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EVALUATING FOOD AVAILABILITY USING TOPSIS METHOD: A CASE STUDY IN THE SULTANATE OF OMAN

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Abstract — The objective of this study is to analyze the availability of food in Oman. This will be done by considering eight different parameters and using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method, which is based on the entropy weight method. The study utilizes input parameters obtained from the National Centre for Statistics and Information (NCSI) for the period of 2000 to 2021. These parameters include population growth rate, government investment, average temperature degree, average rainfall amount, cultivated land area, agricultural and fishing production, net food import, and food industry output. The study concluded with the implementation of multivariate regression analysis. This analysis involved the consideration of eight distinct parameters as independent variables, while the dependent variable was determined by the TOPSIS food availability index result. Based on the results of this study, it was determined that the level of food availability reached its peak in the year 2020. Furthermore, Oman experienced instances characterized by varying levels of risk, including high risk, medium risk, and low risk. The period of insecurity spans from 2001 to 2002 and includes the year 2019. Conversely, the years of security encompass 2013, 2016, 2018, and the range from 2020 to 2021.
Keywords — Availability, TOPSIS, Risk, Oman

Introduction

According to (Mechlem, 2004) "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". In order to enhance global living standards, a primary area of focus pertains to the assurance of food security and sustainability, given its persistent status as a global challenge with widespread implications for affected populations (Mtolo, 2016). Food security is also a core component of the human development and capability paradigm, since food access and entitlements are critical for reinforcing essential human capabilities (Conceição et al., 2016). Therefore, food security was dedicated in the second goal in the 2030 Sustainable Development Agenda due to food insecurity, as it has been considered as a crisis since the World Food Conference held in 1974 when large-scale shortages of food and starvation were considered imminent (Food and Agriculture Organization of the United Nations. et al., 2019). Moreover, as indicated by the 2018 Global Report on Food Crises, an alarming 124 million individuals across 51 nations are presently facing the life-threatening effects of food insecurity.

Globally, there are several persistent challenges that food security and sustainability deal with; including a growing population expected to reach approximately 10 billion toward the end of the 21st century, changes in diet preferences, declining in natural resources and a planetary change in climate (Elmi, Alomirah and Al-Zenki, 2016). For instance, the world population growth is likely to reach 9.1 billion, 34 percent greater than today. Hence, the demand towards food is expected to raise significantly by 2050, as The United Nations Food and Agriculture Organization (FAO) reported that world food production will have to increase by more than 75 percent over the next 33 years to ensure food supplies for 9.6 billion people by the year 2050, compared to 7.5 billion todays.

Many countries should work to improv the crops production policy and some domestic polices to achieve the food security target by 2050 and that also include addressing the challenge of negative impact of environmental factors (Mazloum et al., 2021).

Furthermore, the changes in climate conditions have a detrimental impact on both food security and sustainability. Countries experiencing unfavourable weather conditions face challenges in terms of agricultural productivity and crop availability. This challenge predominantly appears in the Middle East and arid countries, particularly in the hot Arabian Gulf region. As a result, in order to cooperate with the increase number in population, the loss of environmental resources and problematic climate change, countries achieve food security and sustainability by importing a huge quantities of food from various countries across the globe and increasing domestic food production (Devesh and Asrul Affendi, 2020). For instance, $35 billion of food were imported in two decades and yearly expected to increase to $70 billion in the middle east because of the dry climate, as specified by the International Center for Agricultural Research in the Dry Areas.

In a similar vein the practise of food importation has become a prevalent strategy in Gulf Cooperation Council (GCC) countries, primarily driven by the need to ensure food security and sustainability. In 2020, the GCC countries experienced a notable increase in population, resulting in a significant expenditure of $53.1 billion on food imports. According to representatives from the Ministry of Environment and Water who attended the World Food Security Summit in the United Arab Emirates, the dependence of countries on trade for a significant portion of their food supply will result in several consequences. These include an increase in the population of developing nations, growing revenues, variations in consumption patterns, and consequently, a corresponding rise in the volume of food imports. Also, the need of the GCC countries to suffice on food, prompted some of these countries to purchase lands as an investment in countries like Africa, Australia and Latin America, as investing in agriculture is an effective strategies for achieving critical development goals related to poverty and hunger, nutrition and health, education, economic and social growth, peace and security, and preserving the world's environment (Devesh and Asrul Affendi, 2020).

