A Multi Criteria Crop Planning Model Based on the "Resistive Economy" Characterizing the Situation in Gaza Strip.

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Since 2006, Gaza Strip has been under siege that resulted in exceptional conditions where both imports and exports are not allowed. The way to deal with this situation is to focus on locally available resources to meet the needs of the population while making sure that scarce resources do not deteriorate especially in the agricultural sector. Therefore; the Palestinian government found itself in a position to plant agricultural crops in governmental lands (known as settlements before Israelis withdrew from Gaza), to sustainably meet the needs of the population. This paper uses Analytic Hierarchy Process (AHP) as a multi criteria decision making tool to draft a cropping plan for Gaza Strip given the constraints imposed by the occupation under the present conditions. Thus, the term" resistive economy" was coined. Criteria and sub criteria governing the concept of resistive economy are first identified, then, crops are ranked based on how closely they achieve the different goals set by the government and ministry of agriculture. The findings of the study ranked which crops to plant in the governmental lands. These findings could also be used as a decision aid to decision makers in the agricultural sector.

Keywords: Multi criteria, Resistive economy, Crop planning, Agriculture, AHP, MCDM

1. Introduction

The siege imposed on Gaza Strip since 2005 basically prevents most types of imports and exports. Unable to find agricultural inputs, farmers tend to grow certain crops that do not depend on imported inputs. Further, the inability to export greatly reduces the possibility of cultivating crops for exporting like strawberries and flowers. Therefore, achieving a state of self sufficiency and food security without the dependency on imports and exports became important and the term "resistive economy" was coined. Ministry of Agriculture (MOA) defines resistive economy as: the ability to adapt different agricultural policies to support the steadfastness over land through achieving a state of food security and self sufficiency of the products that can be produced locally, reducing surplus of local crops, and cultivating the available agricultural lands with crops that are normally imported.

According to MOA (2009), the agricultural history in Gaza Strip can be divided into four stages reflecting major political events that prevailed in the region. Each event has a very clear impact on agricultural policies. These four stages are:

1948-1967 (1948 war- 1967 when Gaza Strip was occupied): In this period, citrus was the first strategic crop, where the total area cultivated was about 80 thousand dunums. Production was for local market and export. The problem was that citrus consume large amounts of water which led to severe shortage of the aquifer. Furthermore, it consumes large amount of nutrients from soil.

1967-1994 (Occupation-Establishment of Palestinian National Authority): In this period, the Israeli citrus competed against Palestinian citrus, which raise quality standards needed for Palestinian export so, farmers cultivated larger areas of vegetables instead of

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citrus. In the late 1970s, vegetables became the first strategic crop. It is known that vegetables consume more water than citrus; therefore, the problem of water shortage was further aggravated.

1994-2006 (Establishment of Palestinian national Authority-Siege): In this period, the agriculture policies were the same but there were occupation restrictions on all crossings and ports, in addition to the control of Palestinian agricultural economy through Paris Economic Convention which has adverse effects on the Palestinian economy, especially through imposing restrictions on exports and imports. This period is characterized by greater consumption of high quality water through focusing on the cultivation of export crops (strawberry, carnation flowers, pimento, etc. ..) which increase the water shortage problem. In addition, the agriculture sector depended on occupation in production requirements. Another problem that characterized this period is the sharp deterioration of resources, whether in water or soil due to excessive use of chemical fertilizers, pesticides, disinfectants.

2006- until now*:* In this period, the MOA re-read the agricultural policies and the status of agriculture for the period 1948 to 2006. The agricultural resistive economy concept was coined in this period, where the attention began to turn to strategic crops that can deal with the existing problems including lack of production inputs, unemployment and water scarcity. Therefore, the proper strategy would aim at decreasing the reliance on the imported production requirements as much as possible, increasing the dependence on local resources, developing new resources, as well as improving farmer's income and living standards and achieving food security.

Many of the problems associated with agriculture under these conditions can be controlled via successful crop planning which is a multi-objective problem where a manager faces a number of different objectives. Therefore, Multi Criteria Decision Making (MCDM) can be used effectively as an optimization technique for obtaining mathematical models that can deal with the crop planning problem. Analytic Hierarchy Process (AHP) is one tool of MCDM.

In this paper, AHP is used to rank the alternative crops with respect to several criteria. This is achieved through 1) Identifying criteria, sub-criteria, and alternatives. 2) Computing the weights of criteria, sub-criteria. 3) Obtaining the final weights of each alternative with respect to sub-criteria. 4) Ranking alternatives. 5) Performing sensitivity analysis.

The paper is organized as follows: Section two covers basic previous studies related to crop planning. Analytic hierarchy process methodology is given in section 3. The application is given in section 4 followed by the results and analysis in section 5. Section 6 concludes the paper.

2. Literature review

Crop planning problem can be formulated either as single or multi objective model. It used to be formulated as a single objective linear programming model. The objective is either the maximization of return from the cultivated land or the minimization of cost cultivation. Given the fact that a single objective does not realistically represent the cropping problem, several studies used multi objective models. The following paragraphs review these multi-objective studies.

Sarker and Quaddus (2002) formulated the crop planning problem as a single objective which is to maximize the total contribution that can be obtained from cropping. Later this objective was reformulated as three goals: (i) maximize the return from cultivated land, (ii) minimize the dependency on import of basic food like the cereal and (iii) minimize the investment required for cultivation.

Linear programming and fuzzy optimization models were developed by Sahoo et al. (2006) for planning and management of available land-water-crop system of Mahanadi-Kathajodi delta in eastern India. The models were used to optimize the economic return, production and labor utilization, and to allocate the related cropping patterns and intensities with specified land, water, fertilizers and labor availability, and water use pattern constraints.

Haouari and Azaiez (2000) proposed a mathematical model for optimal cropping patterns under water deficits in dry regions. They identified both the total area and the irrigation level allocated to a given crop. Then, the model determined the global optimal cropping plan of entire region.

Mohaddes and Mohayidin (2008) developed a model that focused on attaining three objectives simultaneously, namely, profit maximization, employment maximization and erosion minimization. Results of the model indicated that, when compared with the current cropping structure, the implementation of the optimal cropping pattern could increase profit and employment and decrease soil erosion significantly.

Wei et al. (2009) suggested an optimal crop planting scheme based on the character of Sichuan province. They used multi-objective programming modeling and solved crop planning problems for optimal production of several seasonal crops in a planning year based on three land types.

