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# A Multi-criteria Multi-stakeholder Industrial Projects Prioritization in Gaza Strip

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**Abstract** This research presents a decision support methodology for selection decisions in which Analytic Hierarchy Process (AHP) model is used to prioritize main industries in Gaza Strip not only from the view point of a single stakeholder and a single criteria, but also from that of multiple stakeholders and multiple criteria. Literature review, in addition to experts' interviews were used to identify the main selection criteria and sub-criteria. These main criteria are economic criteria, financial criteria, marketing, technical, political and social, and environmental criteria. In addition, the alternatives were identified via Palestinian Federation of Industries (PFI). These alternatives are food industries, garment industries, chemical industries, plastic industries, wood industries, metal industries, and construction industries. Results show that different stakeholders choose different alternatives. The aggregate ranking of the industries under consideration is as follows: food, garment, construction, wood, chemical, metal, and plastics.

**Keywords** MCDM · AHP · Industrial projects · Prioritization · Selection

**الخلاصة**

يقدم هذا البحث منهجية لدعم اتخاذ القرار لاختيار القرارات التي تستخدم أنموذج طريقة التحليل الهرمي (AHP) لتحديد أولويات الصناعات الرئيسية في قطاع غزة ، ليس فقط من وجهة نظر صاحب المصلحة الواحدة والمعيار الواحد ، ولكن أيضاً من العديد من أصحاب المصلحة والمعايير المتعددة . وقد استخدمت مراجع الأدبيات ، إضافة إلى مقابلات الخبراء لتحديد معايير الاختيار الرئيسية والمعايير الفرعية . وهذه المعايير الرئيسية هي : معايير اقتصادية ، ومعايير مالية ، وأخرى تسويقية ، وتقنية وسياسية واجتماعية وبيئية . إضافة إلى ذلك تم تحديد البدائل عن طريق الاتحاد العام للصناعات الفلسطينية (PFI) . وهذه البدائل هي صناعات الغذاء ، وصناعة الملابس الجاهزة ، والصناعات الكيميائية، والبلاستيكية ، والخشبية ، والمعدنية ، والإنشائية . وقد أظهرت النتائج أن مختلف أصحاب المصلحة يختارون بدائل مختلفة . والترتيب الإجمالي للصناعات قيد النظر ، هي : الغذاء والملابس الجاهزة ، والبناء ، والخشب ، والكيميائية ،والمعدنية ، والبلاستيكية.

## 1 Introduction

The industrial sector is one of the most important productive sectors due to its vital role in economic development along with its ability to contribute to the growth of economic, political, and social fields. It is noted that the industrial sector's contribution to the Palestinian Gross Domestic Product (GDP) increased from 8 %, during the Israeli occupation period from 1967 to 1994, to 17.4 % after the establishment of the Palestinian National Authority (PNA). After the start of the political unrest in 2000, the industrial contribution slipped to 13 %, however, it remained unchanged until 2007 [1].

In addition to the total dependency on Israeli industry and frequent boarder closures, the weakness of Palestinian industrial sector performance is attributed to the absence of suitable clear and effective economic policies [1]. Therefore, and in order to regain and continuously improve the industrial sector contribution to the Palestinian GDP, suitable industrial planning programs are needed. Part of these programs is the subject of the current study which is performed through defining the projects selection criteria and sub-criteria from academics, consultants, and governmental viewpoints, in addition to identifying and prioritizing the alternatives that represent the main industries in Gaza Strip.

The methods, being used in Gaza Strip, rank the industries from the best to the worst without benefitting from the

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consistency checking provided by the AHP method. Further, some of the current practices use only quantitative data and no regard is given to qualitative data though qualitative criteria may be the deciding factor in the ranking process. Industrial projects prioritization is essentially a Multiple Criteria Decision Making (MCDM) problem, which involves multiple assessment criteria. One of the (MCDM) approaches, the Analytic Hierarchy Process (AHP) is particularly suitable for modeling both quantitative and qualitative criteria [2]. The selection of AHP in this research can be attributed to the fact that it provides a realistic description of the problem by incorporating all aspects in the hierarchy. Moreover, AHP provides a useful mechanism for checking consistency of the evaluation measures and thus reducing bias in decision-making [3].

Therefore, it is the purpose of this paper to use AHP to rank the industries from the view points of three main stakeholders. In order to achieve the above objective, the hierarchy of each stakeholder is constructed based on the corresponding criteria and sub-criteria. Industries were then classified to represent the alternatives which were ranked for each stakeholder. Finally, a single aggregate rank of each industry is given. Thus, this work would provide the decision makers especially in the industrial sector with a framework that may be used as a guiding basis for convincing and attracting investors to invest in the most favorable industrial projects.

The paper is organized as follows. In Sect. 2, a brief overview of the literature is given. The paper methodology is described in Sect. 3. Section 3.1 presents the application, while, results and discussions are given in Sect. 5. Section 6 concludes the paper.

