Using Linear Programming Model to Determine Balanced and Least-COST Human Diet for the Poor in Greater Amman, Jordan

Abdul Fattah S. Alkadi and Mohammed Rafiq Hamdan *

ABSTRACT

The poor community in Greater Amman, Jordan suffers from malnutrition due to the deficiency of food budget. The objectives of this study are to define a balanced and least-cost diet for poor people living in that area; to measure the deficiency in food intake, and to find out the effect of the expected price increase on food consumption and cost.

For achieving the objectives of this study, a sample of 158 households has been randomly chosen from the targeted community. The sample has been divided into 10 age and gender groups. Linear programming model has been used to determine the balanced and least cost diets for the different age groups of the sample.

The proposed diet for children costs 0.180 JD, while the recommended diet for average males and females more than 11 years old costs 0.253 JD per capita/day.

Suggested meals for male consumers of all age groups cost more than the other ones recommended to females. The cost of the diet for males and females for the age group of 19-50 years was higher than that for other age groups.

The actual food consumption of the sample indicated insufficient nutrients intake of protein, fats, carbohydrates and energy by 14% for protein, 10% for fats, 4% for carbohydrates and 10% for energy.

The increase in the food price by 10% will increase the cost of food by about 26%.

In order to solve the malnutrition problem of the poor, it is recommended to support their food budget and to start establishing small-scale income-generating projects in an attempt to improve the economic environment and the nutrition status of the poor.

Keywords: Poverty, Malnutrition, Nutrients intake, Balanced and least-cost human diet, Linear programming model, Increase in food price.

1. INTRODUCTION

Economic considerations, mainly insufficient income as well as inadequate nutrition awareness are the main factors affecting the consumer decision in food consumption. Malnutrition may be a result of these factors.

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Under consideration of the individual tastes and food palatability, the application of linear programming techniques in analysis of human diets is however limited. Adding restrictions to the conditions helps in overcoming this problem.

In harmony with Engel's curve; the largest share of the poor household budget is spent on food. The case in Jordan makes no exception. Rational distribution of such budget helps the poor ensuring nutritionally-balanced and economically least-cost diet. Linear programming
Using Linear Programming...  
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2. METHODOLOGY

A field survey including 158 households from ten locations in Greater Amman classified officially as poor communities was implemented in 2005.

A constructed questionnaire was designed and filled directly by the sample of the survey under supervision of trained staff for one continuous week. The questionnaire contains information about household size, gender distribution, age structure, monthly income of the household, amount of food items consumed as well as food prices during the period of the survey.

Recommended nutrients and energy intake, as well as food composition tables were used to calculate the amount of food intake (National Academy, 1989).

In human diets, two objectives of food consumption can be identified: Nutritional and non-nutritional objectives. The nutritional objective is derived from physiological needs for various nutrients, while non-nutritional objectives encompass all other sources of utility in the diet including palatability and preferences (Reidhead, 1979).

The Linear Programming Diet Models

The basic nutrition model of this study assumes that the only concern in diet choice is its untraditional quality, which can be objectively defined in terms of minimum and maximum intake constraints for specific nutrients. The model is:

\[ \text{Min} \quad Z = \sum P_i X_i \]

Subject to:

\[ \sum A_{ij} X_j \geq R_j \]

\[ \sum A_{ij} X_j \leq G_j \]

\[ X_i \geq 0 \quad \text{(non-negative constraint)} \]

Where: \( i = 1 \) to \( 50 \) (food commodities)

\( j = 1 \) to \( 16 \) (constraints of nutrients)

\( X_i = \text{quantity consumed of food commodity } i \)

\( P_i = \text{price of food commodity } i \)

\( A_{ij} = \text{unit of content of nutrient } j \) in food commodity \( i \)

\( R_j = \text{minimum level of nutrient } j \)

\( G_j = \text{maximum level of nutrient } j \)

Some assumptions are made about linear...
programming having a significant bearing upon its application to human diets:

1- The total intake of each nutrient in the diet is a linear function of the intake from each individual food item.

2- The requirement for each nutrient is independent on the requirements for all other nutrients.