Ragkos and Psychoudakis (2008) used a multi-objective programming approach to examine the possibilities of simultaneously achieving environmental goals such as the reduction of agrochemical and irrigation water use as well as acceptable farm incomes. The particular objectives of policy makers and human's preference, especially the acceptance of each crop plan by stakeholders. Alternative crop plans for River Strymonas region in Greece were identified. The results revealed considerable possibilities for reducing input usage.

Clearly most of the above studies used limited, well known and established criteria that characterize normal economy conditions. Still, most of these studies did not mention how these criteria were obtained and how the importance, (weights), of these criteria were computed. Therefore, there is a need for this study which can be further differentiated from previous studies in the following aspects:

1) Most of the previous studies dealt with normal conditions where return maximization is a dominant objective. While this study deals with resistive economy condition and identifies its main criteria and sub criteria.

2) This study considers developing an effective long term crop plan by incorporating additional criteria like self sufficiency, food security, intercropping, organic agriculture, postharvest storage and many other criteria. Meanwhile, the existing studies focused on resources consumption criteria such as land, water, fertilizers, labor which are characteristics of operational level.

3) The agricultural sector in Gaza Strip has many problems that are not typical in related literature.

3. Analytic Hierarchy Process Model

Analytic Hierarchy Process (AHP) is one of the multi criteria decision-making methods; it was originally developed by Thomas L. Saaty in the mid 1970s. It combines tangible and intangible aspects to obtain the priorities associated with the alternatives of the problem.

AHP is a structural framework that allows decision-makers to model a complex problem in a hierarchical structure by breaking it down into smaller parts, then calling for a simple comparison with respect to pairs of judgments to develop priorities within each level of hierarchy. Finally, results are synthesized to obtain overall weights of the alternatives. AHP allows some small inconsistency in judgment because human is not always consistent. AHP

is most useful where teams of people are working on complex problems. Decision situations to which AHP can be applied include: Selection [Serkan et al. (2009), Hambali et al. (2009)]; allocation [Steven (2008)]; evaluation and benchmarking [Agha (2008)]; ranking and prioritization [Babic and Palzibat (1998), Ahmet and Bozbura (2007)].

The AHP methodology is explained in following steps.

3.1. Hierarchical structuring of the problem

In the first stage, the decision maker defines a hierarchical structure representing the problem at hand. A general form of AHP structure is presented in Fig. (1). In the simplest case, the hierarchy has three levels. The first level represents the goal of the decision problem and is analyzed as resulting from the aggregation of evaluation criteria represented by the second level; the last level of the hierarchy involves the alternatives to be evaluated. In more complex cases, there may be more levels, corresponding to splitting criteria into sub-criteria.

INSERT Figure (1): *AHP Hierarchy* [Agha, 2008].

3.2. Performing pair-wise comparisons

Once the hierarchy of the problem is defined, the decision-maker performs a series of pair wise comparisons within the same hierarchical level and then between sections at a higher level in the hierarchy structure to have ***n*(n-1)/2*** comparisons for ***n*** criteria. In comparisons, a ratio scale from ***1-9*** is used to compare any two elements. Table (1) shows the measurement scale defined by Saaty (1980). And $a_{ij} = w_i / w_j$ where **i, j =1,2...,n.**

Table (1) : *Saaty's Scale of Importance Intensities* [Saaty, 1980].

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

The pair wise comparisons of various criteria are organized into a square matrix The diagonal elements of the matrix are ***1***. The criterion in the i^{th} row is better than criterion in the j^{th} column if the value of element ***(i, j)*** is more than 1; otherwise the criterion in the j^{th} column is better than that in the i^{th} row. The principal eigen value and the corresponding normalized eigen vector of the comparison matrix give the relative importance of the various criteria being compared. The elements of the normalized eigen vector are termed weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives.

3.3. Synthesis

Once judgments have been entered for each part of the model, the rating of alternative is multiplied by the weights of the sub-criteria and aggregated to get local ratings with respect to each criterion. The local ratings are then multiplied by the weights of the criteria and aggregated to obtain global ratings. The AHP produces weight values for each alternative based on the judged importance of one alternative over another with respect to a common criterion. The results are then synthesized to obtain rank of the alternatives in relation to the overall goal. The detailed AHP process is shown in Fig. (2).

INSERT Figure (2): *AHP Process*

3.4. Consistency evaluation

The consistency measure is called the Consistency Index (***CI***) which is calculated as:

$$CI = (\lambda_{max} - n)/(n-1) \quad (3.3)$$

Where λ_{max} is the maximum eigen value of the judgment matrix and n is the number of criteria. To obtain the consistency ratio (CR), the value of ***CI*** is divided by the Random Consistency Index, ***RI*** as shown in Table (2). ***CI/RI*** values should be less than **0.1** otherwise, the level of inconsistency is considered unacceptable. In this situation, the evaluation procedure has to be repeated to improve consistency.

Table (2): *Random Consistency Index* ***(RI)*** [Saaty, 1980].

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

4. Application

The goal of this research is to rank crops needed to be cultivated in governmental agricultural lands in Gaza Strip under the prevailing conditions. In order to achieve this goal, several methods were used to collect the necessary data, then, AHP was used to obtain the weight of criteria and alternatives. The next sections describe the procedure.

4.1. Data collection

The data needed for the crop planning are: the criteria, sub-criteria, and (alternatives) crops to be cultivated. Literature review, policies of the Ministry of Agriculture (MOA) and interviews with experts and agricultural engineers from the MOA were the main sources of data in this study.

4.2. Criteria, sub-criteria and alternatives identification

To identify criteria and sub-criteria and alternatives, a questionnaire was designed based on existing literature. The questionnaire was presented to eleven experts and engineers from the ministry of agriculture and other professional agricultural associations. These experts were asked to add missing criteria, sub-criteria and alternatives, modify, combine criteria or remove redundant ones.

The final criteria, sub-criteria and alternatives are shown in Fig. 3. Seven main criteria, twenty nine sub-criteria and eight alternatives were identified. These criteria include economic, financial, marketing, environmental, technical, political and social criteria. More details on the criteria, sub-criteria and alternatives are given in the next paragraphs.

1. Economic criteria

Economic criteria reflect the ability of the proposed crop to generate economic benefits. The main economic criterion is split into seven sub criteria as shown in Fig. (3).