## 2 Literature Review

A literature review reveals that 16 years after the Israeli army redeployment and the establishment of the Palestinian National Authority (PNA) in 1993, no systematic studies, dealing with encouraging investments in the industrial sector are found. Most of the studies are merely economic feasibility studies using a single objective and a single stakeholder (investor). No serious attempts have been made in order to combine quantitative and qualitative data. Therefore, it is clear that there is a lack of realistic and comprehensive studies that simultaneously use multi-criteria and multi-stakeholder. In summary, most of the previous studies related to industry evaluation and prioritization are merely data collection type or at best descriptive in nature. According to [4], the traditional methods normally justify the selection in case of low-capital budgeting. Such an approach may work well for decisions that deal with clearly defined costs and benefits, however, such an assumption does not hold in the case of ranking long-term projects similar to the study under consideration. Yang and Chen argue that the presence of intangibles such as flexibility and quality cannot be easily converted to monetary costs and benefits [5]. As for the use of Multi-criteria Decision Making (MCDM) in industrial projects ranking, Alidi [6] used analytic hierarchy process to evaluate the initial viability of industrial projects in the Arabian Gulf states. In his study, Alidi [6] used hypothetical but representative data to apply the methodology to select among three chemical industries, namely, hydrogen peroxide, magnesium and phenol from the viewpoints of board of directors, company management, and public using only 12 criteria. No results were separately given for each of the three viewpoints. It was not clear how these results were combined to give a single performance measure for each industry. No sensitivity analysis was given in the previous study. [7] developed a model to identify areas of industrial investment using multi-criteria decision making. Virginia and Tabucannon [8] used goal programming to identify priority areas in pulp industries. Nothing in the study was mentioned regarding how the weights of the criteria were obtained to get the coefficients in the objective function which attempts to minimize the deviations from the goals set by the decision makers. Clearly, all these methods fail to account for the presence of more than one stakeholder in addition to the fact that they all used a small number of criteria. The proposed approach attempts to reconcile the conflicts among the different criteria and simultaneously the different stakeholders. Moreover, this study partially aims at helping to fuse the use of the multi-criteria decision making techniques in this particular geographical area in order to promote the use of such techniques in developing countries where their use is not common [3].

Since it was first proposed, AHP has been extensively applied in research. These applications involve selection problems [9–11], evaluation [12–15], allocation and planning problems [16–18], and forecasting problems [19,20]. These applications span a variety of areas ranging from production, manufacturing, healthcare and other services.

## 3 Methodology

In this research, AHP will be used as the main tool to rank the industries under consideration. AHP addresses determining the relative importance of a set of activities in a multi-criteria decision problem. AHP makes it possible to incorporate judgments on intangible qualitative criteria along with tangible quantitative criteria. AHP utilizes pair wise comparisons of alternatives as well as pair wise comparisons of the criteria, and sub-criteria. The use of such pair-wise comparisons allows the decision-maker to focus on the comparison of just two objects, which makes the observation as free as possible from extraneous influences. All the above characteristics do match the nature of the study under consideration and thus the use of AHP.

**Table 1** Saaty's scale of importance intensities [21]

| Intensity of importance | Definition |
|---|---|
| 1 | Equal importance |
| 3 | Weak importance of one over another |
| 5 | Essential or strong importance |
| 7 | Demonstrated importance |
| 9 | Absolute importance |
| 2, 4, 6, 8 | Intermediate values between the two adjacent judgments |

**Table 2** The reference values of RI

| $n$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0.0 | 0.0 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

### 3.1 Proposed Model

AHP is a method developed by Saaty [21] to support multi-criteria decision making. It involves decomposing a complex problem into a hierarchy, assessing the relative importance of decision criteria, comparing decision alternatives with respect to each criterion, and determining the overall priority for each decision alternative. The first step in AHP is to construct the hierarchy in such a way that the overall decision goal is at the top level.

Once the hierarchy is constructed, AHP method provides a structured framework for setting priorities on each level of the hierarchy using pair-wise comparisons that are quantified using 1–9 scale as shown in Table 1.

Pair-wise comparisons between the $m$ decision criteria can be conducted by asking the decision maker or expert questions such as which criterion is more important with regards to the decision goal and by what scale (1–9). The answers to these questions form an $(m * m)$ comparison matrix which is defined as follows:

$$A = (a_{ij})_{m\times m} = \begin{matrix} C_1 \\ C_2 \\ C_3 \end{matrix} \begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mm} \end{bmatrix} \tag{1}$$

where $a_{ij}$ represents a quantified judgment on $w_i/w_j$ with $a_{ii} = 1$ and $a_{ij} = 1/a_{ji}$ for $i, j = 1, \ldots, m$. If the pair wise comparison matrix $A(a_{ij}) = m \times m$ satisfies $a_{ij} = a_{ik} \times a_{kj}$ for any $i, j, k = 1, \ldots, m$, then (A) is said to be perfectly consistent; otherwise it is inconsistent. Form the pair-wise comparison matrix A, the weight vector W, (eigenvector), is determined by solving the following equation:

$$\mathrm{AW} = \lambda_{\max} \times \mathrm{W} \tag{2}$$

where $\lambda_{\max}$ is the maximum eigenvalue of A. Since decision makers may be unable to provide perfectly consistent pair-wise comparisons, it is required that the pair-wise comparison matrix (A) have an acceptable consistency which can be checked using the following consistency ratio (CR):

$$\mathrm{CR} = \frac{(\lambda_{\max} - n)/(n-1)}{\mathrm{RI}} \tag{3}$$

where RI is a random inconsistency index, the value of which varies with the order of pair-wise comparison matrix. Table 2 shows the RI values for the pair-wise comparison matrices with. If CR $\leq 0.1$, the pair-wise comparison matrix is said to have an acceptable consistency; otherwise, it needs to be revised.