3- Intakes of any nutrient beyond the required maximum or minimum intake have no positive nutritional value.

4- The satisfaction of each nutrient requirement is equally important.

5- Food prices are constant.

In order to achieve the objective of this study, the population of the sample was divided into 10 groups. Thus, the study handled 10 models, one model for each group.

These groups are

- Children less than 11 years old,
- Males more than 11 years old,
- Females more than 11 years old,
- Males and females more than 11 years old,
- Males 11-18 years old,
- Males 19-50 years old,
- Males 51 years old and over,
- Females 11-18 years old,
- Females 19-50 years old and
- Females 51 years old and over.

Each group has different nutritional needs and requirements.

Table (1) represents the basic nutritional constraints for each group as follows:

1. Children model.
2. Males 11 years old and over model.
3. Females 11 years old and over model.
4. Average males and females 11 years old model.
5. Males 11-18 years old model.
6. Males 19-50 years old model.
7. Males 51 years old model.
8. Females 11-18 years old model.
10. Females 51 years and over model.

The nutritional requirements (constraints) are identified by 16 constraints (RDA, 1989) as follows:

1. energy (kcal)
2. protein (g)
3. vitamin A (ugRE)
4. vitamin C (mg)
5. vitamin B1 (mg)
6. vitamin B2 (mg)
7. niacin (mg)
8. iron (mg)
9. iodine (ug)
10. animal protein ≥ 20% of total protein.
11. > 25% of energy originates from fat.
12. <30% of energy from fat.
13. >45% of the energy source originates from carbohydrates.
14. <65% of energy source originates from carbohydrates.
15. >10% of energy originates from protein.
16. <12% of energy originates from protein.

The constraints from 1 through 9 determine the amount of energy, protein, vitamin A, vitamin C, vitamin B1, vitamin B2, niacin, iron, and iodine in the food which must be at least equal or greater than the required amount of content of the nutrient in the diet. Constraint 10 provides that the animal protein must be greater or equal 20% of the total protein. Constraints 11 and 12 provide that the produced from fat represents 25-30% of the total energy, while constraints 13 and 14 provide that the energy from carbohydrates represents 45-65% of the total energy intake, and the constraints 15 and 16 provide that the energy from protein represents 10-12% of total protein intake.

However, other constraints were added and some activities were deleted in order to obtain the logic diet in line with the prevailing Food consumption patterns of the population in the study area. Also, the assumption of increase in the price of all food commodities by 10% is examined with respect to the average males and females more than 11 years old model.

The commodities which are consumed in the study area and their prices are shown in table (4). Table (5)
represents the commodities (activities) and their nutrient contents.

TORA program was used to solve the model.

**Previous Studies**

Gould and Sparks (1969) applied linear programming technique to construct balanced and least-cost human diets for Guatemala.

This study showed regional variations in food cost, and potential use of linear programming for regional planning and income determination of households.

Victor Smith (1975) used mathematical programming for constructing optimal diets and food production systems in Nigeria.

Hammad (1997) applied linear model for determining a balanced and least-cost human diet for five different age groups in Jordan.

The increase in food prices due to the rise in energy prices had substantial negative effect on the nutrition of the poor.

Food expenditures amounted to 44.3% of the total household expenditures and 45% of the household income in Jordan (Department of Statistics, 1999).

The implementation of the "Economic Adjustment and Restructuring Programs" and the privatization process which resulted in lifting food subsidy has affected the food consumption patterns of the poor. In 1998, the poor consumed less food, less nutrients and less energy compared with the period preceding the implementation of the programs mentioned above. They consumed more food of low quality and cost.

The average individual consumption in 2006 amounted to 70 gr. protein, 60 gr. fat, 445 gr. carbohydrates as well as 2600 Kcal per day.


Previous studies indicated that about 14.2% of the Jordanian population lived in 2002 under the poverty line which was equal to JD 392, while the average annual individual income of the poor in the sample was JD370. While in Amman Governorate it was JD 419.

Around 60% of the heads of the poor households are unemployed, and 40% are temporal workers. They are employed mainly in the sectors of service, agriculture and constructions. An obvious relationship exists between poverty and education; about 86% of the poor enjoyed the primary education or less while 12.7% of the poor are analphabetic. Only 1.3% of them got the first certificate of higher education.