It is clear that agro-industries is not sub-criteria in this economy condition because under the severe conditions; there will be no excess crops for industries. In other words, limited land areas would cover the local market demand to reach the state of self sufficiency.

2. Financial criteria

It includes 5 sub-criteria. It is noted here that the return per cubic meter of water sub-criteria is rather new. It appeared in recent years with the emergence of resistive economy concept.

3. Marketing criteria

Consumption per capita is the only sub-criteria under marketing because it has a direct relationship to marketing since no exports are allowed and all crops should be directed towards internal market

4. Environmental criteria

The environmental criteria include 6 sub-criteria as shown in Fig. (3). More details regarding these sub-criteria are given later in the results and analysis section.

5. Technical criteria

The performance of the crop in land and in the hand of the consumer is a key indicator of the development, production, and marketing system. The appropriate sub-criteria are shown in Fig. (3). It is noted that storage period criterion is considered in the resistive economy because people in Gaza Strip use the simple old methods to store the agricultural products. Therefore, not all crops can be stored using these methods. In normal economy, people have the ability to treat crops using sophisticated post harvest technologies in which most of crops can be stored. Further, it is noted that intensive cultivation method requires large amounts of fertilizers and pesticides which are not available in resistant economy, so this sub criterion is not found in resistant economy.

6. Political criteria

Political conditions play a vital role in shaping the trend toward some crops. The sub-criteria are governmental preferences and self sufficiency which is a pre-requisite for a free political will.

7. Social criteria

The social impact of a crop plan can be assessed using food security and improving living standards.

INSERT Figure (3): *AHP Hierarchy for Crop Planning Problem in Resistive Economy*

As for the alternatives, crops are classified in such a way that experts can easily compare these alternatives with respect to the sub-criteria under consideration. Therefore, crops with similar characteristics are grouped in one alternative. The final list of alternatives includes: vegetables, fruits, citrus, olives, palm, export crops, field crops and medical and aromatic crops. It is noted that this classification is the same as that used by the (Ministry of Agriculture) MOA (2009). These types of crops are discussed in Table (3).

Table (3): *Alternatives definition*

Crops	Definition
1. Vegetables	Crops characterized by high consumption of water, pesticides and fertilizers and need large number of employees.
2. Fruits	Tree crops excluding palm, olives and citrus. Fruits tolerate moderate environmental conditions, for example fruits need moderate water quality.
3. Citrus	Crops characterized by high consumption of high quality water. In Gaza Strip, it has high a competitive advantage all over the world.
4. Palms	Crops characterized by low consumption of water, pesticides and fertilizers and may use treated water for irrigation, as it can be grown in stressed soil.
5. Olives	Crops tolerate severe environmental conditions. Olives have the same characteristics as palms, but differ in that olives have higher competitive advantage than palms, and they differ in the per capita consumption, so olives are segregated as an individual alternative

6. Export crops	Mainly, strawberries and flowers which were exported in large amounts before year 2005. These crops have very high competitive advantage, however they consume very large amounts of high quality water, for example, one strawberry fuirtage consumes 20 liters of high quality water, knowing that Gaza Strip is suffering from a shortage of water.
7. Field crops	Crops refer to legumes, fodder, cereals and potatoes. Well-known legumes include peas, beans, soy, peanuts…....etc. They have a protein content which is almost double that of cereals and similar to the amount found in meat, eggs, fish and dairy products. Legumes are used as fertilizers due to their ability to fix atmospheric nitrogen, thanks to a symbiotic relationship with bacteria found in root nodules of these plants. It is known that field crops require large cultivation area in order to have economically feasible production.
8. Medical crops	Crops characterized by low amount of production per dunum. Thyme, mint and parsley, etc. are examples.

4.3. AHP implementation

After identifying criteria, sub-criteria and alternatives, a hierarchy of four levels, was constructed as shown in Fig. (3). The subsections below describe the main steps of implementing the AHP model.

4.3.1. Establishing the pair wise comparison matrix

Because of the large number of comparisons, a questionnaire was designed to conduct the pair wise comparisons. The questionnaire was distributed to the same experts who participated in identifying the criteria, sub-criteria and alternatives. In this questionnaire, experts were asked to assign a value from one to nine for each pair-wise comparison. For example, a question would be, given two criteria, which one is more important and by how much? The questionnaire was designed in a way that helps the experts to easily and carefully complete it. This was mainly achieved using a simple example given on the cover page of the questionnaire.

After receiving the completed questionnaires from experts, the consistency of each questionnaire was checked. Since some of the questionnaires had a consistency ratio more than 0.1, the researchers conducted a Nominal Group Technique (NGT) meeting for the experts where the process of pair wise comparison is silent and independent. NGT was used because silent process reduces the time required for pair wise comparisons [Liu and Wei 2000].

In this meeting, the researchers again presented the purpose of the study to the experts and gave a summary on AHP method and how it can be applied, and finally, the researchers explained why some of independent individual questionnaires were inconsistent. After this introduction, the comparison matrix of the main criteria obtained from the questionnaires was presented. Each expert was asked to give his/her opinion (why this score). The discussion focused on the outlier scores, then, the experts were asked to refill the comparison table associated with the main criteria. The same procedure was repeated for the sub criteria and alternatives comparisons. After the NGT meeting, each expert was asked to rank the sub criteria according to their importance with respect to the main criteria and the alternatives with respect to the sub criteria. The consistency ratios of the questionnaires were tested again and found to be less than 0.1. Thus, the data is ready to enter in the Expert Choice (E.C. 11.5) software. After running expert choice, the performance of each crop with respect to sub-criteria was obtained and the weights of these crops with respect to the objective were

computed, then, alternatives were ranked based on their weights. Results and analysis are given in the next section.

5. Results and Analysis

Results including criteria, sub-criteria, their weights and the performance of each alternative in addition to sensitivity analysis are given and analyzed in the following subsections.

INSERT TABLE (4): ***Weights for Main and Sub Criteria and Alternatives under Resistive Economy***

5.1. Criteria results

Bold numbers in column (1) in Table (4) show the weight of each criterion with respect to the goal. The results indicate that environmental criterion is the most important as its relative weight was 0.42. Political criterion comes second with a relative weight of 0.18 whereas social criterion ranks the lowest among these criteria as it scored 0.04 of the total weight. Economic and financial criteria equally contribute to the goal for a weight of 0.107. The fact that environmental criterion has the highest weight supports the idea of sustainable agriculture as a part of sustainable development which strives to meet the needs of the present generation without compromising the needs of future generations. Sustainable agriculture is a system that can evolve indefinitely toward greater human utility, greater efficiency of resource use and a balance with the environment which is favorable to humans and most other species. This finding is consistent with the objectives of the Ministry of Agriculture (MOA) as they consider environmental factors the most critical determinants in selecting the crop types, especially under resistive economy conditions where are sharp shortages in many resources.

