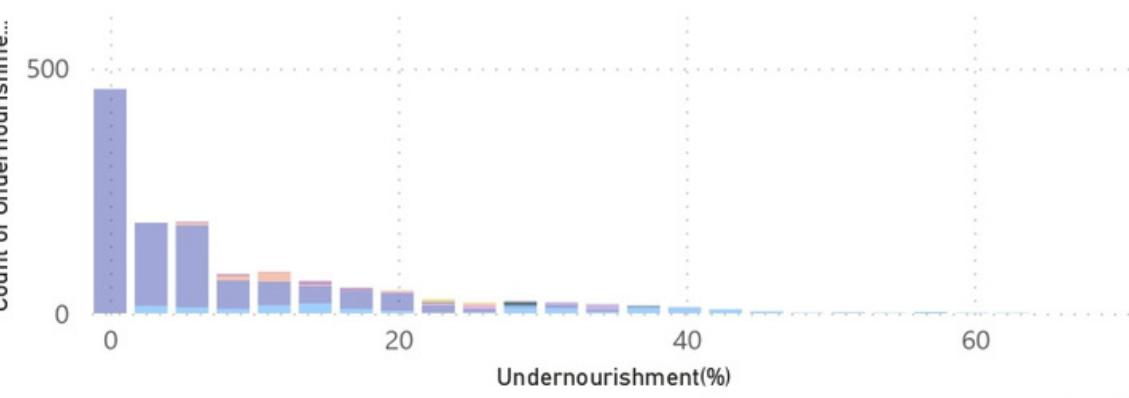
Stunting and Cluster

Cluster ● -1 ● 0 ● 1 ● 2 ● 3 ● 4 ● 5 ● 6 ● 7



Undernourishment and Cluster

Cluster ● -1 ● 0 ● 1 ● 2 ● 3 ● 4 ● 5 ● 6 ● 7



Cluster 4

Undernourishment : High

Child Stunting : Very High

Child Mortality : High

Women's Anemia : Very High



45.75

Average of Anemia(%)

87.79

Average of Mortality(per 1000)

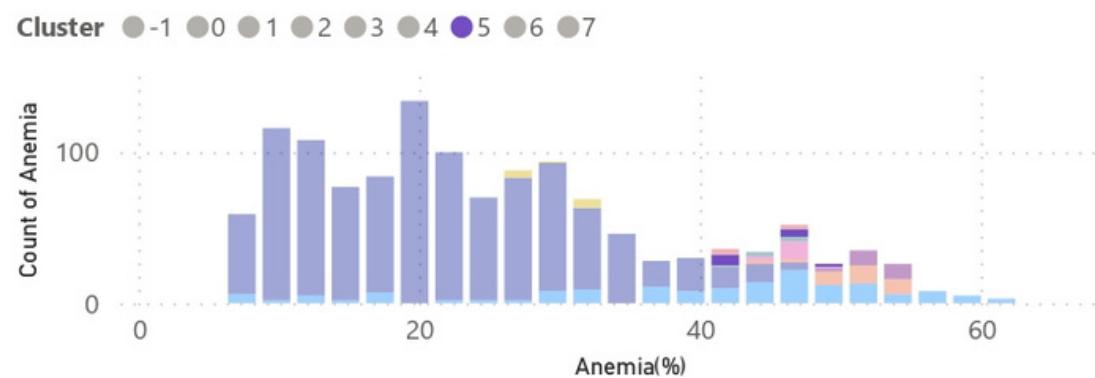
30.24

Average of Stunting(%)

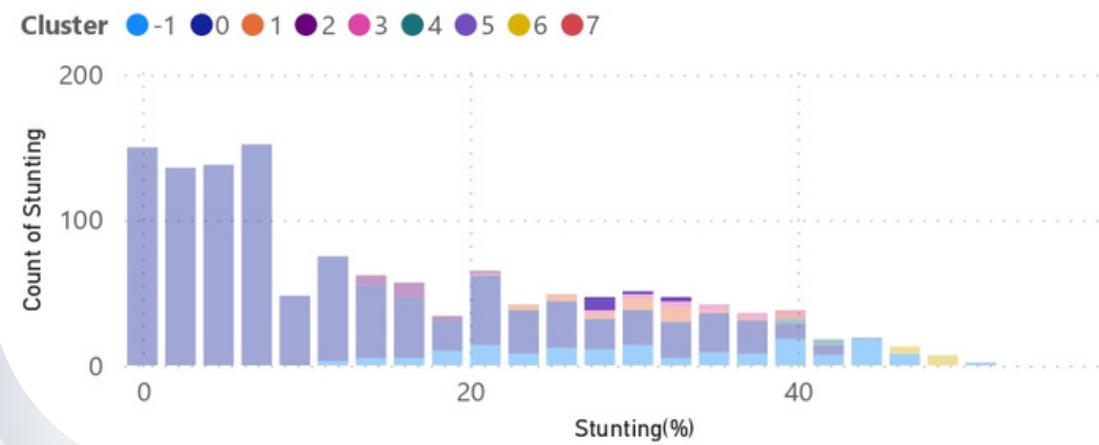
35.03

Average of Undernourishment(%)