Decision alternatives can be compared pair wisely with respect to each sub-criterion in the same way. After the weights of criteria and the weights of alternatives with respect to each criterion are obtained, the overall weight of each alternative with respect to the decision goal can be obtained using Eq. (4).

$$W_{Ai} = \sum_{j=1}^{m} W_{ij} W_j \qquad i = 1, \ldots, n, \tag{4}$$

where $W_j$ $(j = 1, \ldots, m)$ are the weights of criteria, $W_{ij}$ $(i = 1, \ldots, n)$ is the weight of alternative "$i$" with respect to criterion "$j$", and $W_{Ai}$ $(1, \ldots, n)$ is the overall weight of alternative "$i$". Table 3 shows how the overall weights can be computed in a given format easily and conveniently. Based upon the overall weights of alternatives, decision can be made and the alternatives are ranked. The best alternative will be

**Table 3** Computation of overall weights

| Alternatives | Criteria | | | Overall weight |
|---|---|---|---|---|
| | $C_1$ | $C_j$ | $C_m$ | |
| | $W_1$ | $W_j$ | $W_m$ | |
| $A_1$ | $W_{11} \ldots$ | $W_{1j} \ldots$ | $W_{1m} \ldots$ | $W_{A1} = \sum_{j=1}^{m} w_{ij} w_j$ |
| $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ |
| $A_2$ | $W_{1i} \ldots$ | $W_{ij} \ldots$ | $W_{im} \ldots$ | $W_{Ai} = \sum_{j=1}^{m} w_{ij} w_j$ |
| $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ | $\vdots$ |
| $A_n$ | $W_{n1} \ldots$ | $W_{nj} \ldots$ | $W_{nm} \ldots$ | $W_{An} = \sum_{j-1}^{m} w_{ij} w_j$ |

the one with the highest overall weight with respect to the goal.

The hierarchy for each stakeholder included the goal of selecting the industries as the first level, the criteria and sub-criteria as second and third level, and the alternatives as the fourth level.

To conduct pair-wise comparisons for each stakeholder's hierarchical structure, three different questionnaires were designed, based on the interviews with the three stakeholders, and distributed to three experts from each group of stakeholder. Pair-wise comparison results obtained from questionnaires were entered into Expert Choice (E.C 11.5) software [22], and then consistency ratio (CR) and the relative weights vector of alternatives, sub-criteria, and criteria with respect to main goal were calculated.

## 4 Application

The data needed for in this study includes identifying and ranking of criteria and sub-criteria, and the industries existing in Gaza Strip. The following sections describe the methods used in data collection.

### 4.1 Criteria and Sub-criteria Identification

To identify the criteria and sub-criteria of industrial projects selection, literature review was conducted. This review showed that different studies used different criteria and sub-criteria. These criteria and sub-criteria were then discussed separately with academics, consultants, and governmental stakeholders. Each stakeholder group consisted of four experts who were asked for their input and feedback regarding the criteria and sub-criteria. After thorough and intensive discussions with the experts, a final list of criteria and sub-criteria, as they pertain to the local environment, was obtained. A hierarchy was built for each stakeholder, but for brevity, only consultants' hierarchy is given in Fig. 1. As it can be seen from Fig. 1, consultants focused more on financial criteria through listing more specialized sub-criteria such liquidity, Internal Rate of Return (IRR), and Net Present Value (NPV). As for the marketing criteria, consultants considered the availability of local and global markets as sufficient sub-criteria, whereas government added market growth and academics added competitive advantages and marketing elements. Criteria, sub-criteria, and their weights for the three stakeholders are shown in Tables 4, 5, and 6.

### 4.2 Alternatives Identification

Experts from the Palestinian Federation of Industries (PFI) were interviewed to come up with a list of alternatives representing the main categories of industries in Gaza Strip. The agreed upon list includes seven industries as follows: plastic, food, garment, chemical and medical, wood, metal and engineering, and construction industries.

## 5 Results and Discussion

In the following, the output of Expert Choice from government, academics, and consultants' viewpoints is given. Further, different types of sensitivity analysis of stakeholders' viewpoints are performed.

### 5.1 Criteria Results

The criteria mentioned earlier were evaluated by the corresponding three experts separately in each group of stakeholders, then the average relative weight vectors of criteria with respect to the goal were calculated and the results are shown in Fig. 2.

It is clear from Fig. 2, that the three stakeholders highly rated financial and economic criteria. On the other hand, the Eco-friendly nature of the Palestinian industries explains the fact that the environmental criteria were ranked relatively low by the three stakeholders. In other words, the three stakeholders share the same belief that the types of industries present in Gaza Strip do not constitute a source of harm to the environment. Differently said, most of the industries would not cause a significant environmental damage or degradation. Moreover, results showed that although the technical criteria were modestly rated from government and academic viewpoints, consultants considered it as significant criteria.

### 5.2 Sub-criteria Results

Results of relative weights for the sub-criteria for each stakeholder group are shown in Tables 4, 5, and 6. In these tables, local weight refers to the contribution of each sub-criterion to the main criteria, while global weight refers to the contribution of each sub-criterion to the goal.

Results in Table 4 show that government focuses on the internal market share. This result is expected given the fact that international and even regional trade between Gaza Strip and the world is almost non-existing due to the frequent borders closures from the Israeli side. From government viewpoint though, these closures have a positive side in that they eliminate global and regional competitions against local products.