5.2. Sub-criteria results

The third level in the constructed hierarchy is the sub-criteria level. This level has twenty nine sub-criteria each has a local and a global weight as shown in Table (4) column (1) and column (2). The local weight indicates the weight of sub-criteria with respect to the main criterion, whereas, the global weight is the weight of the sub-criteria with respect to the goal (the first level in the hierarchy).

Column (2) in Table (4) indicates that water consumption and self sufficiency are the most important sub-criteria with respect to the overall goal. This result reflects the two major problems present in Gaza Strip. The first is water shortage which is important in both resistive and normal conditions. Thus, and since water is the scarcest agricultural resource in Gaza Strip, it would have a great effect on determining the cultivated area for each crop. The second problem is the need to reach self sufficiency state and consequently achieving a free political will.

According to column (2) Table (4), the crop shortage coverage and the availability of production inputs are the most important sub-criteria with respect to the economic criteria. In resistive economy, the availability of production inputs is an important factor in the agricultural practice. Many crops are not cultivated in Gaza Strip simply because they need inputs (seeds) which are not available due to siege.

As for financial sub-criterion, payback period is the most important financial sub-criterion. This could be attributed to the unstable conditions in Gaza Strip which require that payback period of a crop be as short as possible. In other words, investors want their money back as soon as possible. For the environmental criterion, water consumption is the most important sub-criterion; its relative weight is 0.35. Competitiveness is the most important

technical sub-criterion. With respect to political criteria, it is noticed that the weight of self sufficiency criterion is about five times that of government preference criterion. Finally, in social criteria, food security weight is about four times that of improving living standards criterion weight.

5.3. Crops performance

The performance of (crops) alternatives with respect to each criterion is shown in bold in Table (4). These performances can be read at the intersection of the main criteria and each of the crops. Palms and olives (columns 3.5 and 3.4) are the highest performers in the economic criteria. Their contributions to the economic criterion are around 0.21 and 0.19 respectively. These high weights could be mainly attributed to the availability of their inputs. Palms and olives are followed by field crops and fruits with relative weights of 0.14 and 0.13 respectively.

It is clear that vegetables and export crops; citrus and medical crops score pretty low. This could be due to the fact that they are mainly for exports and thus their poor performance given the fact that borders are closed.

The area requirement to cover the market needs of a certain crop is a determinant factor in selecting the types of crops. Some types of crops are needed in large amounts such as field crops, but this criterion prevents cultivating these crops in large amounts since they require large space to be economically feasible. It is noted here that if all the agricultural lands in Gaza Strip are cultivated with field crops, the production will not meet the local demand [MOA, 2009].

As for the financial criteria, palms, olives, vegetables and field crops have approximately the same performance. Export crops are poor performers with respect to financial criteria in the resistive economy condition. This could be attributed to two factors. The first is its low returns on cubic meter of water and its annual returns because seige does not allow exporting these crops in addition to the fact that they do not have a significant local market in Gaza Strip.

As for marketing criterion, field crops and vegetables are the highest performers. This could be due to the fact that the per capita consumption of these crops is very high.

With respect to the environmental performance of crops, it is noted that field crops and palms have the highest score in environmental performance. This is because their water consumption is low in addition to the fact that they do not need high quality water. On the other hand, vegetables and export crops consume large amounts of high quality water and nutrients from soil and thus their scores are low.

The following paragraphs will further elaborate on all environmental sub-criteria due to their importance.

As for the impact of crops on soil fertility, crops are divided into three types. The first type includes crops that have a positive effect on soil. Such crops, like legumes increase soil fertility. Therefore, they are used as secondary crops in the agricultural rotations to reduce the need for soil fertilizers. In some cases, soil has to be cultivated by particular types of crops to improve the already stressed soil fertility to allow the cultivation of crops that require good soil condition. The second type of crops adversely affects soil fertility. This type includes corn and other crops that strain the soil and absorb nutrients. Therefore, after their cultivation, soil needs treatment to be suitable for cultivation again. The third type is the trees category such as citruses, fruits, olives and palm. Their impact on the soil fertility can be ignored because of the long life of a tree, where their life time is several years, thus no crop will be planted after them in a certain period of time.

Some crops like palms can be cultivated in severe conditions (poor soil, salts). The quality of water used in the irrigation process differs according to the crop types. Some crops require fresh water such as export crops and citrus. Other types of crops like palms can

tolerate degrees of salinity in water. This sub-criterion is important in resistive economy where there is a trend to cultivate crops that can tolerate large degrees of salinity. This is one of the methods to deal with the water problem in Gaza Strip.

As there is a shortage in water resources in Gaza Strip, treated water can be used to irrigate crops that are not eaten fresh such as wheat, or its leaves are not eaten. Further, treated water can be used to irrigate trees which have inedible outer layer of its fruitages. Fodders can be irrigated with treated water.

For the organic agriculture sub-criterion, it is, according to MOA (2009), considered the optimal cultivation method in the resistive economy condition where there is a lack of chemical fertilizers and pesticides. Crops vary in how easy they can be organically cultivated, for example, palm and olive trees are easier to cultivate organically than vegetables.

As for the technical criterion, it is noted that vegetables are the best performers unlike their performance with respect to environmental criterion. This may be attributed to its competitiveness, its high yield rate and the fact that many types of vegetables, like tomatoes, can be harvested many times in the same season.

Olives are the best performers with respect to political criteria because olives have the ability to reach the self sufficiency state if the amount of cultivated olives increases, whereas vegetables and export crops are already cultivated in large amounts in the private agricultural land, which satisfies the local demand. This explains the fact that their performances are low.