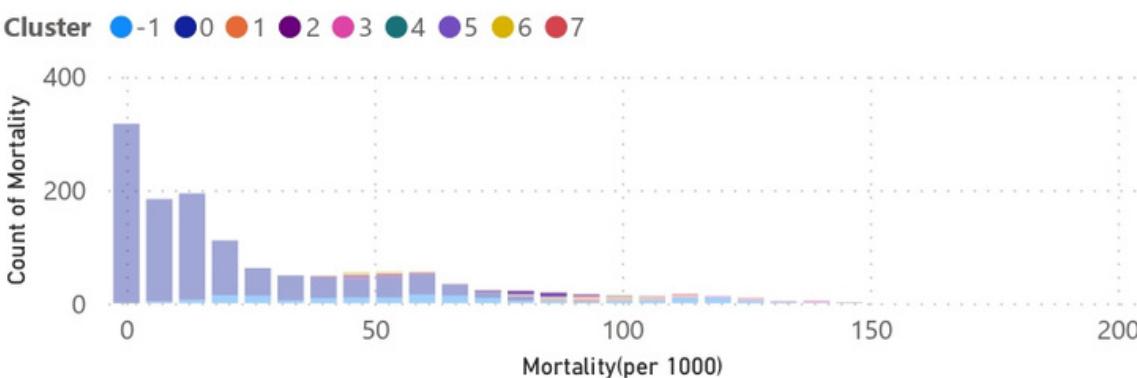
Anemia and Cluster



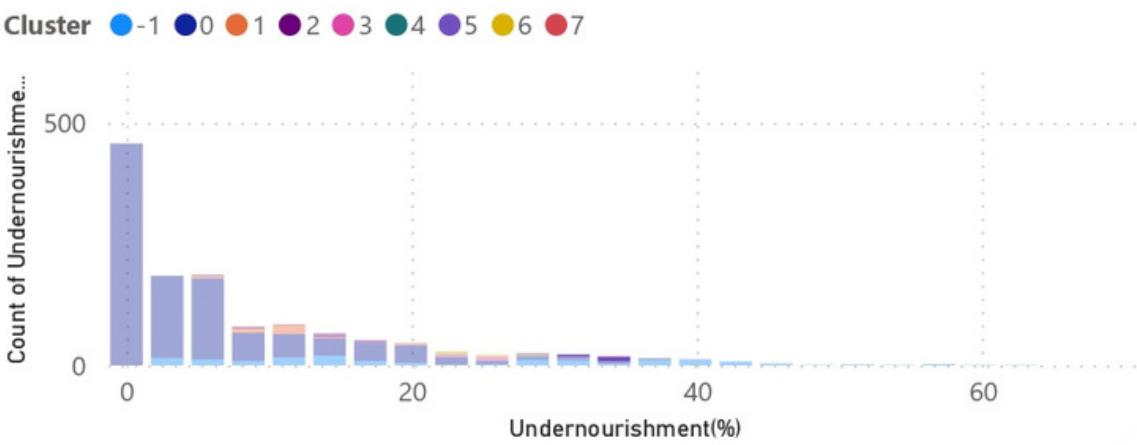
Stunting and Cluster



Mortality and Cluster



Undernourishment and Cluster



Cluster 5

Undernourishment : **Very High**

Child Stunting : **Very High**

Child Mortality : High

Women's Anemia : **Very High**



31.23

Average of Anemia(%)

53.84

Average of Mortality(per 1000)

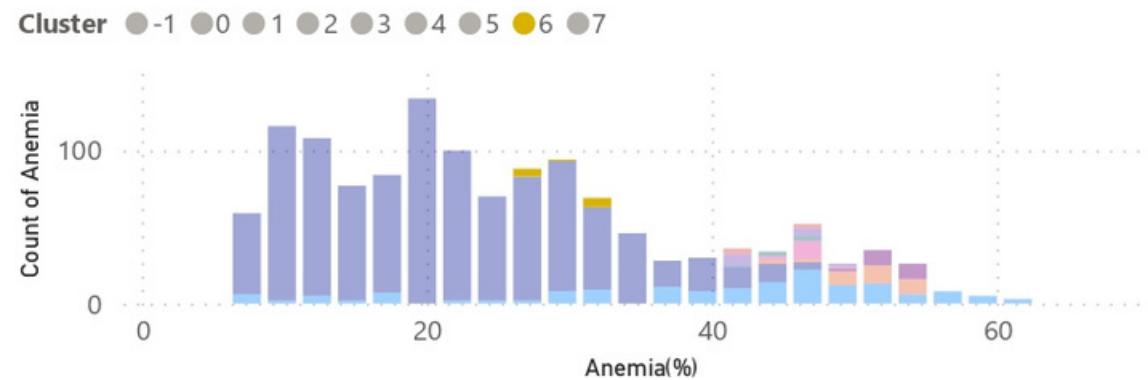
49.08

Average of Stunting(%)

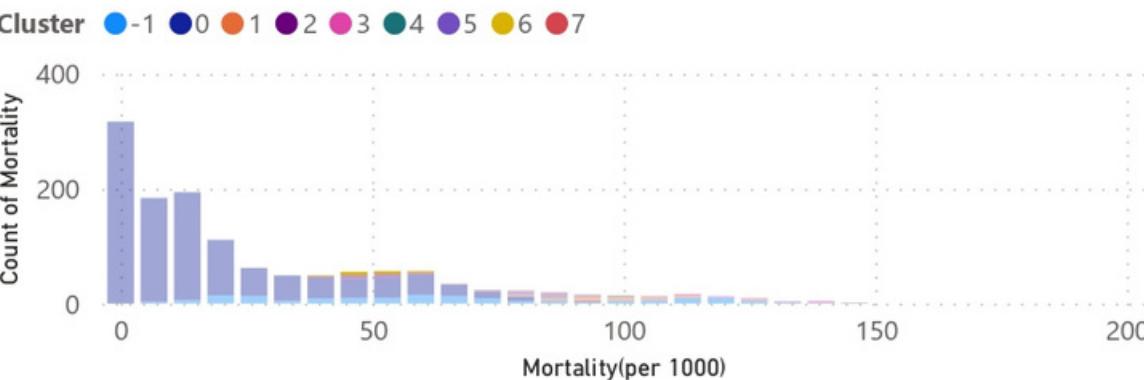
24.61

Average of Undernourishment(%)

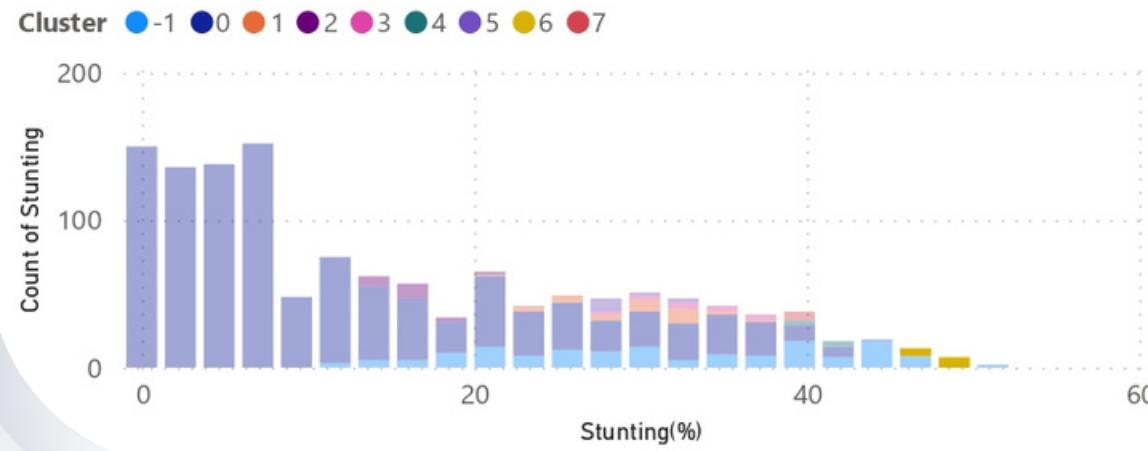
Anemia and Cluster



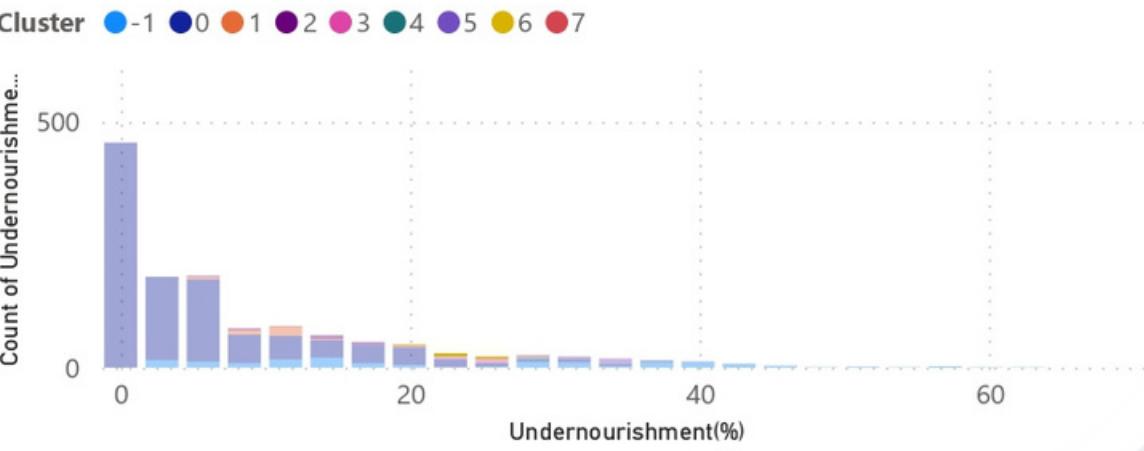
Mortality and Cluster



Stunting and Cluster



Undernourishment and Cluster



Cluster 6

Undernourishment : Medium

Child Stunting : Very High

Child Mortality : Medium

Women's Anemia : Medium



45.11

Average of Anemia(%)