It is clear from Table 5 that academics highly rank employment creation which can be attributed to the fact that most academics are usually in touch with graduates searching for employment and graduating seniors who are still pondering about the employment opportunities available to them upon graduation. Moreover, public support of the project was considered an important sub-criterion from governmental

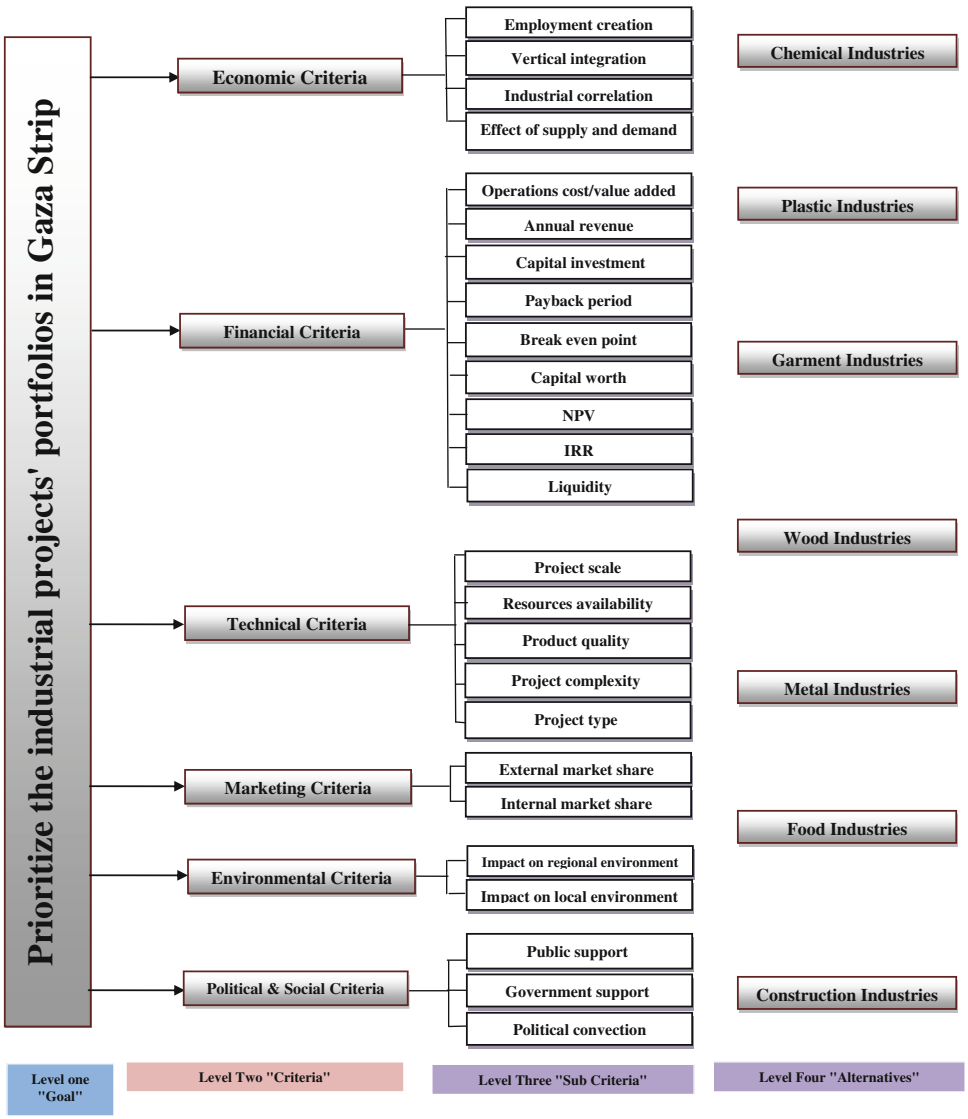


**Fig. 1** AHP hierarchy for industrial projects selection from consultant's viewpoint

viewpoint. Such a result is explainable given the fact that academics viewpoint states that projects' publicity and subsequently their success mainly depend on the project's conformance to the public habits and beliefs.

Results in Table 6 give an evidence of the consultants' emphasis on product quality, projects' public support, and the effect of supply and demand curves. These results are expected because these sub-criteria heavily affect sales volume which is one of the determinants of the project feasibility. Consultants' focus on product quality is due to the fact that they are in direct contact with different products whether local or imported. Normally, consultants are approached by different industrialists and importers to help them put forward plans to increase sales. That is why they are aware of the criticality of product quality. Moreover, the consultants' high ranking of the internal market can be explained based on the fact that consultants consider the Palestinian industries as embryonic projects. Therefore, their corresponding products are powerless to compete against global or regional products specially when taking into account the raw material prevention and the frequent borders closures which force the Palestinian businessmen to lose their contracts, and even reputation, in foreign markets. All these obstacles are transformed to overhead costs that lead their effort to the infeasible area.

For more insights, Table 7 shows how each of the above stakeholders ranked each alternative with respect to the main criteria.

### 5.3 Alternatives Ranking

The seven alternatives were evaluated against the decision hierarchy using pair-wise comparisons. The results of this evaluation are shown in Table 8.

It is seen from the aggregate alternatives ranking, shown in Table 8, that food and garment industries are the most

**Table 4** Local and global weights of each sub-criterion from government's viewpoint

| Main criteria | Sub-criteria | Local weight | Global weight |
|---|---|---|---|
| Economic | Employment creation | 0.333 | 0.081 |
| | Vertical integration percent | 0.333 | 0.081 |
| | Industrial correlation | 0.333 | 0.081 |
| Financial | Annual revenues | 0.169 | 0.046 |
| | Capital investment | 0.319 | 0.087 |
| | % of operat. Surp.\value added | 0.120 | 0.033 |
| | Payback period | 0.141 | 0.038 |
| | Breakeven point | 0.159 | 0.043 |
| | Percent of value added | 0.051 | 0.014 |
| | Percent of wages to value added | 0.041 | 0.011 |
| Technical | Project scale | 0.094 | 0.009 |
| | Project complexity | 0.177 | 0.018 |
| | Project type (requires special safety procedures and special location) | 0.156 | 0.016 |
| | Easiness of having license | 0.244 | 0.024 |
| | Resources availability | 0.161 | 0.016 |
| | Product quality standards | 0.167 | 0.017 |
| Marketing | Internal market share | 0.667 | 0.145 |
| | External market share | 0.333 | 0.072 |
| Environmental | Impact on local environment | 0.198 | 0.016 |
| | Legal issues | 0.212 | 0.017 |
| | Environmental strategy | 0.211 | 0.017 |
| | Cross boarder issues | 0.181 | 0.015 |
| | Relevant convection | 0.198 | 0.016 |
| Political and social | Political convection | 0.341 | 0.030 |
| | Governments' support | 0.178 | 0.016 |
| | Public support | 0.205 | 0.018 |
| | Donors support | 0.276 | 0.025 |

preferred in Gaza Strip, while plastic and metal industries are ranked the lowest among the alternatives. It is further noted that garment industry was ranked first by government, and ranked second by academics and consultants. More insights into the results are given in the next sections.