The term self-sufficiency appeared with the appearance of the resistive economy idea. This sub-criterion ranks the agricultural crops according to their ability of actually getting into a state of self-sufficiency (covering all the demand), and not according to the existing quantities. This sub-criterion would tend to assign high weights to crops that have a shortage in the market (the private sector does not satisfy demand), but it can reach the self-sufficiency state by cultivating them in large amounts in the governmental land. Thus, if one crop is actually being cultivated in the private agricultural lands and meets its market demand, then, there is no need to cultivate in the governmental land, like vegetables. In this case, it will be assigned a smaller weight than other crops which need to be feasibly cultivated in governmental land to reach the self sufficiency state. Although Gaza Strip market suffers from severe shortage in local field crops, they have low weights with respect to this criterion because they cannot reach the state of covering all the demand due to area requirement constraint as discussed earlier.

Finally, as for the social performance of crops, it is clear that vegetables and field crops are considered the most important safe food that should be available in any home. Therefore, they are high performers with respect to social criterion. Export crops, on the other hand, are low performers with respect to social criterion because they are not basic food when considering food security sub- criterion.

5.4. Crops ranking

The ranking of crops, according to AHP method, is shown the last row in Table (4). Palms and field crops rank first. Each has a relative weight of 0.194. Remaining alternatives are ranked as follows: olives, fruits, vegetables, medical crops, citrus and export crops, respectively.

Results of AHP method indicate that palms and field crops have the first priority to be cultivated in Gaza Strip in the resistive economy. Given the fact that agricultural experts in MOA and some associations have pointed out the infeasibility of cultivating field crops in Gaza Strip because field crops require large areas for feasible production, while the available land is insufficient to meet this requirement, these results can be explained as follows: (i) Field crops score high (0.25) with respect to the environmental criterion which is the most important criterion as it has a relative weight of 0.42. (ii) Field crops include potatoes which are a primary crop in Gaza Strip. This could have biased the experts' opinions. (iii) The only

constraint that restricts increasing the amounts of field crops is the area requirement criterion, while the weight of this criterion is only 0.15 which is approximately one third the weight of environmental criteria. Therefore, this criterion does not greatly affect the total performance of the field crops.

5.5. Sensitivity analysis

The purpose of sensitivity analyses is to graphically see how the alternatives change with respect to the importance of the criteria. The most important types of sensitivity analysis include: performance and gradient sensitivity.

5.5.1. Performance sensitivity

The Performance sensitivity graph displays how the alternatives perform with respect to each criteria as well as the overall objective. The performance graph for the crops under study is shown in Fig. (4). In this Fig. , the "left y-axis" is used to read each criterion's weight, and the "right y-axis" is used to read the alternative score with respect to each criterion.

From Fig (4), it is noted that vegetables rank first among the other alternatives with respect to marketing, technical and social criteria, but they perform poorly with respect to the environmental criterion; this reduces the total performance of vegetables with respect to the overall goal. On the other hand, export crops have the worst performance with respect to all criteria except the technical criterion, because export crops have competitiveness advantage which is the most important technical sub-criterion. Fruits perform moderately on all criteria except the technical criteria. This could be due to the fact that they do not have good competitiveness advantage or high yield rate as they are the most important sub-criteria in technical criteria. Field crops perform well with respect to all criteria especially the environmental and marketing criteria, but their performance with respect to political and technical criteria is not superior. Medical crops and citrus are relatively similar to each other in their performance. Palms have superior performance on all criteria except the technical criterion.

INSERT Figure (4): *The Performance Graph for the Crops under Resistive Economy Condition.*

5.5.2. Gradient sensitivity

Gradient sensitivity graph shows the alternatives' priorities with respect to one criterion at a time. Changes in the weight of criteria or the judgments may lead to changes in the outcome of the decision. In the following and for brevity reasons, only gradient sensitivity of economic, environmental, and political criteria will be given. For example, Fig. (5) shows the sensitivity of the decision to changes in the relative importance of the economic criterion. The vertical line represents the priority of the selected criterion and is read from the X-axis intersection. The performance of each alternative is read from the Y-axis; it is determined by the intersection of the alternatives with the criterion (vertical) priority line.

INSERT Figure (5): *Gradient Sensitivity Analysis for Economic Criteria under Resistive Economy Condition.*

For the current relative weight of the economic criterion, that is 0.11, palms and field crops are the highest performers. Palms remain the top-ranking crop regardless of the weight of the economic criteria. It is noted that the overall performance of field crops decreases. However, if the weight of the economic criteria increases to larger than 0.35, olives will rank second and field crops will rank third.

The performance of palms and field crops increase as the weight of environmental criterion increases. This is shown in the Fig. (6). If the current weight of environmental

criterion decreases from 0.42 to less than 0.25, olives will be the top-ranking alternative, but the overall performance of olives seems to be insensitive to the increase in environmental criteria's weight. The overall performance of vegetables and fruits deceases as the weight of environmental criterion increases.

INSERT Figure (6): *Gradient Sensitivity Analysis for Environmental Criteria under Resistive Economy Condition.*

Figure (7) shows the gradient sensitivity analysis for political criterion. The overall performance of palms, citrus and medical crops are approximately insensitive to changes in political criterion's weight. In other words, increasing or decreasing the weight of the political criterion does not change their scores with respect to the overall objective. On the other hand, the overall performance of olives and fruits increases as the weight of political criteria increases. Finally, an increase in the political criterion weight increases, the performance of field crops and vegetables decrease.

INSERT Figure (7): *Gradient Sensitivity Analysis for Political Criteria under Resistive Economy Condition.*

6. Conclusions

The study used AHP as a multi-criteria decision making method to rank crops under resistive economy conditions. First, criteria, sub-criteria, and alternatives characterizing the conditions are identified using Nominal Group Technique (NGT). AHP is then used to obtain the weights of each criterion, sub-criteria and obtain the performance of each alternative with respect sub-criteria, criteria and overall goal.

On the criteria level, it was observed that environmental criterion is the most important of all where it accounted for 0.42 of the total weight. The order of the rest of the criteria was as follows: Political; economic and financial; marketing; technical and finally social criteria. As for the contribution of the sub-criteria to the overall objective, it was found that water consumption per dunum comes first followed by self sufficiency.

Taking crops as groups forced the researchers to approximate data, and to have more accurate results it is recommended for future work to apply this study to individual crops.

The findings of the study reflects the importance of sustainable agriculture as a part of sustainable development during resistive economy condition, so the ministry of agriculture should make sure that everyone in the agricultural process implements the basics of sustainable agriculture.

To generalize the developed crop planning model, it is recommended to include the private agriculture sector in the model. This can be applied by subtracting the private agriculture production from total demand, then distributing the remaining crops demands to the governmental area under consideration.