84.41

Average of Mortality(per 1000)

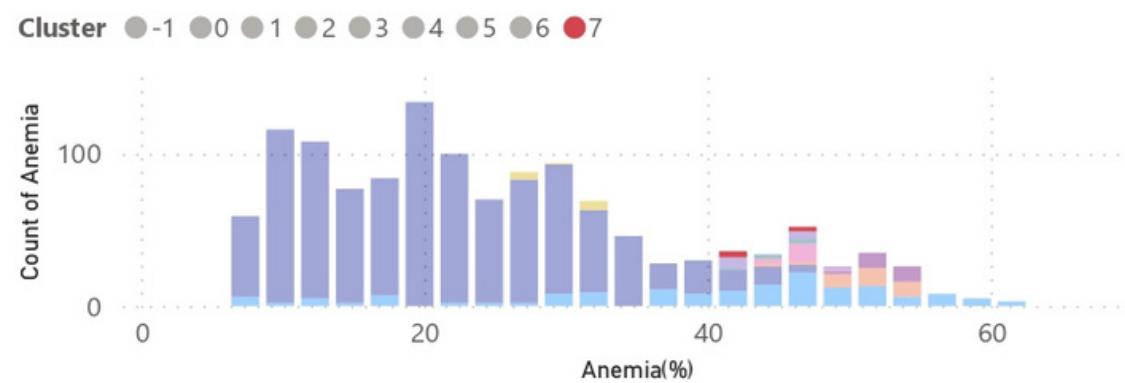
40.94

Average of Stunting(%)

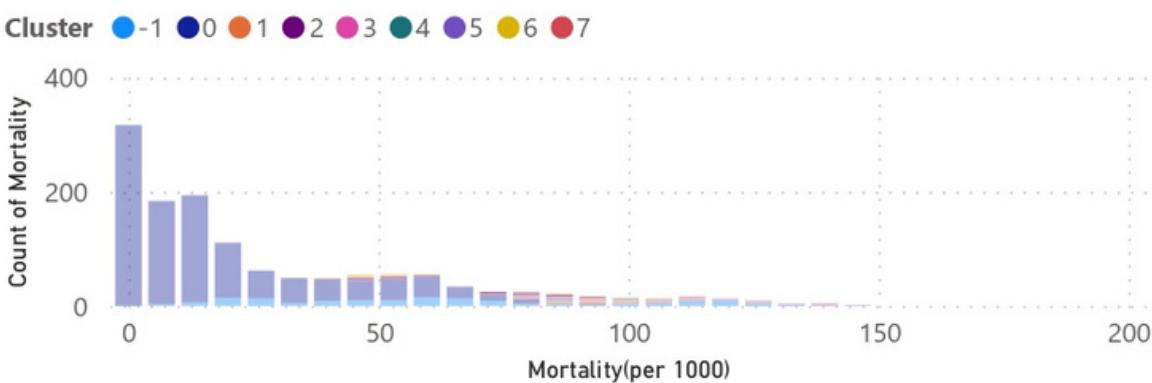
33.03

Average of Undernourishment(%)