Countries in Latin America, Africa and Middle East of different food self-sufficiency degrees, have experienced food subsidy of the poor. The cost of the subsidy constituted 12% of the total budget in Sri-Lanka, 13% in Egypt, 2% in Mexico, 10% in Bangladesh, 7% in Pakistan, and 6% in Zambia.

(Jochem von Braun, 2006).

A study has been conducted with the purpose of evaluating the impact of the "Economic Restructuring and Adjustment Programs" implemented in Jordan since 1989 on the nutrition patterns of the poor households in Greater Amman. The survey included 166 poor households. The study indicated that the food consumption patterns of the poor contained 63.7 gr. protein, 58.2 gr. fats and oils, 424 gr. carbohydrates, and 2475 Kcal/capita/day. Compared with the same consumption of the same layer of people registered 1987 -period preceding implementing such programs- a decrease in the intake of nutrients and energy has been noticed.

The nutrition patterns of the poor indicated a deficit in the consumption of total protein, animal protein, and fats by about 1.3 gr., 4.6 gr., 10.8 gr., respectively.

Adding 20 gr. of poultry meat, 100 gr. of milk, 30 gr. of broad beans, and 1 gr. of oil may help to achieve the level required for optimal nutrition at an additional cost of 100 Fils daily (JD = 1000 Fils) (Hamdan, 2000).

As it is the case in 1992, there was big difference in the food consumption Patterns between poor and people of higher income. Poor consumers consumed 59 gr. total protein, 19.3 gr. animal protein, 48.4 gr. Fat, 344 gr. Carbohydrates, which created 2065 Kcal, compared with the intake of high-income consumer; 70 gr. total protein, 33.6 gr. animal protein, 65 gr. fat, 420 gr. carbohydrates
as well as 2545 Kcal per capita per day. (DOS, Study of Income, 1992).

The most critical point in the Jordanian system of food security is the dependence of the domestic food demand on the foreign food markets of food items of strategic nutrition value such as wheat, sugar and rice.

The average self-sufficiency degree in the second half of the nineties constituted about 10% for wheat, 15% for legumes, 36% for red meat, 50% for milk and equivalents, and 0.0% for rice and sugar. The annual per capita consumption in the period 1988-2002 amounted to 176 kg of wheat, 136 kg of fruits, 74 kg of milk and equivalents, 33 kg sweeteners, 34 kg of meat and offal as well as 12 kg of vegetable oils (Dept. of Statistics, Study of Income).

Carbohydrates supply around 65% of the dietary energy supply, while fats supply 25%, and protein 10%. About 35% of the protein intake is of animal origin. At least 20% of the protein intake should be of animal origin.

Jordan exports vegetables and fruits, and is self-sufficient in poultry and eggs.

In general, Jordan is strongly dependent on the western world food markets in ensuring the required food of strategic nutrition value; mainly, cereals with a self-sufficiency degree of 5%-10%, red meat and dairy products (50% for both), rice and sugar (6% for both).

The main trade partners for Jordan are Europe and USA, though neighboring Arab countries can be strategic partners of foreign trade for Jordan.

(WHO, Towards, 2006)
www.jifp.gov.jo
www.DOS.gov.jo
www.mit.gov.jo)

Linear programming is illustrated by comparing the economic value of two food supplements, traditional blended flour and a nutrient-dense spread (a "foodlet") in rural Chad. The paper illustrates how this technique can be used to estimate the economic benefits expected from the introduction of different fortified foods using local food prices.

(Andre' Briend, Elaine Ferguson, and Nicole Darmon, 2001).

A similar study in Ghana that used the same methodology applied in this research examined the impact of gender and source of food under constant price ratio.

The study revealed that farmers face the same prices for selling and purchasing farm produce. The result did not change when the price for selling the produce and the price for purchasing for consumption were kept at the same level, portraying a typical characteristic of subsistence farmers.