## 5.4 Sensitivity Analysis

In order to gain an in-depth insight into the problem, sensitivity analysis was used to investigate the effect of slight changes in the weights of priorities on the alternatives selection. In this study, two types of sensitivity analysis were performed. These include: Performance, and Gradient analysis.

### *5.4.1 Performance Sensitivity Analysis*

This type of analysis shows how the alternatives are prioritized relative to other alternatives with respect to each criterion as well as the overall performance. Figure 3 shows the performance sensitivity analysis graph, where $X$-axis represents the criterion. The height of the bar represents the weight of each criterion. The left $Y$-axis represents each criterion weight, while the right $Y$-axis represents the scores of alternatives with respect to each criterion, and the overall score of each alternative.

The main advantage of this type of sensitivity analysis is that it represents preference between two alternatives with respect to each criterion. This graph shows the criteria at which the competitor alternative may perform better. Therefore, industries may focus on the criteria in which their scores are weak compared to other competitors.

Figure 3 shows the ranking of the alternatives for each of the main criteria from the academics' point of view. For brevity, figures representing consultants and government will not be given here. Food industries, for example, ranked first with respect to three criteria and ranked second with respect to financial and economic criterion, but according to environmental criterion, it did not perform well. Clearly, academics are aware of the fact that for food industries to thrive, most of the vegetables, and trees, etc. have to be grown locally

**Table 5** Local and global weights of each sub-criterion from academic viewpoint

| Main criteria | Sub-criteria | Local weight | Global weight |
|---|---|---|---|
| Economic | Employment creation | 0.419 | 0.119 |
| | Vertical integration percentage | 0.231 | 0.066 |
| | Industrial correlation | 0.183 | 0.052 |
| | Strategic product | 0.166 | 0.047 |
| Financial | Annual profit | 0.375 | 0.073 |
| | Annual revenue | 0.188 | 0.037 |
| | Capital investment | 0.188 | 0.037 |
| | Payback period | 0.188 | 0.037 |
| | Break-even point | 0.063 | 0.012 |
| Technical | Product quality | 0.278 | 0.041 |
| | Resources availabilities | 0.256 | 0.038 |
| | Project scale | 0.161 | 0.024 |
| | Easiness of having licenses | 0.133 | 0.020 |
| | Project location | 0.093 | 0.014 |
| | Project complexity | 0.079 | 0.012 |
| Marketing | External market share | 0.424 | 0.062 |
| | Internal market share | 0.141 | 0.021 |
| | Demand growth | 0.190 | 0.028 |
| | Competitive advantage | 0.123 | 0.018 |
| | Marketing elements (4P's) | 0.123 | 0.018 |
| Environmental | Impact on local environment | 0149 | 0.010 |
| | Legal issues | 0.225 | 0.015 |
| | Relevant convection | 0.259 | 0.017 |
| | Cross boarder issues | 0.171 | 0.012 |
| | Impact on global environment | 0.196 | 0.013 |
| Political and social | Public support | 0.594 | 0.094 |
| | Government support | 0.249 | 0.039 |
| | Political convection | 0.157 | 0.025 |

and thus creating more pressure on the already strained and scarce water resources.

### *5.4.2 Gradient Sensitivity Analysis*

The gradient sensitivity analysis assigns each criterion a separate gradient graph. The vertical axis represents the current priority of the selected criterion. The dotted lines represent the alternatives. The current priority of an alternative is where the alternatives lines intersect the vertical criterion line. Examples of gradient sensitivity analysis with respect to some criteria are given in the next paragraphs.

Figure 4 shows the gradient analysis for economic criterion from governmental point of view, the weight of this criterion may change positively or negatively in the future. When the weight of the economic criteria is adjusted downward (just past 0.2), the first choice will change more than one time, which means that the decision will be sensitive to the decrease in the weight of this criteria. On the other hand, increasing the weight above its current value would still render food industries as the top choice. This result shows the vitality of economic criteria for the success of food industries.

As for environmental criterion from governmental view point, the decision will change if the weight approaches to 0.1. In this case, metal industries will be ranked first as shown in Fig. 5. If on the other hand, the weight of the environmental criteria reaches 0.8, which may not be possible, construction industries will have the highest score. This conclusion is expected given the fact that a low weight was voted for the environmental criteria by all stakeholders as shown in Fig. 2.