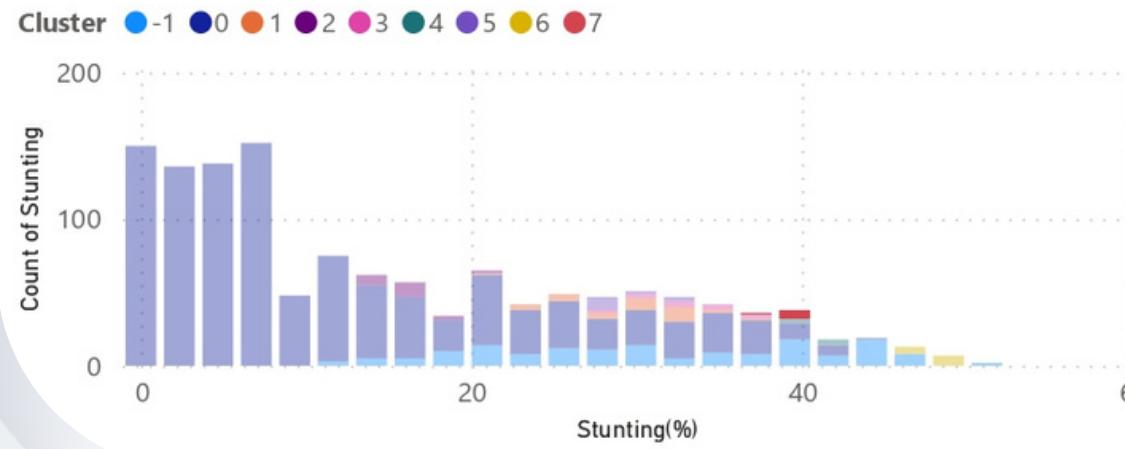
Anemia and Cluster



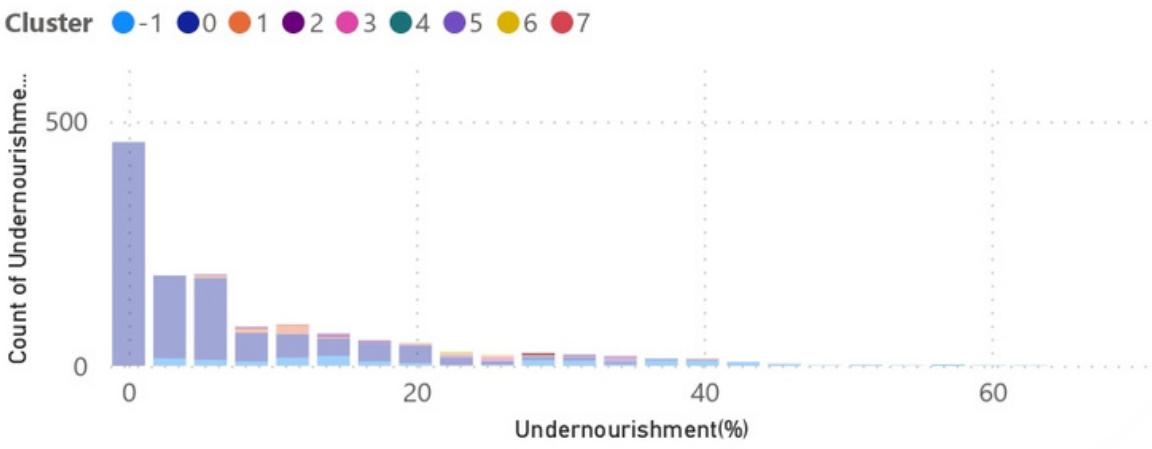
Mortality and Cluster



Stunting and Cluster



Undernourishment and Cluster



Cluster 7

Undernourishment : High

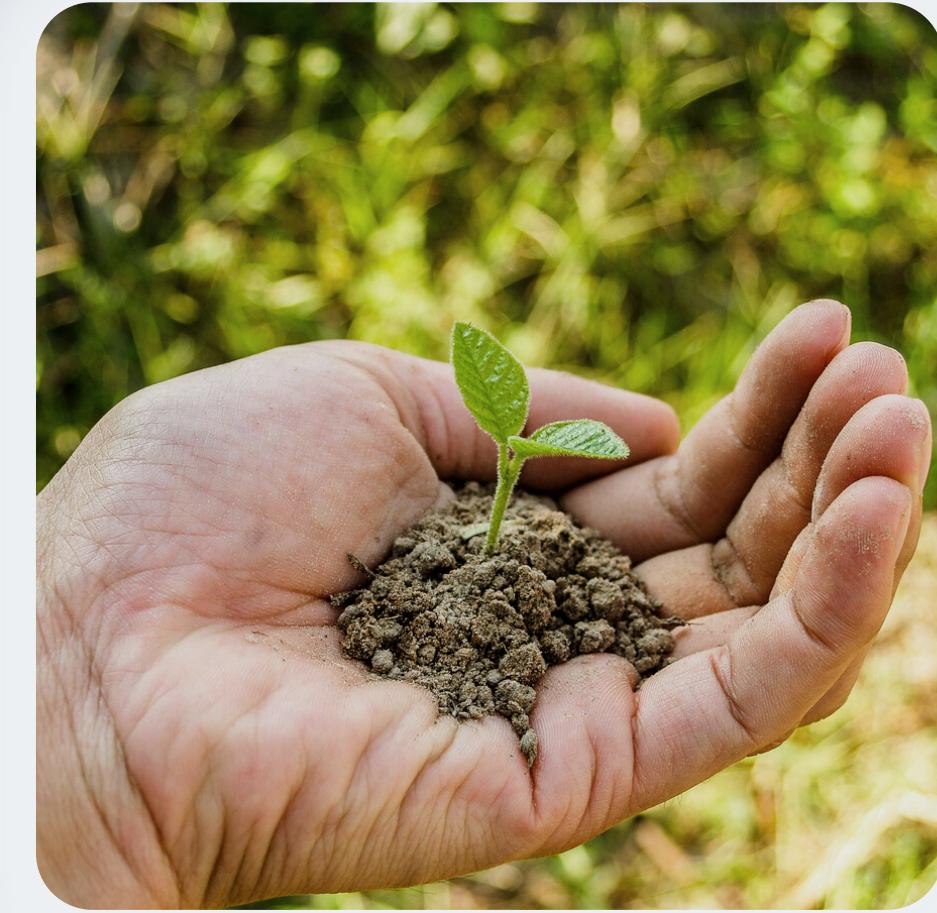
Child Stunting : Very High

Child Mortality : High

Women's Anemia : Very High

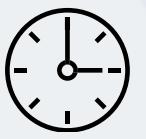


Insight and Recommendations



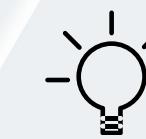


Cluster 0



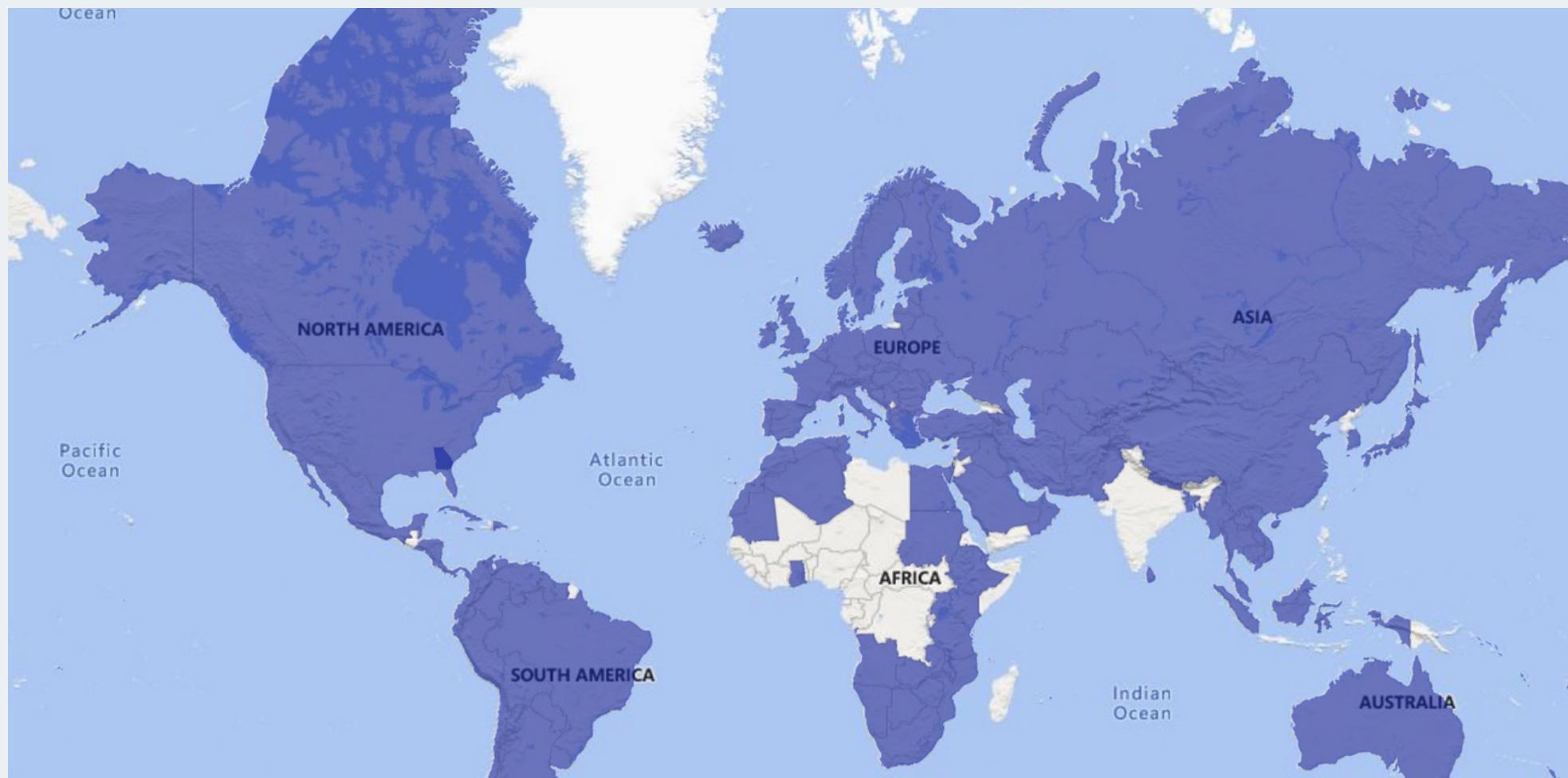
Insights

Compared to other clusters, cluster 0 demonstrates a better performance in controlling undernourishment, child stunting, child mortality, and women's anemia.