The main advantage of AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting objectives. On the other hand, AHP approach has two major weaknesses. One is the well-known ranking reversal problem as discussed by many researchers such as Belton and Gear (1983). In many scenarios, the rankings of alternatives obtained by the AHP may change if a new alternative is added. The other is its limited capability in dealing with the issue of uncertainty which is the common problem of decision-making in early product development stages. In fact, uncertainty can be induced in two ways: incomplete data and imprecise judgments. The desirability of alternative management options

can be ranked for individual stakeholder groups. Priority rankings are confined to within stakeholder groups and little assistance is provided towards dispute resolution.

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Table (4): *Weights for Main and Sub Criteria and Alternatives under Resistive Economy*

Criteria	Local Weight (1)	Global Weight (2)	Crop Type (3)							
			Vegetables 3.1	Fruits 3.2	Citrus 3.3	Olives 3.4	Palms 3.5	Export crops 3.6	Field crops 3.7	Medical crops 3.8
1. Economic Criteria	**0.107**	**0.107**	**0.093**	**0.130**	**0.092**	**0.187**	**0.210**	**0.075**	**0.144**	**0.070**
1.1. Availability of production inputs	0.262	0.028	0.029	0.073	0.067	0.186	0.306	0.022	0.207	0.111
1.2. Contribution on animal production sector	0.116	0.012	0.198	0.071	0.059	0.085	0.123	0.041	0.394	0.028
1.3. Crop shortage coverage	0.298	0.032	0.051	0.220	0.116	0.214	0.216	0.030	0.087	0.067
1.4. Using crop by-products except compost	0.040	0.004	0.086	0.059	0.129	0.290	0.292	0.024	0.074	0.046
1.5. Area requirement	0.138	0.015	0.100	0.163	0.115	0.314	0.169	0.040	0.042	0.056
1.6. Compost production	0.031	0.003	0.336	0.089	0.057	0.056	0.166	0.041	0.215	0.040
1.7. Employment generation	0.115	0.012	0.173	0.082	0.085	0.070	0.093	0.416	0.025	0.057
2. Financial Criteria	**0.107**	**0.107**	**0.155**	**0.089**	**0.075**	**0.156**	**0.137**	**0.042**	**0.153**	**0.193**
2.1. Return per cubic meter of water.	0.209	0.022	0.101	0.047	0.035	0.173	0.182	0.057	0.146	0.260
2.2. Annual return per dunum	0.123	0.013	0.177	0.180	0.084	0.299	0.086	0.035	0.034	0.104
2.3. Labor cost per dunum	0.090	0.010	0.026	0.102	0.111	0.132	0.160	0.024	0.315	0.130
2.4. Production cost per dunum	0.271	0.029	0.029	0.064	0.091	0.200	0.235	0.022	0.234	0.125
2.5. Payback period	0.308	0.033	0.333	0.099	0.075	0.054	0.034	0.058	0.087	0.260
3. Marketing Criteria	**0.101**	**0.101**	**0.289**	**0.138**	**0.124**	**0.075**	**0.044**	**0.023**	**0.281**	**0.026**
3.1. Per capita consumption	1.00	0.101	0.289	0.138	0.124	0.075	0.044	0.023	0.281	0.026
4. Environmental Criteria	**0.420**	**0.420**	**0.051**	**0.070**	**0.082**	**0.187**	**0.251**	**0.024**	**0.250**	**0.085**
4.1. Impact on soil fertility	0.077	0.032	0.114	0.087	0.094	0.122	0.060	0.052	0.388	0.082
4.2. Cultivation in severe conditions	0.166	0.070	0.068	0.060	0.052	0.240	0.308	0.024	0.202	0.046
4.3. Water quality	0.174	0.073	0.068	0.062	0.063	0.215	0.350	0.021	0.164	0.057
4.4. Water consumption per dunum	0.358	0.150	0.032	0.069	0.055	0.189	0.168	0.020	0.351	0.116

Table (4) Cont.: *Weights for Main and Sub Criteria and Alternatives in Resistive Economy*

Criteria	Local Weight (1)	Global Weight (2)	Crop Type (3)							
			Vegetables 3.1	Fruits 3.2	Citrus 3.3	Olives 3.4	Palms 3.5	Export crops 3.6	Field crops 3.7	Medical crops 3.8
4.5. Organic agriculture	0.117	0.049	0.045	0.064	0.067	0.148	0.333	0.023	0.187	0.134
4.6. Treated water use potential	0.108	0.045	0.025	0.096	0.258	0.141	0.328	0.023	0.095	0.034
5. Technical Criteria	**0.052**	**0.052**	**0.234**	**0.079**	**0.119**	**0.115**	**0.107**	**0.158**	**0.087**	**0.099**
5.1. Yield rate per dunum	0.187	0.010	0.405	0.105	0.142	0.087	0.115	0.072	0.043	0.030
5.2. Competitiveness	0.323	0.017	0.194	0.069	0.175	0.143	0.058	0.304	0.028	0.029
5.3. Time to harvest	0.156	0.008	0.250	0.067	0.042	0.032	0.026	0.147	0.132	0.303
5.4. Number of harvest times	0.133	0.007	0.365	0.073	0.074	0.034	0.066	0.131	0.069	0.188
5.5. Intercropping	0.074	0.004	0.051	0.153	0.113	0.159	0.407	0.052	0.033	0.031
5.6. Post-harvest storage period	0.127	0.007	0.032	0.047	0.085	0.248	0.189	0.020	0.299	0.079
6. Political Criteria	**0.178**	**0.178**	**0.040**	**0.190**	**0.090**	**0.253**	**0.205**	**0.023**	**0.094**	**0.106**
6.1. Government preferences	0.162	0.029	0.044	0.133	0.045	0.256	0.279	0.024	0.060	0.160
6.2. Self sufficiency	0.838	0.149	0.039	0.201	0.098	0.252	0.191	0.022	0.101	0.096
7. Social Criteria	**0.037**	**0.037**	**0.237**	**0.084**	**0.071**	**0.153**	**0.148**	**0.037**	**0.224**	**0.046**
7.1. Food security	0.806	0.030	0.258	0.059	0.052	0.143	0156	0.020	0.270	0.042
7.2. Improving living standards	0.194	0.007	0.150	0.190	0.146	0.197	0.113	0.107	0.034	0.064
Final Crop Weight			**0.105**	**0.108**	**0.089**	**0.179**	**0.194**	**0.038**	**0.194**	**0.092**
AHP Rank			**5**	**4**	**7**	**3**	**1**	**8**	**1**	**6**