In the Sultanate of Oman, the population was approximately 4.9 million individuals in 2022, with projections indicating an expected rise to 7.8 million by the year 2040. This entailed a request for the government to allocate additional funds towards the provision of sustenance for the entire population. The country's reliance on food imports to fulfil the demand for essential commodities such as rice, wheat, wheat flour, milk powder, vegetable oils, maize, and tea or coffee emerged as a strategy to ensure adequate food reserves. Therefore, the country has a significant reliance on food imports, facilitated by the existence of a distinct entity called the "Public Authority Food Supply Distribution." This organisation operates under the Ministry of Commerce and Industry in collaboration with the Ministry of Agriculture. The implications of population growth on food imports are expected to have a significant influence on the Gross Domestic Product (GDP). Consequently, it is imperative for policymakers in Oman to conduct a thorough analysis of the relationship between the food import bill and GDP growth, as highlighted by Devesh and Asrul Affendi (2020). In addition to balance the risks, countries should enlarge the domestic agricultural products that would require capital investment in greenhouse structures, irrigation technology, and skilled labor (Elmi, Alomirah and Al-Zenki, 2016).

In light of the previous discussion, the inclusion of food security and sustainability policies within regional policy frameworks holds crucial significance. This inclusion aims to identify pragmatic elements that can enhance the functioning of market economies. For instance, an enhanced strategic planning and strict policies were established by Oman to support the development of sustainable agriculture and its place as one of the most food secure nations in the Gulf Corporation Council (GCC) in the long run (Devesh and Asrul Affendi, 2020). Evidence show that Oman faces several issues that threaten its food security. Oman has not been studied yet in the international academic literature on food security and sustainability. The EIU Global Food Security Index offers a comprehensive assessment of the vulnerability of countries to food insecurity on a global scale. It evaluates 113 countries based on four key factors: affordability, availability, food safety and quality, sustainability, and adaptation. This index provides valuable insights into the countries that are most and least at risk of food insecurity. Nevertheless, the index is accessible for the country of Oman, providing a depiction of its ranking as 35th with a corresponding score of 71.2 (The Economist Group, 2022).

Therefore, in this paper, we provide a brief evaluation of the food availability performance including multiple and conflicting criteria. Using TOPSIS technique as a multi-criteria method, we have built a dynamic quantitative national-level index to benchmark all indicators of food availability in order to find out the Challenges in the food system in Oman. The rest of the paper is structured as follows: the following section considers the literature review; in section 3, we introduce TOPSIS technique and present the drivers' data of dimensions of food security; section 4 reports our results. The final section provides the conclusions.

Literature Review

Food security can be defined in two groups the first group is for the countries which has advance agricultural system and the other grouping countries with basic production systems this study analysis the impact of this variations on food security and it's shows there is relation between advance production and food security and sustainability(Campi, Dueñas and Fagiolo, 2021). Population and family size impact the food security level According to (Ansah, Gardebroek and Ihle, 2019) concluded that households with more flexibility on the number of kids have good food security. Household expenditure is one of food security drive the food security (Allee, Lynd and Vaze, 2021).

Achieving food security depends on safeguarding four critical dimensions: food availability, accessibility, affordability, and utilization. For example, a country with sufficient food availability but limited accessibility and affordability would still face food insecurity. Food availability is considered to be a critical approach to food security performance because of its impact on nourishment and population healthiness (Burchi and De Muro, 2016). In which, understanding food availability is essential for assessing the adequacy and accessibility of food resources within a population, as it helps policymakers and researchers identify regions and communities at risk of food insecurity and develop targeted interventions to improve access to nutritious food (Burchi and De Muro, 2016). Hence, food availability is known as the amount of total physical quantities of food available in a country or an area in the form of domestic production, import, exchange, processed and stocks after deducting the total financial and economic access to food and food stability in addition to the stability of these factors over time (Firdaus et al., 2019).