Actions

Maintain strong **monitoring systems**, invest in **sustainable agriculture** and **healthcare infrastructure**, promote **nutritional education**, ensure **food security**, stay adaptable to changing circumstances

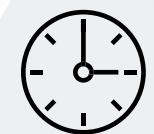


High prevalence
Cluster 3, 4, 7



Very high prevalence
Cluster 5

Cluster with High Undernourishment



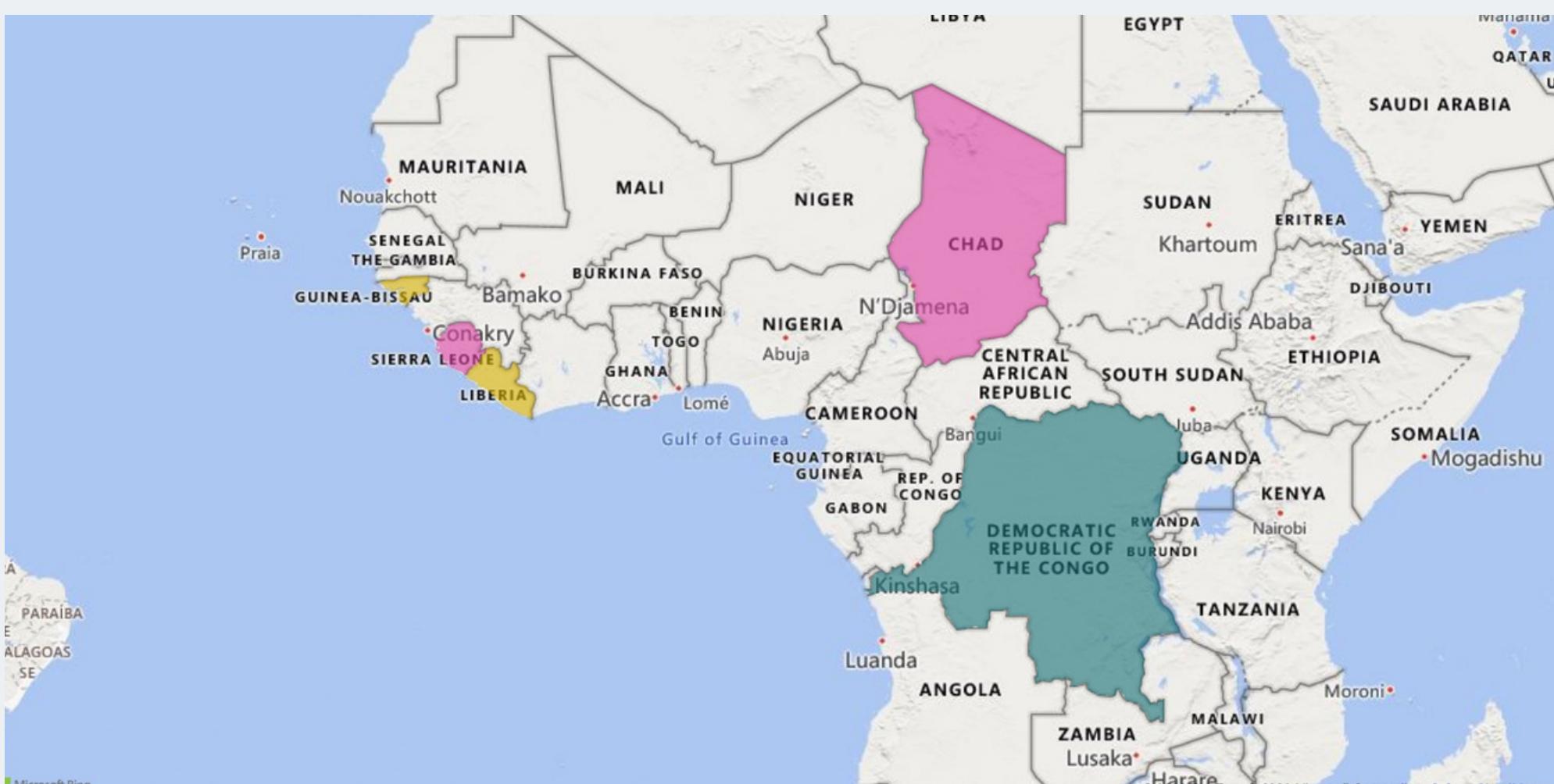
Insights

High undernourishment prevalence is typically driven by **poverty**, **poor agricultural practices**, **climate change affecting crop yields**, **rapid population growth** straining resources, and many more.



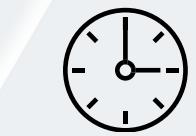
Actions

Improve agricultural practices, **increase food availability**, **implement social safety nets**, and **enhance healthcare services** to ensure the nutritional well-being of the population.





Cluster with High Stunting in Children



Insights

Child stunting is an indication that **children are experiencing inadequate nutrition**, particularly in their early years of life when proper nutrition is crucial for physical and cognitive development.



Actions

Nutritional education for parents, improved access to **healthcare**, initiatives to **promote breastfeeding and proper infant nutrition**.