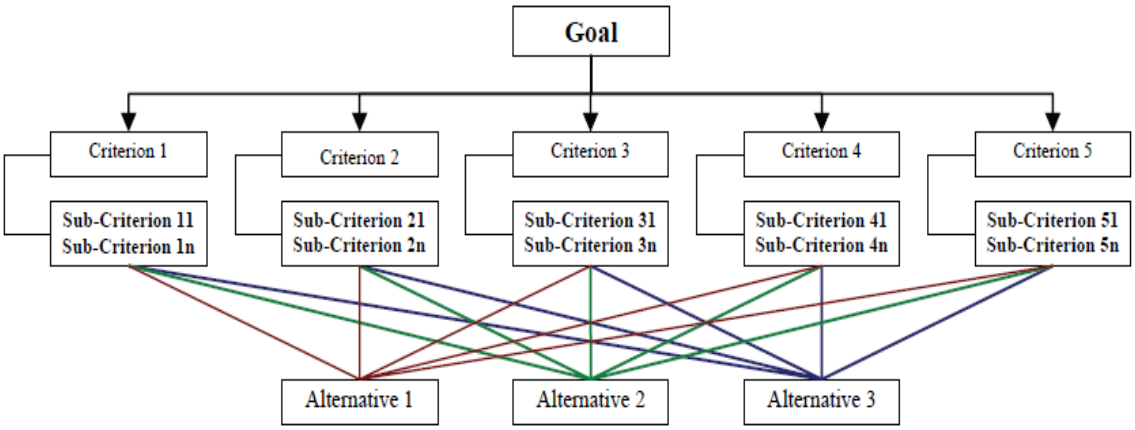

Figure (1): *AHP Hierarchy* [Agha, 2008]