Different methodologies were employed to measure food availability, such as, Surveys on dietary patterns and consumption habits (e.g., household consumption surveys and national food consumption surveys), and food balance sheets that provide information on food production, imports, and exports, and enables the assessment of national and global food availability (Burchi and De Muro, 2016). Therefore, food availability was assessed using a verity of indicators. According to FAO (2018), calorie availability per capita is a commonly used indicator to assess food availability, because it measures the average caloric intake per person within a population (FAO et al., 2018). Dietary diversity is another important indicator that captures the range of foods consumed and reflects the nutritional quality of diets (Beal, Morris and Tumilowicz, 2019). Additionally, food production indicators, such as crop yields and livestock production, provide insights into the potential for self-sufficiency and food availability at the national level (Burchi and De Muro, 2016).

In case of Oman, food availability performance is influenced by a variety of factors; economic, environment, and social. For instance, agricultural productivity that considered to be an economic factor, plays a crucial role, as it determines the quantity and quality of food produced (Green et al., 2020). Simultaneously, land use patterns and climate change poses a significant threat to food availability, as it affects agricultural production, water availability, and land suitability for farming (Chowdhury, Bhadra and ..., 2017). Besides, other economic and social factors such as population growth, urbanization, food distribution systems, market dynamics, government expenditure, and food import bill contribute to variations in food availability (Garner et al., 2018). Thus, the performance of food availability will be explored by utilizing the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) to obtain an inclusive understanding of food availability that addresses food security challenges in Oman country.

Materials and Methods

To assess multiple dimensions' concepts, multi-criteria tools are often used Multi-Criteria Decision Aid (MCDA) or Multi-Criteria Decision Making (MCDM) methods have received much attention from researchers and practitioners in evaluating, assessing, and ranking alternatives across diverse industries (Elsayed, Dawood and yan, 2017) (Velasquez and Hester, 2013). The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a widely used MCDA/MCDM method that has demonstrated satisfactory performance in various application domains. The research findings in the field of TOPSIS decision-making, as presented by Behzadian et al. (2012) and Topcu (2022), offer valuable insights into the TOPSIS method. These insights not only contribute to our comprehension of TOPSIS, but also provide a foundation for future research endeavours in this area. The recommendations put forth in these studies emphasise the need for a forward-looking and practically oriented approach to further investigate the TOPSIS method. The principle behind TOPSIS is simple: The chosen alternative should be as close to the ideal solution as possible and as far from the negative-ideal solution as possible (Ardakani, Bartolini and Brunori, 2017). The ideal solution is formed as a composite of the best performance values exhibited (in the decision matrix) by any alternative for each attribute. The negative-ideal solution is the composite of the worst performance values. Proximity to each of these performance poles is measured in the Euclidean sense (e.g., square root of the sum of the squared distances along each axis in the "attribute space"), with optional weighting of each attribute.(Bhattacharya, Abraham and Vasant, 2008). On other hand, TOPIS has some disadvantages are that it does not consider the relationship between the criteria, and it is difficult to weight the criteria (Velasquez and Hester, 2013). The good advantage of TOPSIS is appropriate for the cases with a large number of criteria and alternatives and it is especially accessible when quantitative data are specified .(Zaidan et al., 2015).

Furthermore, the TOPSIS method is favoured for its straightforward and comprehensible application stages as well as its easily interpretable outcomes. Hence, this study incorporates a comprehensive and up-to-date description of the TOPSIS calculation procedure, making it a valuable reference for research in the field of food security. This paper aims to provide a comprehensive explanation of the step-by-step calculation procedure of the TOPSIS method within the context of food availability analysis. Hence, our study aims to quantitatively assess and analyse the various effects on the eight indicators of a food system in relation to food availability. To achieve this, we have employed the "Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS)" as a multi-criteria approach. Through this methodology, we aim to identify the dimensions that pose the greatest challenges. Therefore, by addressing the primary vulnerabilities within food systems, our research endeavours have the potential to assist policymakers in formulating effective strategies to alleviate food insecurity within a nation.

The initial stage of the methodology involves the creation of a decision matrix, which encompasses the relevant data. The normalised matrix is derived from the decision matrix. Subsequently, the decision matrix is subjected to normalisation, followed by the assignment of weights. Subsequently, the values for the ideal solution and the negative ideal solution are determined. Following that, the optimal and suboptimal distances, along with the available alternatives, are computed. The optimal choice is determined by identifying the alternative with the highest score value in the final-results table. The application steps outlined for the TOPSIS method are as follows:

Scoring.