High rate per 1000

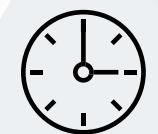
Cluster 4, 5, 7



Cluster with High Mortality in Children

Very high rate per 1000

Cluster 1, 3



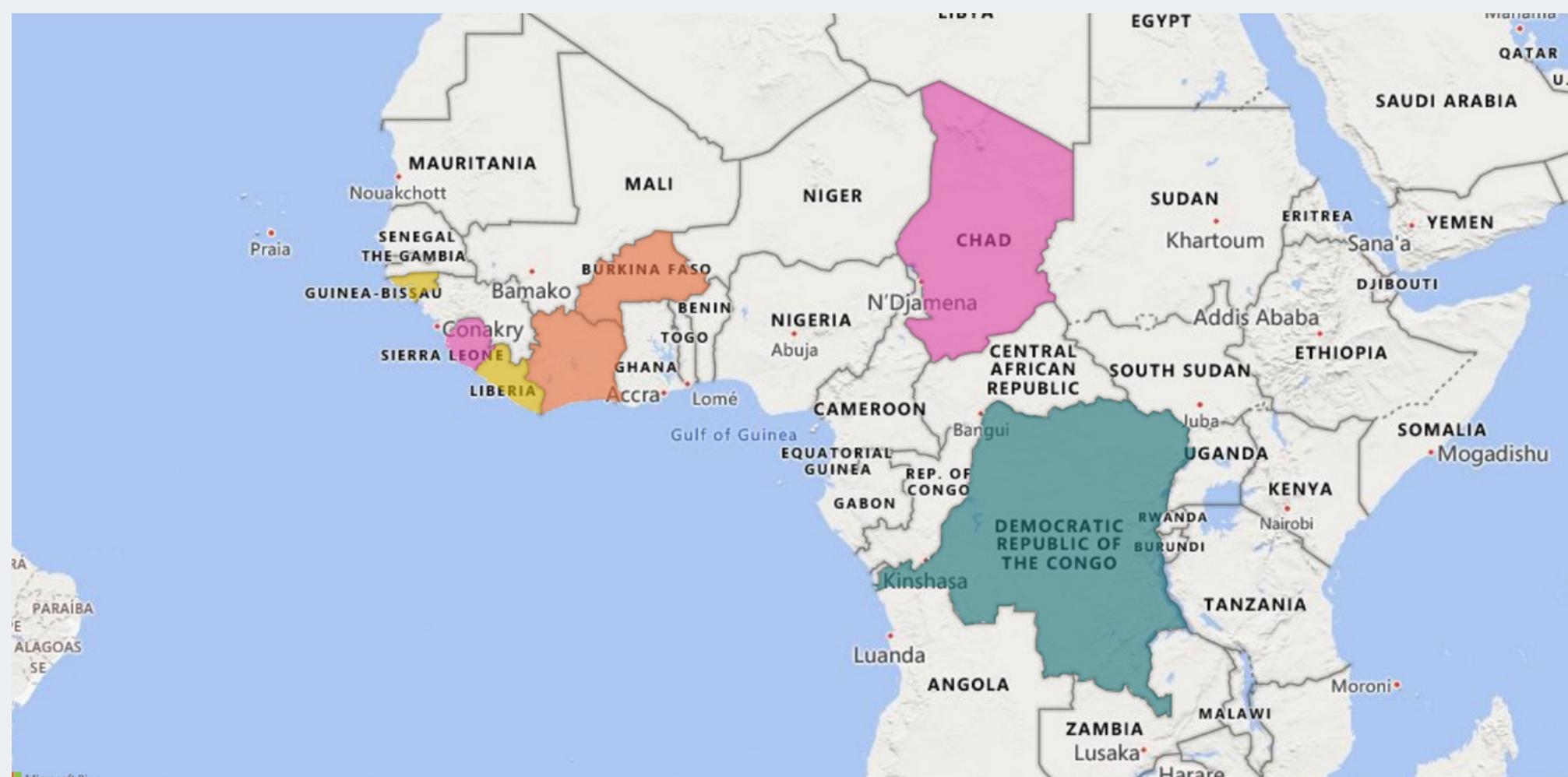
Insights

High child mortality rates signify issues such as **inadequate healthcare access, infectious diseases, poor nutrition, and subpar maternal and child health services.**



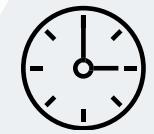
Actions

Improvements in **healthcare infrastructure, increased access to medical services, vaccination programs, and nutritional support** for children





Cluster with High Anemia in Women



Insights

High prevalence of women's anemia can be caused by several factors, such as **nutritional deficiencies (especially iron)**, **chronic diseases**, and **limited awareness about health practices**.



Actions

Nutritional education, supplementation programs, improved access to **healthcare**, and initiatives **focusing on maternal and reproductive health**.



Dashboard

Types of dashboards:

- “Overview”
- “Clustering Result”
- “Clustering Result by Feature”
- “Clustering Result by Area”
- “Insight and Recommendation”

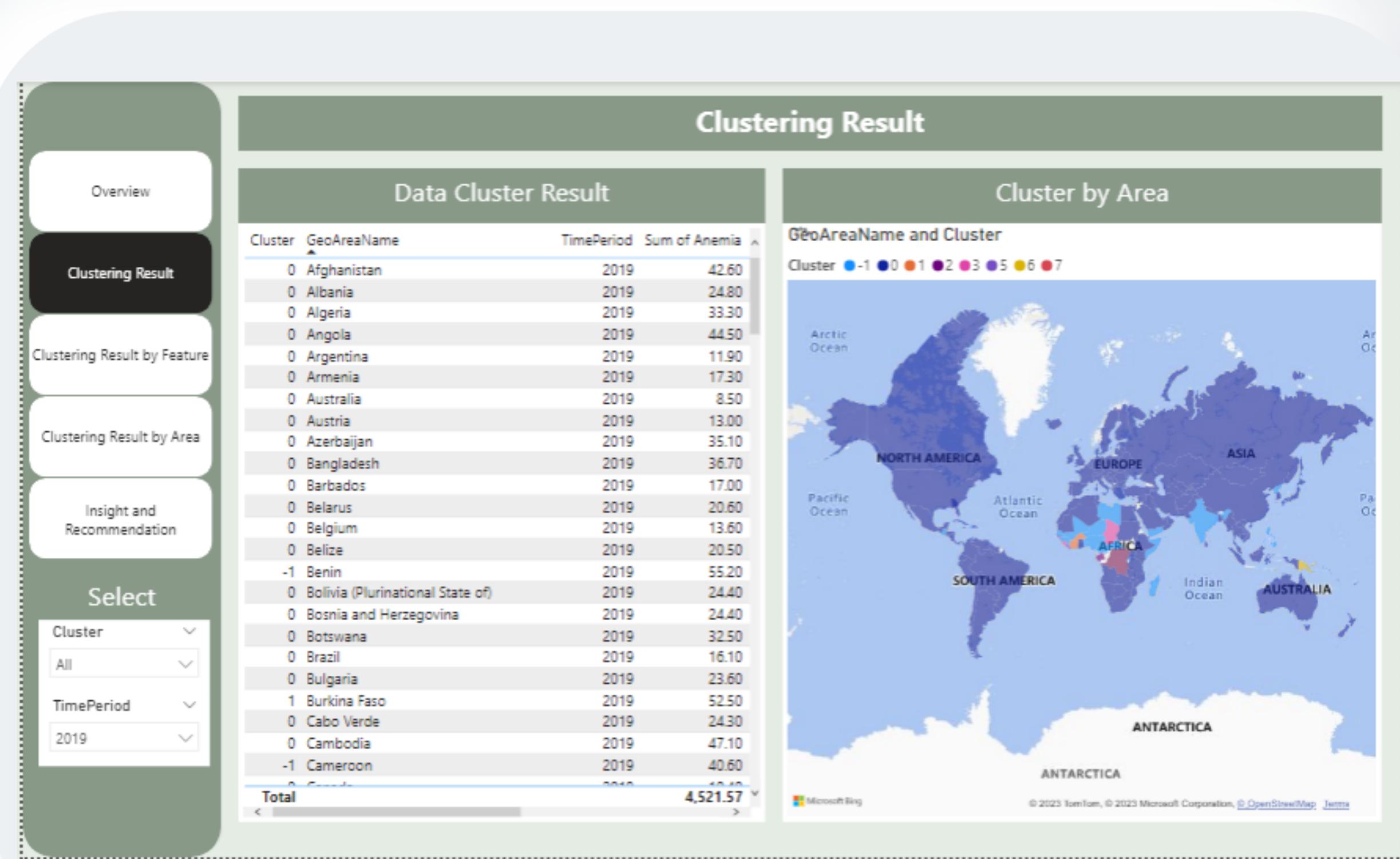
Features of dashboards:

-  Dashboard Navigation
-  Filter



“Overview”

It is the first page of the dashboard that provides an overview of the cluster analysis results we conducted based on our reference, the Global Hunger Index (GHI). It consists of four line graphs representing four variables we analyzed: Undernourishment, Child Mortality, Child Stunting, and Woman Anemia, based on periods (years) and countries.