Promoting intensified maize production for female farmers as well as promoting female farm enterprises may improve the food security of rural households. Due to limited access to resources, farmers would need to allocate their resources more efficiently and combine farm enterprises in a way that will result in increasing their income (Dagmar Kunzo, 2006).

The same technique of linear programming has been used in Malawi as a method to design nutrient adequate diets of optimal nutrient density and to identify the most stringent constraints in nutritional recommendations and food consumption patterns in a population's diet.

The resultant diet was based on vegetables, legumes, and animal products (meat, fish, and eggs). In this highly nutrient-dense diet, the vegetable food group (172 gr. cassava leaf, 172 gr. Chinese cabbage, and 652 gr. tomato) was the major contributor for both total energy (76.8%) and total weight (97.9%) and contributed > 100% of the calcium, iron, folate, vitamin C, and copper needs. Legumes (14 gr. ground flour) and fish (7 gr. dry usipa) contributed 16.7% and 6.3% of the total energy, respectively (Nicole Darmon, 2002).

3. RESULTS AND DISCUSSION

This research revealed the following results:

The minimum cost of food per capita per day that satisfies the nutritional requirements is estimated by 0.171 JD for children and increases to 0.284 JD, 0.293 JD, 0.237 JD for males 11-18 years, 19-50 years, and more 51 years old, respectively. While the cost of food
for females is less than that for males of all categories, it is estimated by 0.227 JD, 0.228 JD, 0.203 JD for females 11-18 y, 19-50 y and more than 51 years old, respectively.

Thus, the estimated average cost of food for males more than 11 years old is 0.277 JD and for females in the same category 0.224 JD, while, the average cost of food for males and females more than 11 years old is estimated by 0.253 JD (Table2).

The food items for children that satisfy their nutritional requirements consist of bread, burghul, rice, sugar, vegetable oil, mlokya and poultry, while the food items for females more than 51 years old consist of bread, burghul, sugar, vegetable oil, mlokya and poultry. Food items for other groups consist of bread, burghul, sugar, vegetable oil, radish, mlokya, and poultry with different quantities from one category to the other (Table2).

If eggs and milk are being introduced in the diet recommended to children, the cost of food will increase from 0.171 JD in the present solution to 0.180 JD per capita per day. The suggested commodities in this case are bread, burghul, rice, vegetable oil, fresh milk, mlokya, and eggs with the amounts of 0.092 kg, 0.185 kg, 0.09 kg, 0.037 kg, 0.04 kg, 0.193 kg and 0.025 kg, respectively.

The solution for all models is valid as long as the price of the commodities in the solution doesn’t increase more than 0.165, 0.429, 0.256, and 0.267 JD/kg for bread, burghul, rice and sugar, respectively, and than 0.875, 1.784, 0.288, 1.321 JD/kg for vegetable oil, radish, mlokya and poultry, respectively (Table 3).

The highest degree of sensitivity is to be seen in rice, sugar, burghul and bread, since the percentage of the maximum price with respect to current prices is estimated by 102%, 107%, 7 107%, 110%, respectively, and is estimated by 146%, 174%, 191% for vegetable oil, poultry, and mlokya, respectively, while radish with a degree of sensitivity of 892% is the least sensitive.

If the commodities not included in the solution are enforced into the solution, the cost of food will increase by the value of the reduced cost for each commodity multiplied by its amount introduced in the solution (Table4).

According to the above results, any other combination of food staff will lead to the increase in the cost of food. By adding new constraints to the models for males and females more than 11 years old will raise the cost from 0.253 JD/capita/day to 0.289 JD.

If tomatoes and sugar should be included in the manner of the prevailing food consumption patterns of the population, the cost of food will increase to 0.302 JD. The cost will increase to 0.315JD if tomatoes, sugar and olive oil are included, and it will increase to 0.316JD if tomatoes, sugar, olive oil and banana are requested to be included in the recommended diet and it will rise to 0.309 JDs if tomatoes and eggs are introduced in the food.

If a particular food item should be omitted from the model, the food cost will positively change; if poultry for instance is deleted from the list, the cost of food will increase to 0.297 JD and if poultry and beef are deleted together, the food cost will rise to 0.304 JD. So, the composition of food depends on the availability of the food items and their prices in the poor locations.