The statistical data for the variables used in this study were obtained from the National Centre for Statistics and Information (NCSI) of Oman. In food security studies, TOPSIS has been utilized in several studies where the yearly average values of availability parameters were employed. Therefore, it was preferable to analyze the average values on a yearly basis. Table 1 presents the statistics for the food availability variables from 2010 to 2021. The factors used for the period 2010–2021 are as follows:

X1: annual population growth rate
X2 annual government investment
X3: annual average of temperature degree °C)
X4: annual average of rainfall amount (mm)
X5: Share of cultivated land out of the total land in the country
X6: annual value of agricultural and fishing production
X7: annual net of food import
X8: annual output value of food industry

Table 1: Food Availability Variables Data

Year	X1	X2	X3	X4	X5	X6	X7	X8
2000	2401256.00	1229.25	26.72	77.63	3.79	579.99	351079.98	563.35
2001	2477687.00	1391.25	26.50	66.29	3.79	608.91	361011.52	588.26
2002	2537742.00	1466.75	27.83	57.64	4.11	605.70	370762.25	588.70
2003	2340815.00	1750.00	27.17	76.44	4.44	594.33	324286.61	667.94
2004	2415576.00	2587.00	26.02	54.05	4.76	601.05	497070.00	835.14
2005	2508837.00	2416.25	26.12	95.95	4.73	588.18	615060.38	952.90
2006	2577062.00	2998.75	28.60	111.10	4.73	576.14	678590.90	998.63
2007	2743499.00	4243.25	27.79	114.50	4.73	600.53	986917.04	1338.12
2008	2867428.00	5702.25	26.31	54.30	4.71	632.82	1131153.28	1984.53
2009	3173917.00	6727.25	28.54	80.50	4.70	666.87	1201305.00	1576.58
2010	2773479.00	6492.00	27.10	113.90	4.66	737.53	1377666.41	1658.46
2011	3295298.00	7398.75	27.20	92.60	4.64	737.75	1470701.32	2015.59
2012	3623001.00	7216.25	27.10	75.10	4.60	733.97	1735923.90	2107.49
2013	3855206.00	7798.75	28.20	139.20	4.59	850.71	1694067.11	2146.74
2014	3992893.00	8960.39	27.70	89.50	4.59	865.06	2062200.58	2314.59
2015	4159102.00	8287.80	28.70	69.40	4.63	1164.58	1973725.61	2119.86
2016	4414051.00	7321.43	27.80	95.30	4.64	1260.15	2156200.63	2018.67
2017	4559963.00	6638.50	28.40	74.00	4.69	1335.59	1886719.46	2098.75
2018	4601706.00	7220.25	27.40	80.00	4.72	1626.85	1875499.05	2195.30

2019	4617927.00	6684.75	35.80	94.00	4.72	1695.90	2088421.60	2172.43
2020	4481042.00	6041.00	28.70	103.00	4.71	1938.38	2611994.13	2246.52
2021	4527446.00	4563.25	29.80	105.00	4.71	2112.30	2898019.55	2557.64

Source: Compiled by Author Using MS Excel

The scoring results are expressed in the mathematical matrix format, and the generated value matrix is demonstrated in equation 1:

$$D=\begin{bmatrix} x_{11} & x_{1j} & \cdots & x_{in} \\ \vdots & & & \\ x_{i1} & x_{11} & \cdots & x_{in} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{i1} & \cdots & x_{mn} \end{bmatrix} = \begin{vmatrix} D_1 & (x_1) \\ \vdots & (x_j) \\ D_i & \\ \vdots & (x_n) \\ D_m & \end{vmatrix} \quad (1)$$

Standard Matrix Calculation

The feature matrix is normalized to obtain the normalized vector rij and build standardized matrix about normalized vector rij. Normalized vector rij is calculated as in equation 2. Critically, the logarithmic calculation of negative values and zero is not significant. However, some availability data values, such as temperature, might experience negative values, or in the case of rainfall, zero values. Therefore, it is suggested applying equation 2 to take this into account.

$$r_{ij} = \frac{x_{ij} - \text{m} \quad (x_{ij})}{\max(x_{ij}) - \min(x_{ij})}, =1,2,3\ldots\ldots\text{m and j}=1,2,3\ldots\ldots\ldots\text{n} \quad (2)$$

Index Weight Determining

The process of determination and calculation of the weight of each index by means of entropy weight method is as follows.