“Clustering Result”

On this page, there was a table displaying cluster data that can be scrolled horizontally and vertically to view other values. Additionally, there is a map graphic with colored blocks representing different cluster categories of the countries in each region. Different colors indicate different cluster categories.



“Clustering Result by Feature”

This dashboard page displays the overall average values of the four variables. It also includes a histogram graph showing the data distribution and clusters for each variable, where different colors indicate distinct cluster differences.



“Clustering Result by Area”

This dashboard page displays the average values of a specific variable (Anemia, Mortality, Stunting, Undernourishment) for each country. It is visualized using a bar chart that can be scrolled up and down to view the averages of other countries, sorted from the highest to lowest average values.



Insight and Recommendation		
Cluster	Explanation	Insight and Recommendations
-1	Outlier	
0	Undernourishment: Low Child Stunting: Medium Child Mortality: Very High Woman Anemia: Medium	Despite low levels of undernourishment, the presence of medium stunting suggest that there are still issues with the quality of nutrition. These issues require targeted interventions to focus on child nutrition recovery, enhance access to quality child and maternal healthcare monitoring and community engagement.
1	Undernourishment: Low Child Stunting: Very High Child Mortality: Very High Woman Anemia: Very High	While the overall caloric intake might be sufficient, the diet may lack essential nutrients required for healthy growth and development. Children. Inadequate access to healthcare services, poor maternal nutrition, and environmental factors such as unsafe water sources contribute to mortality. Socioeconomic inequalities may further exacerbate health disparities. Addressing this complex scenario requires a comprehensive approach to diet quality, maternal and child healthcare, sanitation, and addressing socio-economic disparities to ensure sustainable improvements.
2	Undernourishment: Low Child Stunting: Medium Child Mortality: Very High Woman Anemia: Very High	While overall caloric intake might be sufficient, deficiencies in essential micronutrients could impact child growth and increase mortality. Limited access to healthcare services, combined with limited healthcare access and socioeconomic disparities, contribute to medium child stunting and high mortality. Socioeconomic inequalities may further exacerbate health disparities. Addressing this complex scenario requires a comprehensive approach to diet quality, maternal and child healthcare, sanitation, and addressing socio-economic disparities to ensure sustainable improvements.
3	Undernourishment: High Child Stunting: Very High Child Mortality: Very High Woman Anemia: Very High	Widespread food insecurity contributes to high undernourishment, while poor dietary quality and insufficient access to essential nutrients. The confluence of limited healthcare access, inadequate maternal and child health services, and socio-economic disparities results in elevated mortality. Severe women's anemia points to significant challenges in reproductive health, inadequate nutrition, and barriers to accessing essential services. This multifaceted crisis requires comprehensive strategies, including improving food security, enhancing nutritional education, strengthening healthcare services, and addressing underlying socio-economic issues to ensure the holistic well-being of women and children.
4	Undernourishment: High Child Stunting: Very High Child Mortality: Very High Woman Anemia: Very High	Widespread food insecurity contributes to high undernourishment, while poor dietary quality and insufficient access to essential nutrients. The confluence of limited healthcare access, inadequate maternal and child health services, and socio-economic disparities results in elevated mortality. Severe women's anemia points to significant challenges in reproductive health, inadequate nutrition, and barriers to accessing essential services. This multifaceted crisis requires comprehensive strategies, including improving food security, enhancing nutritional education, strengthening healthcare services, and addressing underlying socio-economic issues to ensure the holistic well-being of women and children.
5	Undernourishment: Very High Child Stunting: Very High Child Mortality: Very High Woman Anemia: Very High	Pervasive food insecurity contributes to elevated undernourishment levels, while inadequate dietary diversity and nutrient deficiencies. Limited access to healthcare services, coupled with socioeconomic disparities, results in a high child mortality rate. Concurrently, women face substantial barriers to proper nutrition, reproductive healthcare, and overall well-being.
6	Undernourishment: Medium Child Stunting: Very High Child Mortality: Very High Woman Anemia: Medium	The combination of very high child stunting and child mortality, medium undernourishment and woman anemia in a region indicates a severe crisis. Addressing these issues requires targeted interventions to emergency food assistance, nutrition rehabilitation programs, maternal and child health services, anemia prevention and treatment, sanitation and hygiene promotion, collaboration and capacity building.

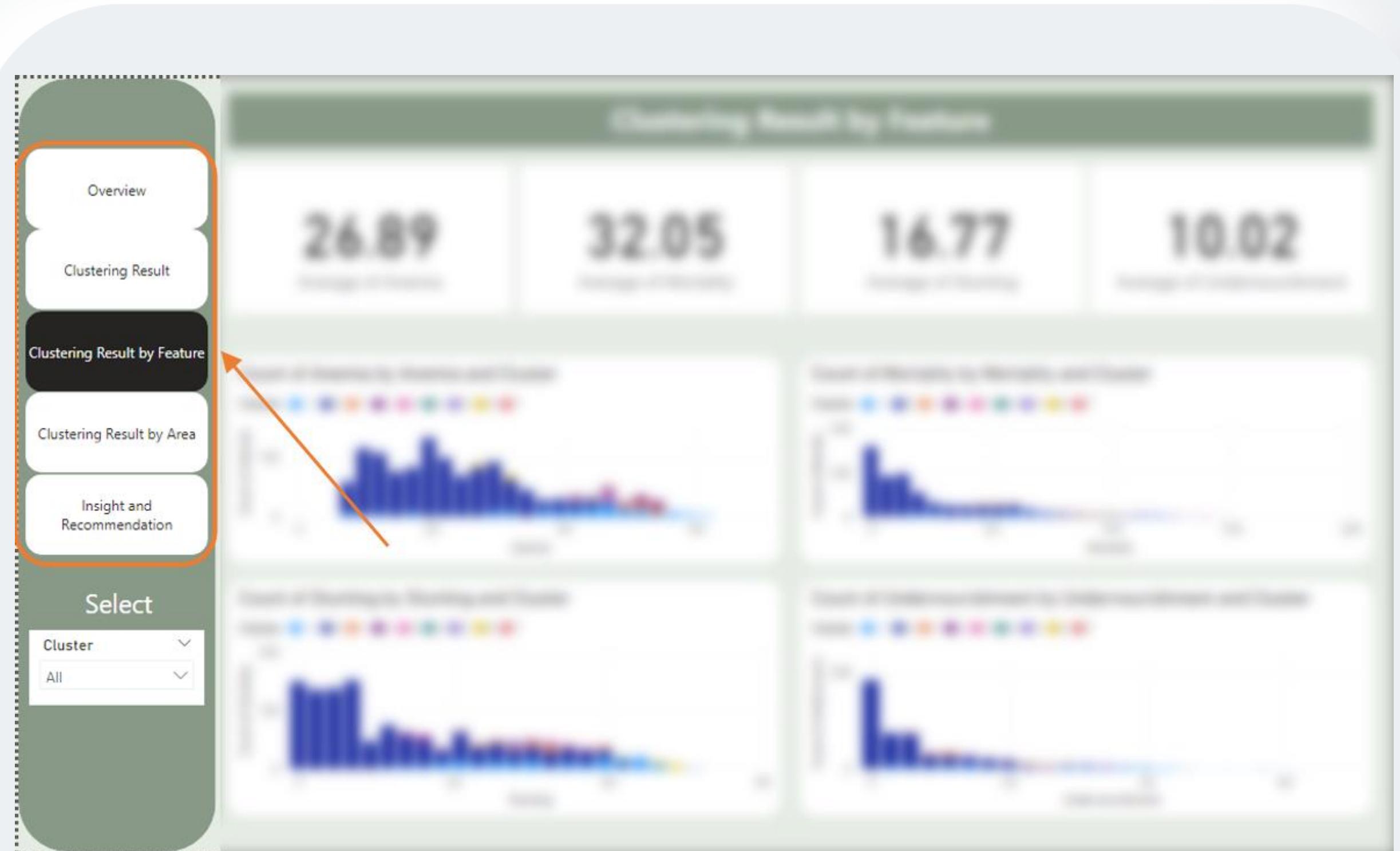
“Insight and Recommendation”