If the prices of available food items increase by 10%, the cost of food will increase from 0.253 JD to 0.319 JD for the average males and females above 11 years old. So, the percentage increment in food cost amounts to 26%, as a result of increasing prices by 10%. This result can be interpreted as a cause for insufficient food consumption and potential malnutrition for the poor.

The poor does not ensure their nutritional needs. The recommended requirements of protein, fats, carbohydrates and energy are estimated by 73g of protein, 67.3g of fats, 354.6 g of carbohydrates and 2435 Kcal of energy per capita/day, while the actual average food intake per capita/day in the area amounted to 63g of protein, 61g of fats, 340 g of carbohydrates and 2255 kcal of energy. This means that poor people are consuming 14% protein, 10% fats, 4% carbohydrates and 10% energy less than recommended.

Referring to the recommended requirements of the energy and energy-producing nutrients intake, adding about 50gr dry milk or poultry meat per capita per day with an additional cost of about 100 Fils to the diet of the...
poor will cover the indicated shortage.

4. RECOMMENDATIONS

Based on the results (obtained from this research, following measures are recommended:

1. In spite of Jordan's membership in the WTO and its commitment to the Economic Adjustment and Restructuring Programs and Privatization policy, the food budget of the poor should be subsidized in order to enable them to overcome the lag in their nutrition. In this case, the gender and age structure of the family should be taken into consideration.

2. Intensifying targeted education and training policy towards the poor.

3. Implementing small-scale income-creating investment projects in rural and poor areas.

4. Encouraging investment in rural areas in an attempt to combat poverty and unemployment.

5. Establishing marketing centers in different areas in Greater Amman to ensure market transparency and price stability.

Acknowledgment

This research has been financially supported by the Dean ship of Academic Research at the University of Jordan.

Table 1: Basic constraint in the models, nutrient requirements per capita per day.

<table>
<thead>
<tr>
<th>Constraint type</th>
<th>Children</th>
<th>Males 11+</th>
<th>Females 11+</th>
<th>Average Males and Females 11+</th>
<th>Males 11-18</th>
<th>Males 19-50</th>
<th>Males 51+</th>
<th>Females 11-18</th>
<th>Females 19-50</th>
<th>Females 51+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-energy (kcal)</td>
<td>1709</td>
<td>2720</td>
<td>2140</td>
<td>2430</td>
<td>2750</td>
<td>2900</td>
<td>2300</td>
<td>2200</td>
<td>2200</td>
<td>1900</td>
</tr>
<tr>
<td>2-protein (g)</td>
<td>22.7</td>
<td>57.6</td>
<td>47.2</td>
<td>52.4</td>
<td>52</td>
<td>60.5</td>
<td>63</td>
<td>48</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td>3-vitamin A (ug)</td>
<td>533.3</td>
<td>1000</td>
<td>800</td>
<td>960</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>4-vitamin C (mg)</td>
<td>43.3</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>55</td>
<td>60</td>
<td>60</td>
<td>55</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>5-vitamin B1 (mg)</td>
<td>0.9</td>
<td>1.4</td>
<td>1.1</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
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<tr>
<td>6-vitamin B2 (mg)</td>
<td>1</td>
<td>1.6</td>
<td>1.3</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.4</td>
<td>1.3</td>
<td>1.3</td>
<td>1.2</td>
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<tr>
<td>7-niacin (mg)</td>
<td>11.3</td>
<td>18</td>
<td>14.6</td>
<td>16.3</td>
<td>18.5</td>
<td>19</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>8-iron (mg)</td>
<td>10</td>
<td>10.8</td>
<td>14</td>
<td>12.4</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
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<tr>
<td>9-iodine (ug)</td>
<td>93</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
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<tr>
<td>10-animal protein (g)</td>
<td>4</td>
<td>11.5</td>
<td>9.4</td>
<td>10.4</td>
<td>10.4</td>
<td>12.1</td>
<td>12.6</td>
<td>9</td>
<td>9</td>
<td>9.6</td>
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<tr>
<td>11-fat (g)</td>
<td>47.2</td>
<td>60.4</td>
<td>59</td>
<td>67</td>
<td>76.4</td>
<td>80.5</td>
<td>51</td>
<td>61.1</td>
<td>61.1</td>
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<tr>
<td>12-leaf (g)</td>
<td>56.7</td>
<td>90.7</td>
<td>71</td>
<td>81</td>
<td>91.7</td>
<td>96.7</td>
<td>89</td>
<td>73.3</td>
<td>73.3</td>
<td>63.3</td>
</tr>
<tr>
<td>13-energy (kcal)</td>
<td>191.3</td>
<td>306</td>
<td>240.7</td>
<td>273.4</td>
<td>309.4</td>
<td>326.3</td>
<td>259</td>
<td>247.5</td>
<td>247.5</td>
<td>213.8</td>
</tr>
<tr>
<td>14-energy (kcal)</td>
<td>267.3</td>
<td>442</td>
<td>348</td>
<td>395</td>
<td>447</td>
<td>471.3</td>
<td>374</td>
<td>357.5</td>
<td>357.5</td>
<td>308.8</td>
</tr>
<tr>
<td>15-energy (g)</td>
<td>42.5</td>
<td>68</td>
<td>54</td>
<td>61</td>
<td>69</td>
<td>72.5</td>
<td>57</td>
<td>55</td>
<td>55</td>
<td>47.5</td>
</tr>
<tr>
<td>16-energy (g)</td>
<td>51</td>
<td>81.6</td>
<td>64</td>
<td>73</td>
<td>83</td>
<td>87</td>
<td>69</td>
<td>66</td>
<td>66</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 2: Solutions of the models: cost (JD) and commodities (kg) / capita/day for each group.