Calculating the proportion pij of index value of project i under index j: pij is calculated as in equation 3

$$\boldsymbol{P_{ij}} = \frac{\boldsymbol{r_{ij}}}{\sum_{i=1}^{m} \boldsymbol{r_{ij}}} \qquad \text{i} = 1,2,3\ldots\ldots\text{m and} \quad \text{j} = 1,2,3\ldots\ldots\text{n} \quad (3)$$

Calculating the entropy ej of index j, ej is identified in equation 4:

$$e_j = -K \sum_{i=1}^{m} [P_{ij} \ln P_{ij}] \quad (4)$$

The k in equation (4) can be calculated in equation 5:

$$\text{K} = \frac{1}{\ln m} \quad (5)$$

Calculating the entropy weight wj of index j, wj is calculated as in equation 6:

$$w_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)} \quad , \quad \sum_{j=1}^{n} w_j = 1 \quad (6)$$

Building standardized matrix of weight: calculate standardized value vij of weight and build standardized matrix of weight, vij is measured as in equation 7:

$$v_{ij} = w_j\, P_{ij} \;\; , i = 1,2,3....m. \;\; ; j = 1,2,3....n. \; (7)$$

Complete Assessment Index Calculation.

Determining the ideal solution and the anti-ideal solution: determine the ideal solution V^+ and the anti-ideal solution A according to standardized value vij of weight. V^+ and V^-are identified in equation 8 and equation 9:

$$\boldsymbol{V^+} = \{(\text{maxi xij} , \; j \in J1) , (\text{mini vij} , \; j \in J2) , I = 1 , 2 \ldots, m) \} \; \boldsymbol{V_1^+} , \boldsymbol{V_2^+}, \ldots\ldots\ldots \boldsymbol{V_n^+} \quad (8)$$

$$\boldsymbol{V^-} = \{(\text{mini xij} , \; j \in J1) , (\text{maxi vij} , \; j \in J2) , I = 1 , 2 \ldots, m) \} \; \boldsymbol{V_1^-} , \boldsymbol{V_2^-}, \ldots\ldots\ldots \boldsymbol{V_n^-} \quad (9)$$

J_1 in equation 8 and equation 9 which reveals the optimum value of index j is a profitability index set; J_2 in equation 8 and equation 9 which shows the worst value of index j is a loss index set. V_j^+ is the distance between index j and the optimum objective while 〖vj〗 ^- is the distance between index j and the worst objective. The larger the profitability index value is or the smaller the loss index is, the better the performance of the evaluation result and vice versa.

Calculating distance scale: the distance between each objective and ideal solution or anti-ideal solution is defined as distance scale and calculated by Euclidean distance. s^+ constitutes the distance between the objective and ideal solution V^+, and s^-shows the distance between the objective and anti-ideal solution V^-. The calculation formula is identified in the following way in 10 and 11:

$$\boldsymbol{S^+} = \sqrt{\textstyle\sum_{i=1}^{n}(\boldsymbol{v_{ij}} - \boldsymbol{V_j^+})^{2}} \quad (10)$$

$$\boldsymbol{S^-} = \sqrt{\textstyle\sum_{i=1}^{n}(\boldsymbol{v_{ij}} - \boldsymbol{V_j^-})^{2}} \quad (11)$$

In 10 and 11, i = 1, 2,..., m, and S^+ represents the closeness between each evaluation and the ideal objective. The smaller the value of S^+ is, the shortest the distance from objective to ideal solution is, and the most preferred the program is, and vice versa.

Calculating closeness degree of ideal solution C+, C+ is calculated as in 12:

$$c_i^* = \frac{S_i^-}{S_i^* + S_i^-} \quad (12)$$

In equation 12, C_i^+ is in the range of 0 to 1. When C_i^+ = 0, then V_i = V^+,which means V_iis the most optimal evaluation objective. From small to large scale, all of the evaluation objectives are categorized based on the value of C_i^+ . The larger the value of C_i^+ is, the better the evaluation objective is. Table 2 shows optimal ideal degree of food availability dimension during the period between 2010 and 2021.