A natural extension of this work may focus on ranking industries within each alternative of the current study. In other words, this study would serve as a frame work or represent a road map for future studies. Moreover, future studies may incorporate the fact that Gaza Strip is now under seige and thus come up with different rankings of the industries by taking into account the realities of this seige where exportation

**Table 6** Local and global weight of the sub-criteria from consultants' viewpoint

| Main criteria | Sub-criteria | Local weight | Global weight |
|---|---|---|---|
| Economic | Employment creation | 0.211 | 0.035 |
| | Vertical integration percentage | 0.105 | 0.017 |
| | Industrial correlation | 0.039 | 0.006 |
| | Effect of supply and demand curves (Demand for the product) | 0.645 | 0.107 |
| Financial | Operation cost to value added cost | 0.075 | 0.013 |
| | Annual returns | 0.075 | 0.013 |
| | Capital investment | 0.083 | 0.014 |
| | Payback period | 0.140 | 0.024 |
| | Break-Even point | 0.168 | 0.029 |
| | Capital worth | 0.177 | 0.030 |
| | Net Present Value (NPV) | 0.088 | 0.015 |
| | Internal Rate of Return (IRR) | 0.106 | 0.018 |
| | Liquidity | 0.149 | 0.025 |
| Technical | Project scale | 0.078 | 0.021 |
| | Resources availability | 0.239 | 0.064 |
| | Product quality | 0.539 | 0.145 |
| | Project complexity | 0.071 | 0.019 |
| | Project type | 0.074 | 0.020 |
| Marketing | External market share | 0.250 | 0.034 |
| | Internal market share | 0.750 | 0.103 |
| Environmental | Impact on global environment | 0.667 | 0.041 |
| | Impact on local environment | 0.333 | 0.021 |
| Political and social | Public support | 0.900 | 0.176 |
| | Political convection | 0.100 | 0.02 |

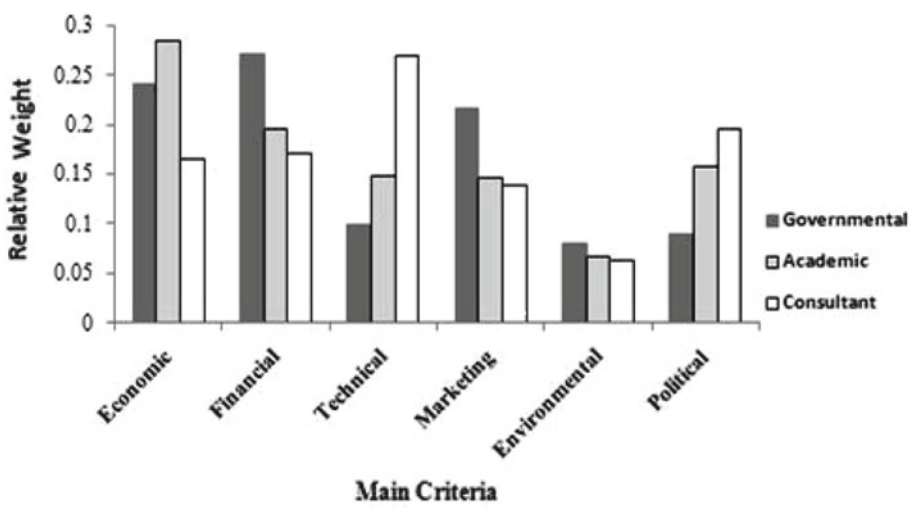


**Fig. 2** Average weights of the criteria with respect to the goal for different stakeholders

and importation and most raw materials including seeds, fertilizers, pesticides, steel, plastics, fuel, etc. are not allowed. Further, a possible venue for future research is to use the obtained weights for the criteria and sub-criteria as inputs to a goal programming model which would attempt to minimize the undesired deviations from given targets that could represent resource constraints. Future research may also attempt to provide a model that integrates industry and agriculture to take into account the interdependance between them where Analytic Network Process (ANP) can be used where dependence is taken into account. Methods other than AHP can be used for comparison purposes. Finally, the four main control criteria (benefits, costs, opportunity, and risk) as suggested later by Saaty [23] can be used for comparison purposes.

**Table 7** Alternatives weights with respect to criteria

| Alternatives (industries) | Alternatives' weights with respect to main criteria | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Government stakeholder | | | | | | Consultant stakeholder | | | | | | Academic stakeholder | | | | | |
| | Eco. | Fin. | Tech. | Mar. | Env. | Pol. | Eco. | Fin. | Tech. | Mar. | Env. | Pol. | Eco. | Fin. | Tech. | Mar. | Env. | Pol. |
| Garment | 0.23 | 0.13 | 0.13 | 0.06 | 0.17 | 0.15 | 0.22 | 0.14 | 0.06 | 0.14 | 0.22 | 0.20 | 0.16 | 0.12 | 0.14 | 0.18 | 0.16 | 0.17 |
| Metal | 0.13 | 0.18 | 0.11 | 0.20 | 0.15 | 0.07 | 0.07 | 0.13 | 0.11 | 0.11 | 0.11 | 0.10 | 0.07 | 0.25 | 0.13 | 0.15 | 013 | 0.08 |
| Wood | 0.19 | 0.13 | 0.14 | 0.13 | 0.16 | 0.12 | 0.15 | 0.07 | 0.07 | 0.13 | 0.16 | 0.12 | 0.15 | 0.13 | 0.14 | 0.15 | 0.19 | 0.15 |
| Food | 0.09 | 0.19 | 0.14 | 0.18 | 0.13 | 0.16 | 0.20 | 0.21 | 0.26 | 0.25 | 0.15 | 021 | 0.22 | 0.22 | 0.16 | 0.19 | 0.12 | 0.22 |
| Chem. | 0.07 | 0.17 | 0.17 | 0.21 | 0.07 | 0.25 | 0.12 | 0.13 | 0.25 | 0.07 | 0.15 | 0.16 | 0.05 | 0.08 | 0.16 | 0.09 | 0.11 | 0.07 |
| Construction | 0.16 | 0.06 | 0.15 | 0.16 | 0.19 | 0.09 | 0.14 | 0.22 | 0.15 | 0.17 | 0.11 | 0.10 | 0.22 | 0.13 | 0.16 | 0.11 | 0.15 | 0.08 |
| Plastic | 0.13 | 0.14 | 0.16 | 0.06 | 0.13 | 0.16 | 0.10 | 0.10 | 0.09 | 0.11 | 0.12 | 0.13 | 0.07 | 0.18 | 0.17 | 0.11 | 0.12 | 0.08 |