<table>
<thead>
<tr>
<th></th>
<th>children</th>
<th>Males 11-18</th>
<th>Males 19-50</th>
<th>Males 51+</th>
<th>Females 11-18</th>
<th>Females 19-50</th>
<th>Females 51+</th>
<th>Males 11+</th>
<th>Female 11+</th>
<th>Average males and females 11+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost JDs</td>
<td>0.17</td>
<td>0.284</td>
<td>0.293</td>
<td>0.237</td>
<td>0.227</td>
<td>0.238</td>
<td>0.203</td>
<td>0.277</td>
<td>0.224</td>
<td>0.253</td>
</tr>
<tr>
<td>Bread</td>
<td>0.194</td>
<td>0.348</td>
<td>0.418</td>
<td>0.350</td>
<td>0.278</td>
<td>0.284</td>
<td>0.239</td>
<td>0.382</td>
<td>0.263</td>
<td>0.314</td>
</tr>
<tr>
<td>Burghul</td>
<td>0.135</td>
<td>0.186</td>
<td>0.164</td>
<td>0.090</td>
<td>0.149</td>
<td>0.141</td>
<td>0.102</td>
<td>0.159</td>
<td>0.138</td>
<td>0.149</td>
</tr>
<tr>
<td>Rice</td>
<td>0.026</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.069</td>
</tr>
<tr>
<td>Sugar</td>
<td>0.020</td>
<td>0.068</td>
<td>0.068</td>
<td>0.081</td>
<td>0.057</td>
<td>0.059</td>
<td>0.066</td>
<td>0.079</td>
<td>0.065</td>
<td>0.054</td>
</tr>
<tr>
<td>v.oil</td>
<td>0.039</td>
<td>0.062</td>
<td>0.065</td>
<td>0.046</td>
<td>0.049</td>
<td>0.049</td>
<td>0.042</td>
<td>0.055</td>
<td>0.057</td>
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<tr>
<td>radish</td>
<td>-</td>
<td>0.001</td>
<td>0.007</td>
<td>0.012</td>
<td>0.0001</td>
<td>0.001</td>
<td>-</td>
<td>0.005</td>
<td>0.003</td>
<td>0.363</td>
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<tr>
<td>mlokya</td>
<td>0.246</td>
<td>0.415</td>
<td>0.400</td>
<td>0.326</td>
<td>0.3118</td>
<td>0.310</td>
<td>0.290</td>
<td>0.378</td>
<td>0.315</td>
<td>0.555</td>
</tr>
<tr>
<td>Poultry</td>
<td>0.021</td>
<td>0.055</td>
<td>0.064</td>
<td>0.066</td>
<td>0.047</td>
<td>0.051</td>
<td>0.033</td>
<td>0.061</td>
<td>0.050</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Sensitivity analysis for objective coefficients (max prices) JD/kg.