Table 2: Optimal Ideal Degree of Food Availability Dimension

Year	A11	A12	A13	A14	A15	A16	A17	A18	Si+	Si-	P1	Rank
2000	0.0004	0.0000	0.0028	0.0061	0.0000	0.0001	0.0002	0.0000	0.0397	0.0388	0.4939	19
2001	0.0008	0.0003	0.0019	0.0031	0.0000	0.0005	0.0002	0.0002	0.0405	0.0391	0.4912	20
2002	0.0012	0.0004	0.0072	0.0009	0.0038	0.0005	0.0003	0.0002	0.0412	0.0341	0.4528	21
2003	0.0000	0.0009	0.0045	0.0058	0.0076	0.0003	0.0000	0.0007	0.0379	0.0380	0.5008	18
2004	0.0005	0.0024	0.0000	0.0000	0.0114	0.0004	0.0011	0.0018	0.0390	0.0425	0.5219	16
2005	0.0010	0.0021	0.0004	0.0108	0.0112	0.0002	0.0018	0.0026	0.0338	0.0434	0.5621	13
2006	0.0014	0.0032	0.0102	0.0147	0.0111	0.0000	0.0022	0.0029	0.0338	0.0364	0.5184	17
2007	0.0024	0.0054	0.0070	0.0156	0.0112	0.0004	0.0042	0.0051	0.0305	0.0396	0.5655	11
2008	0.0032	0.0080	0.0011	0.0001	0.0109	0.0009	0.0051	0.0094	0.0345	0.0426	0.5526	14
2009	0.0050	0.0098	0.0099	0.0068	0.0108	0.0014	0.0055	0.0067	0.0321	0.0351	0.5228	15
2010	0.0026	0.0094	0.0043	0.0154	0.0103	0.0025	0.0066	0.0072	0.0259	0.0429	0.6235	6
2011	0.0058	0.0110	0.0046	0.0099	0.0101	0.0025	0.0072	0.0096	0.0275	0.0411	0.5990	8
2012	0.0077	0.0107	0.0043	0.0054	0.0096	0.0025	0.0089	0.0102	0.0297	0.0405	0.5768	10
2013	0.0091	0.0117	0.0086	0.0219	0.0094	0.0043	0.0086	0.0105	0.0248	0.0428	0.6332	5
2014	0.0100	0.0138	0.0066	0.0091	0.0094	0.0045	0.0109	0.0116	0.0268	0.0409	0.6046	7
2015	0.0110	0.0126	0.0106	0.0040	0.0100	0.0091	0.0104	0.0103	0.0286	0.0370	0.5639	12
2016	0.0125	0.0109	0.0070	0.0106	0.0101	0.0106	0.0115	0.0096	0.0235	0.0409	0.6347	4
2017	0.0134	0.0097	0.0094	0.0051	0.0107	0.0118	0.0098	0.0102	0.0276	0.0378	0.5778	9
2018	0.0136	0.0107	0.0054	0.0067	0.0110	0.0163	0.0098	0.0108	0.0237	0.0431	0.6453	3
2019	0.0137	0.0098	0.0386	0.0103	0.0110	0.0174	0.0111	0.0106	0.0437	0.0294	0.4019	22
2020	0.0129	0.0086	0.0106	0.0126	0.0109	0.0212	0.0144	0.0111	0.0202	0.0438	0.6845	1
2021	0.0132	0.0060	0.0149	0.0131	0.0109	0.0239	0.0162	0.0132	0.0232	0.0435	0.6528	2
V+	0.0000	0.0138	0.0000	0.0219	0.0114	0.0239	0.0162	0.0132	0.0437	0.0438	0.6845	
V-	0.0137	0.0000	0.0386	0.0000	0.0000	0.0000	0.0000	0.0000	0.0202	0.0294	0.4019	

Source: Compiled by Author Using MS Excel

Results

In this study, food availability analysis was conducted for Oman by using eight variables as input parameters in the TOPSIS method for the period 2000 – 2021. The value of TOPSIS ranges from zero to one. High ratio is an indicator of lower food availability risk, and the lower ratio values indicate high food availability risk situation. The values and categories classifications of the TOPSIS food Availability index were built based on the mean (¯Ci=0.5627) and standard deviation (S = 0.07) of C_i^+ as follows.