**Table 8** Scores and rankings of the alternatives with respect to the goal

| Alternatives | Governmental viewpoint | | Academics viewpoint | | Consultants viewpoint | | Average relative score | Aggregate rank |
|---|---|---|---|---|---|---|---|---|
| | Score | Rank | Score | Rank | Score | Rank | | |
| Chemical industries | 0.146 | 5 | 0.096 | 7 | 0.151 | 3 | 0.131 | 5 |
| Plastic industries | 0.120 | 7 | 0.107 | 6 | 0.101 | 7 | 0.109 | 7 |
| Food industries | 0.149 | 4 | 0.213 | 1 | 0.227 | 1 | 0.196 | 1 |
| Garment industries | 0.152 | 1 | 0.155 | 2 | 0.155 | 2 | 0.154 | 2 |
| Metal industries | 0.151 | 2 | 0.130 | 5 | 0.104 | 6 | 0.128 | 6 |
| Wood industries | 0.150 | 3 | 0.149 | 4 | 0.115 | 5 | 0.138 | 4 |
| Construction industries | 0.133 | 6 | 0.152 | 3 | 0.146 | 4 | 0.143 | 3 |

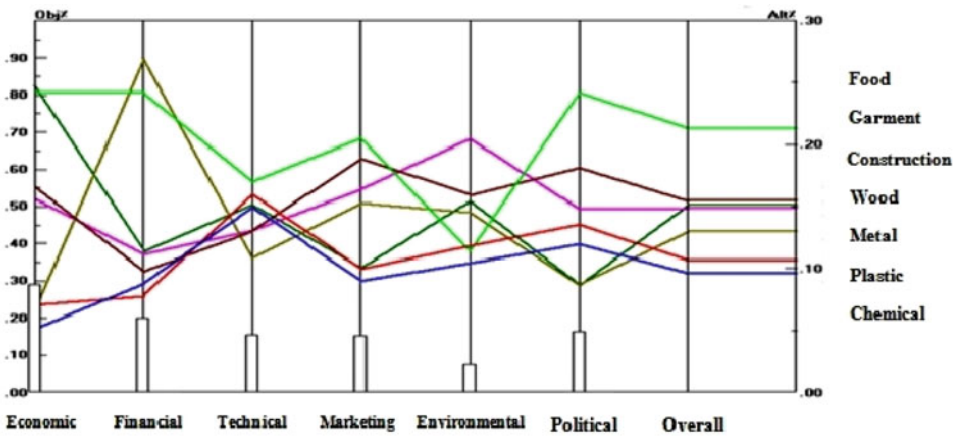


**Fig. 3** Performance sensitivity analysis from academics viewpoint

## 6 Conclusions

It is clear from the study that AHP is an effective tool for ranking industrial projects and it resolves the conflict between the different stakeholders. As expected, different stakeholders would differently prioritize the alternative industries. The identified criteria were financial, technical, marketing, environmental, and political.

The sub-criteria of employment creation and public support were highly ranked from academic viewpoint, while product quality, public support. The effect of supply and demand curves were significantly weighted from consultant viewpoint. Food and garment industries were found to be the most preferred while plastic and metal industries are least preferred based on the aggregate scores. The final results are undoubtedly in close agreement with the general perception of the ranking and thus the results confirm the suitability of using AHP.

It is clear that the rankings would help allocation of resources to different industries. In other words, more