<table>
<thead>
<tr>
<th>Groups</th>
<th>bread</th>
<th>burghul</th>
<th>rice</th>
<th>sugar</th>
<th>v.oil</th>
<th>radish</th>
<th>mlokya</th>
<th>poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>0.165</td>
<td>0.429</td>
<td>0.256</td>
<td>0.267</td>
<td>0.875</td>
<td>-</td>
<td>0.288</td>
<td>1.321</td>
</tr>
<tr>
<td>Males 11-18</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>Males 19-50</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>Males 51+</td>
<td>0.157</td>
<td>0.428</td>
<td>-</td>
<td>0.267</td>
<td>0.866</td>
<td>1.260</td>
<td>0.288</td>
<td>1.310</td>
</tr>
<tr>
<td>Females 11-18</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>Females 19-50</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>Females 51+</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>Males 11+</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>Females 11+</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
<tr>
<td>av.M&amp;P 11+</td>
<td>0.165</td>
<td>0.429</td>
<td>-</td>
<td>0.267</td>
<td>0.875</td>
<td>1.784</td>
<td>0.286</td>
<td>1.308</td>
</tr>
</tbody>
</table>

Table 4: Reduced cost and price of commodities for the model of average males and females 11 years old and more.

<table>
<thead>
<tr>
<th>Activity (commodity)</th>
<th>Price JD/kg</th>
<th>Reduced cost</th>
<th>Activity (commodity)</th>
<th>Price JD/kg</th>
<th>Reduced cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1: bread</td>
<td>0.15</td>
<td>0.00</td>
<td>X26: onion</td>
<td>0.15</td>
<td>0.1</td>
</tr>
<tr>
<td>X2: semolina</td>
<td>0.25</td>
<td>0.09</td>
<td>X27: garlic</td>
<td>0.30</td>
<td>0.18</td>
</tr>
<tr>
<td>X3: burghul</td>
<td>0.4</td>
<td>0.00</td>
<td>X28: cabbage</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>X4: macaroni</td>
<td>0.71</td>
<td>0.26</td>
<td>X29: cauliflower</td>
<td>0.15</td>
<td>0.01</td>
</tr>
<tr>
<td>X5: rice</td>
<td>0.25</td>
<td>0.05</td>
<td>X30: radish</td>
<td>0.2</td>
<td>0.06</td>
</tr>
<tr>
<td>X6: potatoes</td>
<td>0.20</td>
<td>0.04</td>
<td>X31: pepper</td>
<td>0.2</td>
<td>0.06</td>
</tr>
<tr>
<td>X7: lentils</td>
<td>0.5</td>
<td>0.17</td>
<td>X32: beans</td>
<td>0.6</td>
<td>0.46</td>
</tr>
<tr>
<td>X8: check beans</td>
<td>0.5</td>
<td>0.27</td>
<td>X33: spinach</td>
<td>0.2</td>
<td>0.07</td>
</tr>
<tr>
<td>X9: broad beans</td>
<td>0.43</td>
<td>0.03</td>
<td>X34: mlokya</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>X10: beans</td>
<td>0.5</td>
<td>0.24</td>
<td>X35: lettuce</td>
<td>0.25</td>
<td>0.16</td>
</tr>
<tr>
<td>X11: peas</td>
<td>0.5</td>
<td>0.17</td>
<td>X36: okra</td>
<td>0.70</td>
<td>0.52</td>
</tr>
<tr>
<td>X12: sugar</td>
<td>0.25</td>
<td>0.13</td>
<td>X37: g. broad bean</td>
<td>0.50</td>
<td>0.22</td>
</tr>
<tr>
<td>X13: jam</td>
<td>1.05</td>
<td>0.72</td>
<td>X38: dawali</td>
<td>1.20</td>
<td>1.19</td>
</tr>
<tr>
<td>X14: olive oil</td>
<td>2.00</td>
<td>1.39</td>
<td>X39: carrot</td>
<td>0.20</td>
<td>0.22</td>
</tr>
<tr>
<td>X15: veg oil</td>
<td>0.6</td>
<td>0.00</td>
<td>X40: apple</td>
<td>0.50</td>
<td>0.42</td>
</tr>
<tr>
<td>X16: ghee</td>
<td>0.76</td>
<td>0.38</td>
<td>X41: citrus</td>
<td>0.20</td>
<td>0.13</td>
</tr>
<tr>
<td>X17: fresh milk</td>
<td>0.3</td>
<td>0.00</td>
<td>X42: banana</td>
<td>0.50</td>
<td>0.40</td>
</tr>
<tr>
<td>Commodity</td>
<td>Energy (kcal)</td>
<td>Protein (g)</td>
<td>Vitamin A (μg)</td>
<td>Vitamin C (mg)</td>
<td>Vitamin B1 (μg)</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------</td>
<td>-------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>X18: powder milk</td>
<td>2750</td>
<td>82</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X19: laban</td>
<td>3350</td>
<td>113</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X20: labaneh</td>
<td>3430</td>
<td>125</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X21: cheese</td>
<td>2250</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X22: tomatoes</td>
<td>800</td>
<td>150</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>X23: cucumber</td>
<td>700</td>
<td>237</td>
<td>40</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>X24: squash</td>
<td>700</td>
<td>226</td>
<td>60</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>X25: eggplant</td>
<td>700</td>
<td>226</td>
<td>60</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 5: Commodities and their nutrient contents per kg.