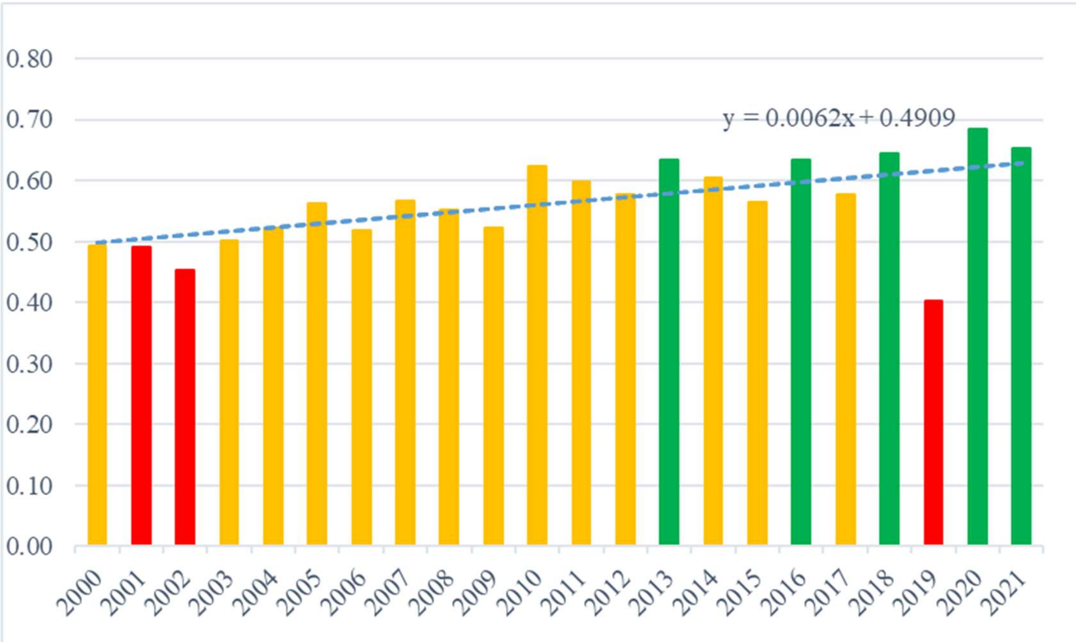
Table 3. Food Availability Category According to TOPSIS Values

Security level	Interval
Low Risk (SECURE)	$C_i^+ > 0.6331$

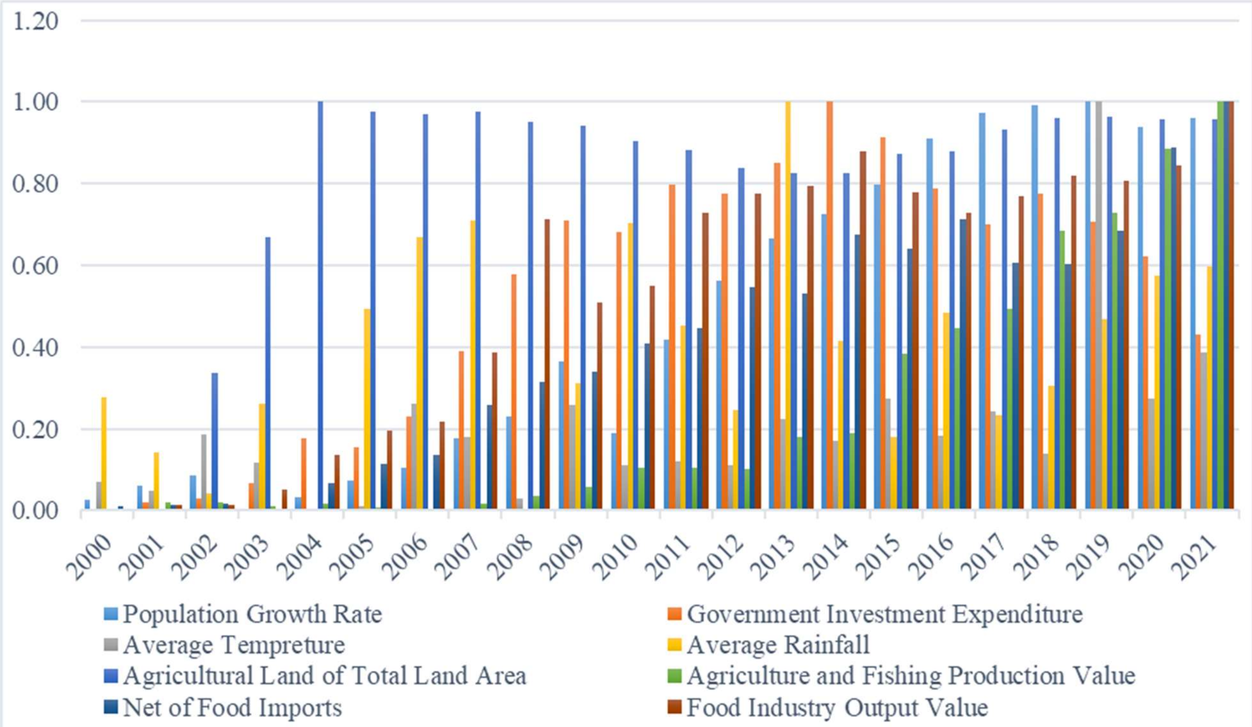
Medium Risk (MODERATELY SECURE)	$0.4923 \leq C_i^+ \leq 0.6331$
High Risk (INSECURE)	$C_i^+ < 0.4923$