This is the final dashboard page, containing insights obtained after the clustering process by examining the characteristics of each cluster and recommendations based on the insights we gathered.



Dashboard Navigation

The dashboard navigation feature on the left side can be used to easily switch between dashboard pages. There are five menu options available in the Dashboard Navigation: "Overview", "Clustering Result", "Clustering Result by Feature", "Clustering Result by Area", and "Insight and Recommendation". *ctrl + click* can be used by users to move from one page to another.





Filter

The filtering feature, named "Select" allows users to display data graphs based on desired data filters, such as specific clusters and/or particular time periods.

A screenshot of a data visualization application interface. On the left, a vertical navigation menu is visible with options: Overview, Clustering Result, Clustering Result by Feature, Clustering Result by Area (which is highlighted in purple), and Insight and Recommendation. Below this menu is a 'Select' button, which is highlighted with an orange border. A dropdown menu for 'Cluster' is open, showing the option 'All'. An arrow points from the text 'The filtering feature, named "Select"' in the previous slide to this 'Select' button. The main area of the interface shows several large, blue, semi-transparent rectangular bars stacked vertically, representing data clusters or results. The background has some blurred text and icons, suggesting a complex dashboard environment.

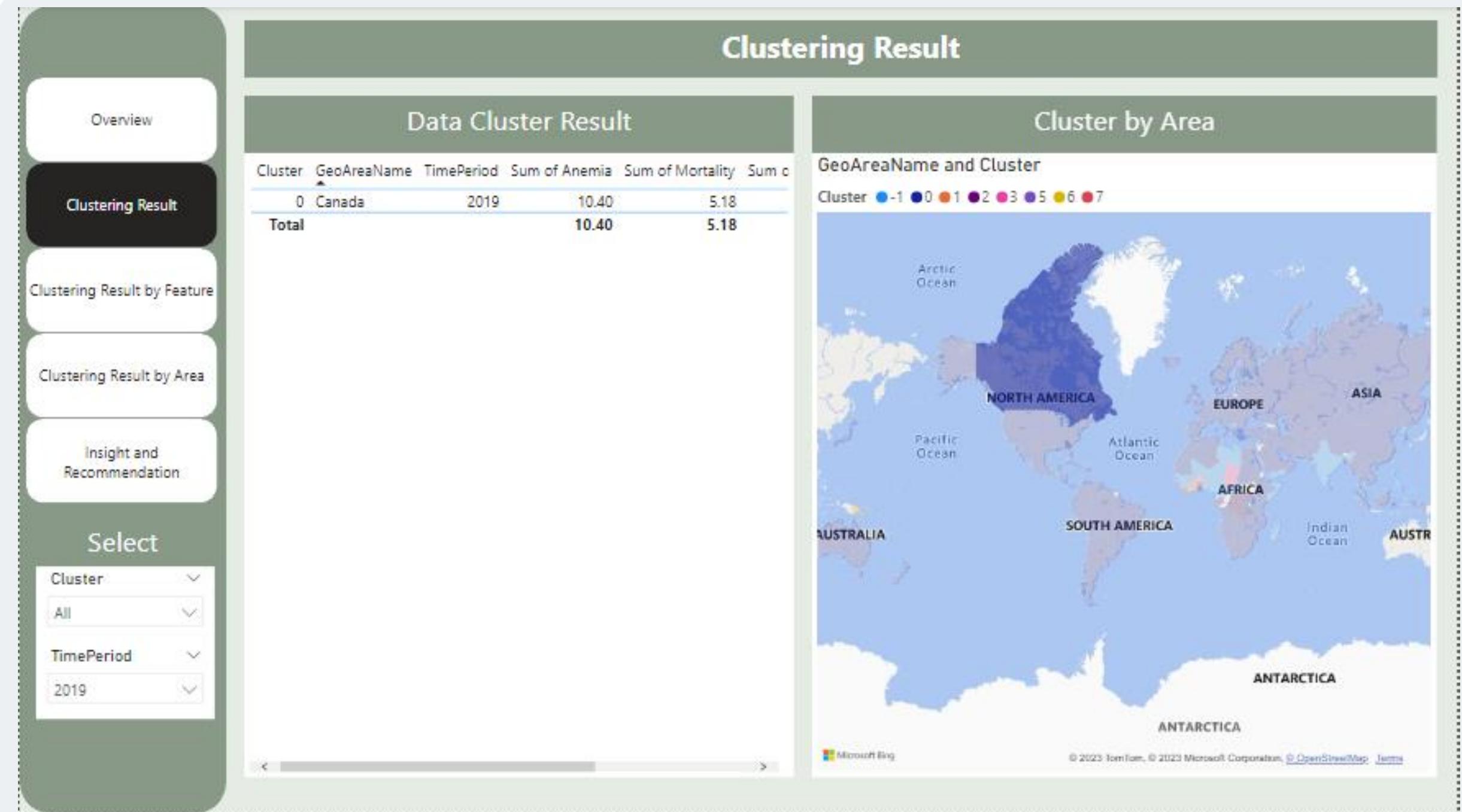


Filter (2)

Users can click on a specific region, such as North America, on the map and select the desired year in the select filter. Then the cluster data table will automatically filter based on the country and year clicked.

Note:

If the map image does not appear as above, the user can perform the following steps: click *file - options and settings - options - global - security - click Use ArcGIS for Power BI*, and use *Map and Filled Map Visual*.





References

Birant, D., & Kut, A. (2007). ST-DBSCAN: An algorithm for clustering spatial-temporal data. *Data and Knowledge Engineering*, 60(1), 208–221. <https://doi.org/10.1016/j.datak.2006.01.013>

Khan, K., Rehman, S. U., Aziz, K., Fong, S., Sarasvady, S., & Vishwa, A. (2014). DBSCAN: Past, present and future. *5th International Conference on the Applications of Digital Information and Web Technologies, ICADIWT 2014*, 232–238. <https://doi.org/10.1109/ICADIWT.2014.6814687>



“A winner is a dreamer who never gives up.”

~Nelson Mandela

Thank you!