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استخدام البرمجة الخطية لتحديد الوجبة الغذائية المتوازنة بأقل كلفة ممكنة للفقراء في عمان الكبرى/ الأردن

عبد الفتاح صالح القاضي ومحمد رائف حمدان

ملخص

تعاني المجموعات الفقيرة في عمان الكبرى من سوء التغذية نظرًا لعيوب الميزانية الغذائية وضغط قدرتها الشرائية. وقد أظهر هذا البحث على مدى عقد، أن كل الكافيات الغذائية متوازنة وقياس كمية الحمضيات للكميات المجموعات Operations Research، لارتفاع سعرات الفراء على الكافيات الغذائية وفاعلية أهداف الدراسة فقد أدى تعرف على 158 حالة من المجتمع المستهدف بأسلوب العينة الشتوية وقد تم مجتمع العينة إلى عشرين مجموعة عمرية وجنسية واستخدمت البرمجة الخطية لتحديد كل الكافيات الغذائية متوازنة. بلغت الكافيات المقدرة للأطفال 180 فلسًا، بينما بلغت كفاية الكافيات الذكور والأذلون الذين زودتهم عن 11 عامًا حوالي 253 فلسًا للفرد في اليوم.

وكتفت الوفيات المقررة للذكور من جميع الكافيات العمرية أكثر من تلك الموجودة بها للأطفال. وقد كانت كافية التغذية في الفئة العمرية 19-50 سنة من كل الجنسين في الأعلى من بين جميع الفئات. كما أظهرت نتائج الدراسة وجود تفوق في المحتوى الغذائي لجميع أفراد العينة كذب حوالي 4% في البروتين، 10% في الدورة، 4% في الكربوهيدرات، 10% في الطاقة، وآن زيادة إسهام المواد الغذائية بنسبة 10% يؤدي إلى زيادة كفاءة الغذاء بنسبة 25%.

فقد أوصي الدراسة لحل مشكلة النقص الغذائي لهذه المجموعات بدعم من ميزانية الغذاء للعوامل والشراع بشكل مشاريع صغيرة تمثل الفئة للعمل كمحاولة لتحسين البيئة الاقتصادية والغذائية لدى الفقراء.

الكلمات المفتاحية: الفقر، سوء التغذية، المحتويات الغذائية، الوجبة الغذائية المتوازنة بأقل كلفة ممكنة، نموذج البرمجة الخطية، أسعار الغذاء.