Source: Retrieved from (Wang et al., 2021)

Oman food availability TOPSIS results are considered as the whole series, it is determined as 5 years have food availability secure, 14 years have medium risk, 3 years have high food availability risk (insecure). The food availability condition by year for the periods between 2000 – 2021 is shown in Figure 1.



The TOPSIS method has been successful in detecting food availability events in Oman, as shown in Figure 1. According to the results, the years 2013, 2016, 2018, and 2020–2021 are considered secure in terms of food availability. However, the years 2001–2002 and 2019 are classified as insecure. Furthermore, during the years 2000 and the period from 2003 to 2012, there was a moderate level of risk in terms of food availability. Figure 2 illustrates the different factors that have influenced the levels of food availability in Oman from 2000 to 2021, leading to both high and low optimal situations:



Government investment in agriculture and food production has been consistently identified as a key factor contributing to high levels of food availability in Oman, as depicted in figure 2. Increased government investment in these sectors creates a favorable environment for farmers and agribusinesses to flourish and increase food production. Consequently, this leads to improved food availability. Another crucial factor that contributes to food production is the size of the cultivated land area. Increased availability of land for cultivation results in a greater capacity to grow food, thereby leading to higher levels of food availability.

Food production value is another significant factor that impacts the availability of food. A high value of food production indicates that there is an increased amount of food being produced, which in turn indicates a greater likelihood of addressing the population's food demands. The net value of food imports is an important factor that should be taken into consideration. Countries that heavily depend on food imports are at risk of being vulnerable to disruptions in the global food supply chain, which can have a significant impact on the availability of food. Conversely, a country that can produce a sufficient quantity of food to fulfil its own needs and even has the ability to export surplus food tends to be more resilient in dealing with disruptions in the global food supply. Another important factor is the value of the output in the food industry. When the food industry is thriving and generating substantial economic activity, it has the potential to enhance food availability by creating employment opportunities and fostering the expansion of food production and distribution networks. The analysis also emphasizes that food availability can be influenced by average temperature and rainfall levels. Although the average temperature had a minimal impact on food availability in the period under study, it is crucial to acknowledge that extreme weather events like heatwaves, droughts, and floods can greatly affect food production and availability.

The analysis indicates that improving food availability in Oman relies on a combination of factors such as government investment, land availability, food production value, and food industry output value. Although the population growth rate may not have an immediate impact on food availability, it is crucial to consider its long-term implications. As the population continues to grow, it places increasing pressure on food systems, making it important to address this issue in the future.

Conclusion

The Food Availability Security event is an important aspect of investigating food security and sustainability in Oman. It is crucial to understand and analyse this dimension in order to enhance the overall food security situation in the country. Short-term situations of insecure food availability can be managed and mitigated by taking measures to prevent harm. However, long-term food insecurity can have permanent negative effects on society and the economy. Food security analysis and the use of indices hold significant importance in studies conducted in Oman. The study utilized the TOPSIS model to analyze food availability in Oman. An exploration was conducted to examine eight different food availability parameters from 2011 to 2021. In Oman, the summer weather is extremely hot, and the country experiences a low average of rainfall. The availability values in TOPSIS also reflected the characteristics of the continental climate. Based on the analysis results, it was found that in terms of food availability performance, the year 2019 had the lowest score of 0.4019, indicating a high level of insecurity. Contrary to expectations, the year with the highest level of food security was 2020, with a score of 0.6845 in the food availability dimension.

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