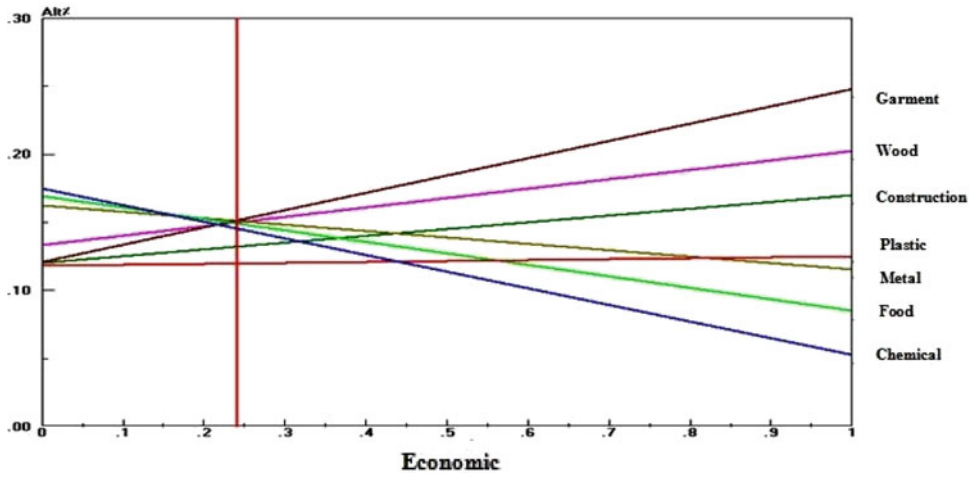


**Fig. 4** Gradient sensitivity analysis for economic criterion from governmental viewpoint

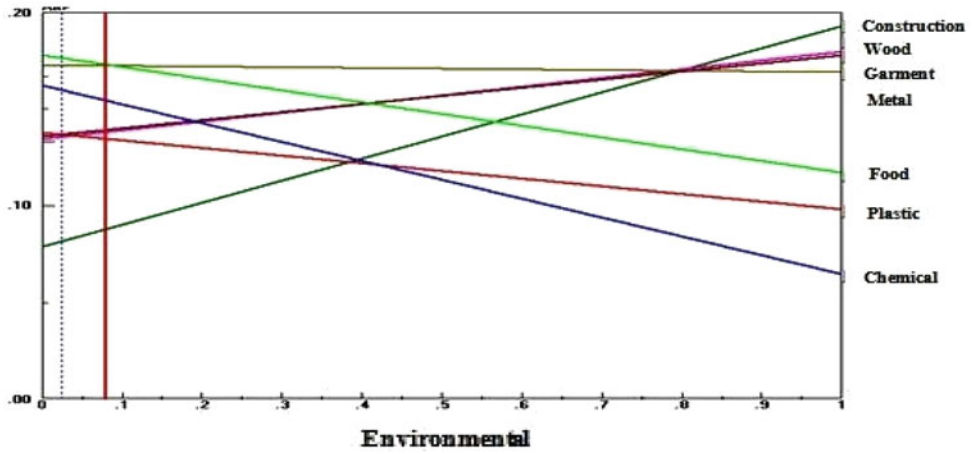


**Fig. 5** Gradient sensitivity analysis for environmental criterion from governmental viewpoint

resources should be allocated to food and garment industries due to the fact that these industries rank high from the overall view point of the three stake holders. Further, the findings may be used to promote investments in those high ranking sectors. Finally, if government sees that a given sector should be given a priority different from the one obtained in this study, then, government would need to identify which criteria/ sub-criteria should be given priority to improve so that the given sector can be pushed up in the ranking.

## References


1. Palestinian Central Bureau of Statistics
2. Ho, W.: Integrated analytic hierarchy process and its applications—a literature review. Eur. J. Oper. Res. **186**(5), 211–228 (2008)
3. Vaidya, O.; Kumar, S.: Analytic hierarchy process: an overview of applications. Eur. J. Oper. Res. **169**(1), 1–29 (2006)
4. Parsaei, H.; Wilhelm, M.: A justification methodology for automated manufacturing technologies. Comput. Ind. Eng. **16**(3), 363–373 (1989)
5. Yang, C.; Chen, B.: Supplier selection using combined analytical hierarchy process and grey relational analysis. J. Manuf. Technol. Manage. **17**(7), 926–941 (2006)
6. Alidi, A.S.: Use of the analytic hierarchy process to measure the initial viability of industrial projects. Int. J. Project Manage. **14**(4), 205–208 (1996)
7. Virginia, D.J.; Tabucannon, M.T.: Multi-objective models for selection of priority areas and industrial projects for investment promotion. Eng. Costs Prod. Econ. **10**, 173–184 (1986)
8. Tabucanon, M.T.: A model for identifying areas for industrial investment priorities for the board of investments. In: Proceedings of International Conference on Systems Modeling in Developing Countries, May 8–11, AIT-Bangkok (1978)
9. Lai, V.; Wong, B.K.; Cheung, W.: Group decision making in a multiple criteria environment: a case using the AHP in the software selection. Eur. J. Oper. Res. **1**(1), 134–144 (2002)
10. Shang, J.; et al.: A unified framework for the selection of a flexible manufacturing system. Eur. J. Oper. Res. **2**(85), 297–315 (1995)
11. Archer, N.P.; Ghasemzadeh, F.: An integrated framework for project portfolio selection. Int. J. Project Manage. **17**(4), 207–216 (2002)
12. Wang, Y.; Liu, J.; Elhag, Taha M.: An integrated AHP–DEA methodology for bridge risk assessment. Comput. Ind. Eng. **54**(3), 513–525 (2007)
13. Weiwu, W.; Jun, K.: Highway transportation comprehensive evaluation. Comput. Ind. Eng. **27**(2), 257–259 (1994)
14. Chin, K.S.; Chiu, S.; Tummala, V.M.R.: An evaluation of success factors using AHP to implement ISO 14001 based EMS. Int. J. Qual. Reliab. Manage. **16**(4), 341–361 (1998)

15. Agha, S.R.: Evaluating and benchmarking non-governmental training programs: an analytic hierarchy approach. Jordan J. Mech. Ind. Eng. **2**(2), 77–84 (2008)
16. Andijani, A.: A multi-criterion approach to kanban allocations. Omega **4**(26), 483–493 (1998)
17. Kwak, N.K.; Changwon, L.: A multi-criteria decision making approach to university resource allocations and information infrastructure. Eur. J. Oper. Res. **2**(110), 234–242 (1998)
18. Ramanathan, R.; Ganesh, L.: Using AHP for resource allocation problems. Eur. J. Oper. Res. **80**(4), 410–417 (1995)
19. Ulengin, F.; Ulengin, B.: Forecasting foreign exchange rates: a comparative evaluation of AHP. Omega **22**(5), 505–519 (1994)
20. Korpela, J.; Tuominen, M.: Inventory forecasting with a multiple criteria decision tool. Int. J. Prod. Econ. **45**(3), 159–168 (1997)
21. Saaty, T.L.: The Analytic Hierarchy Process, 3rd edn. McGraw-Hill, New York (1980)
22. Expert Choice Inc.; Expert Choice, Expert Choice Software and Manual. 4922 Ellsworth Ave., Pittsburgh (2004)
23. Saaty, T.L.: Decision making with the analytic hierarchy process. Int. J. Serv. Sci. **1**(1), 83–98 (2008)