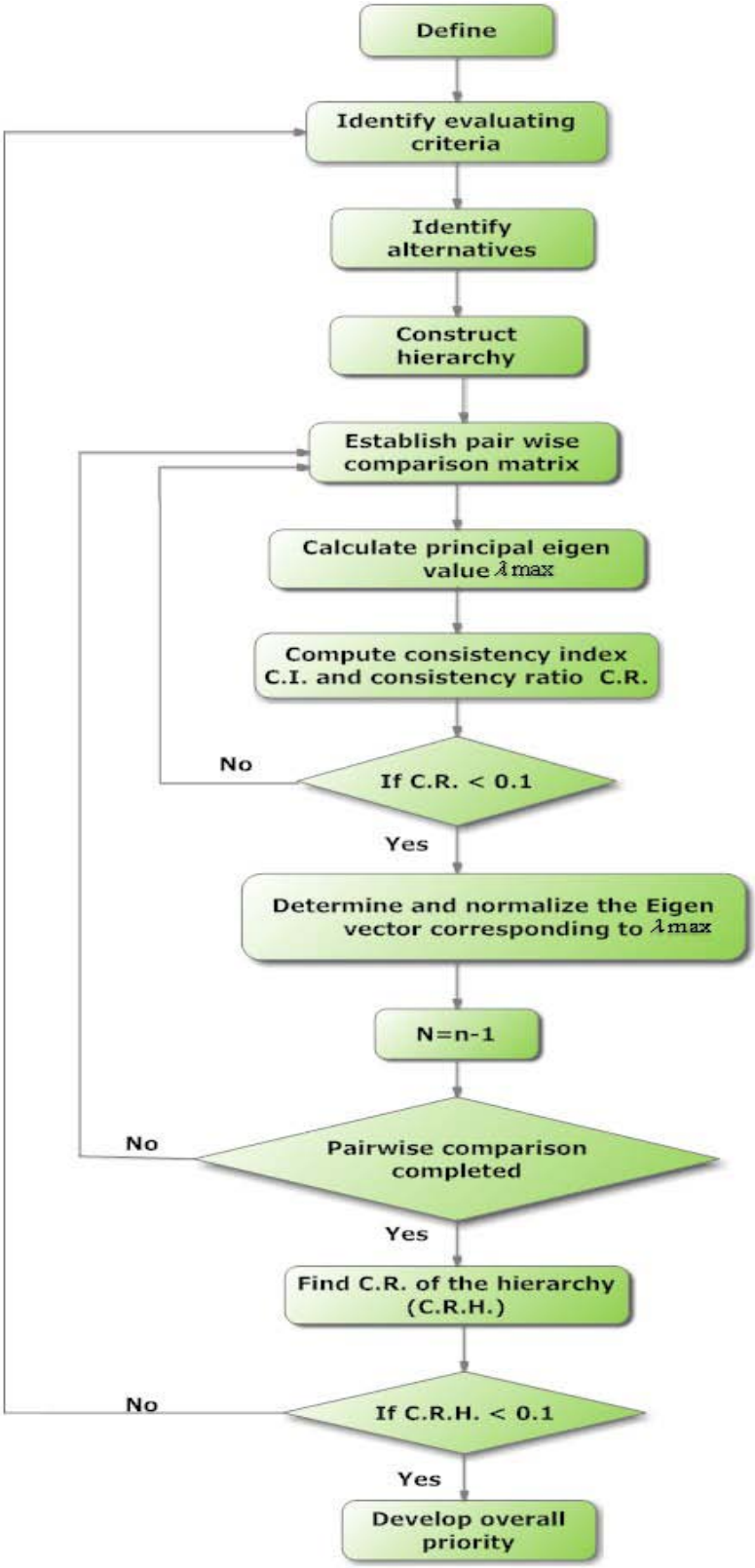

Figure (2): *AHP Process*

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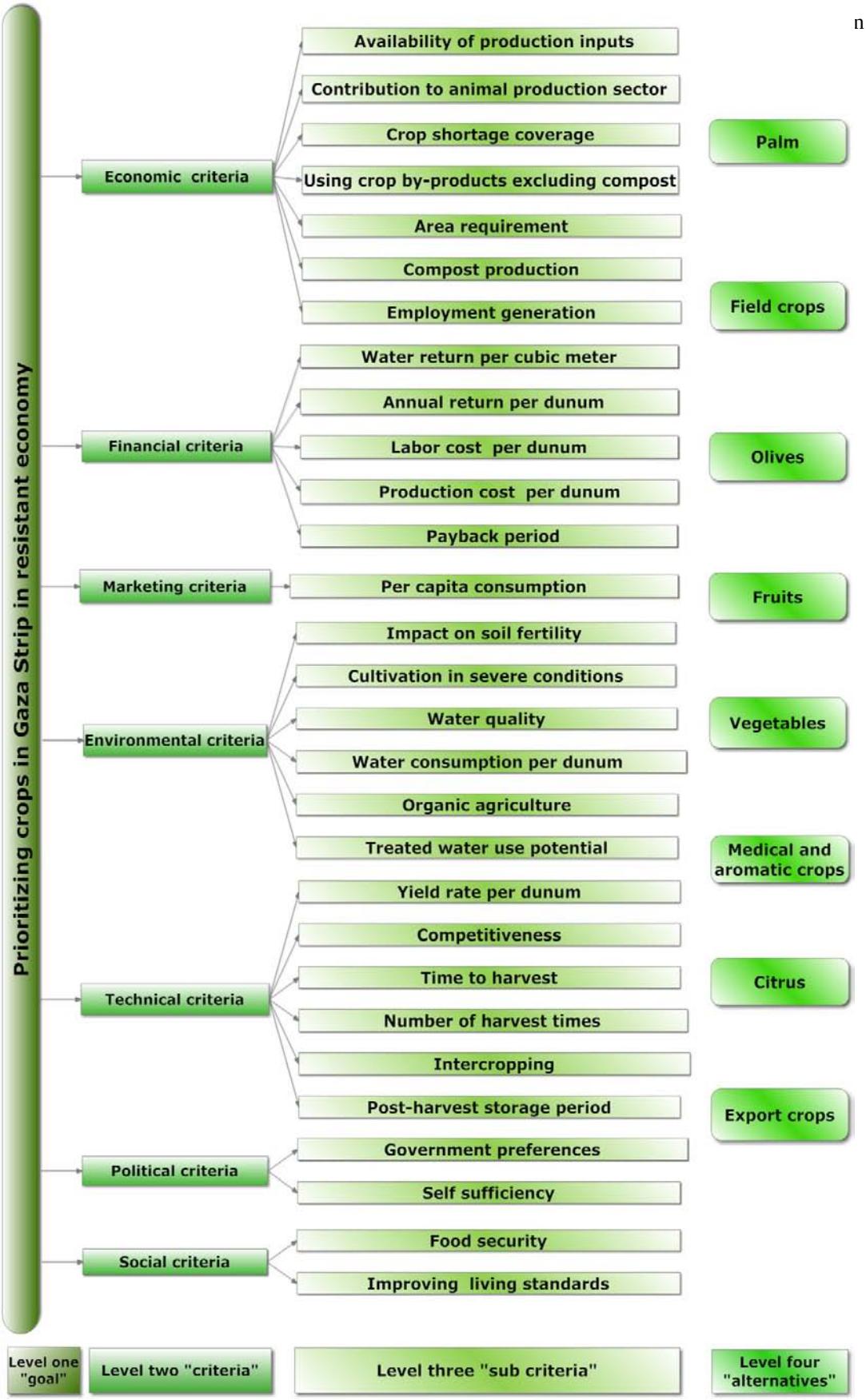

Figure (3): *AHP Hierarchy for Crop Planning Problem in Resistive Economy*

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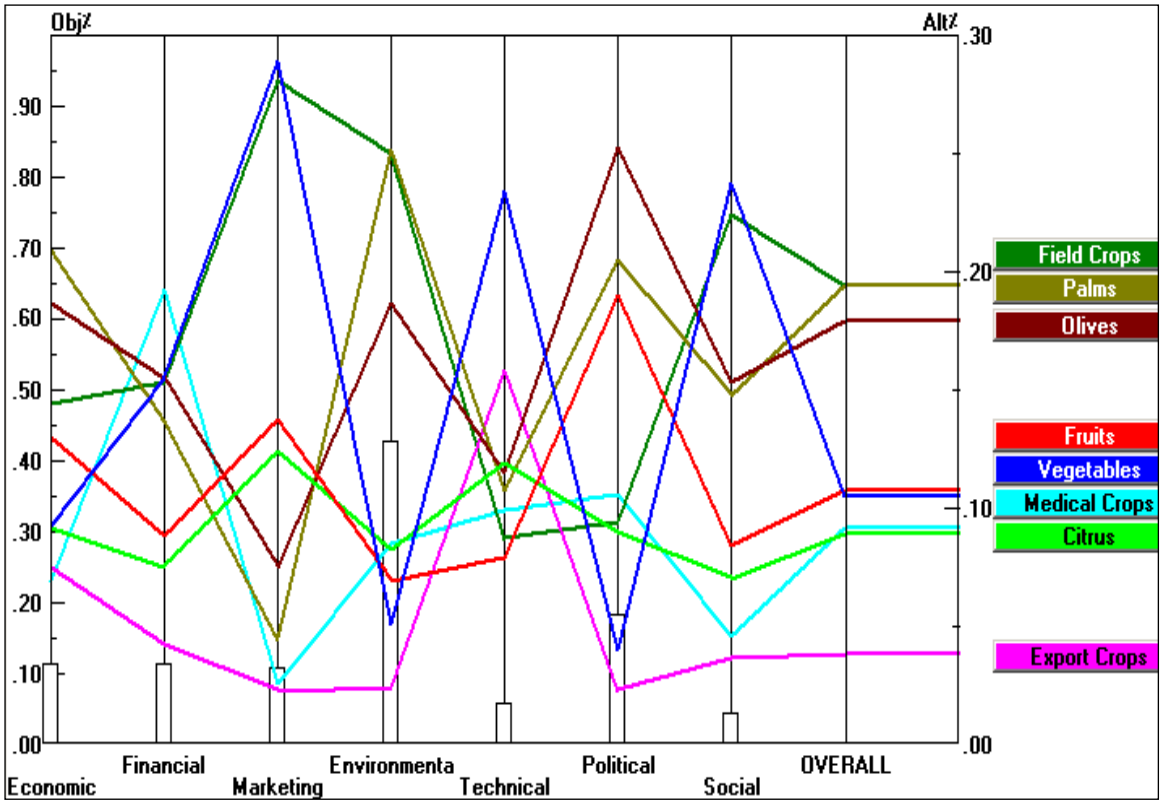

Figure (4): *The Performance Graph for the Crops under Resistive Economy Condition*

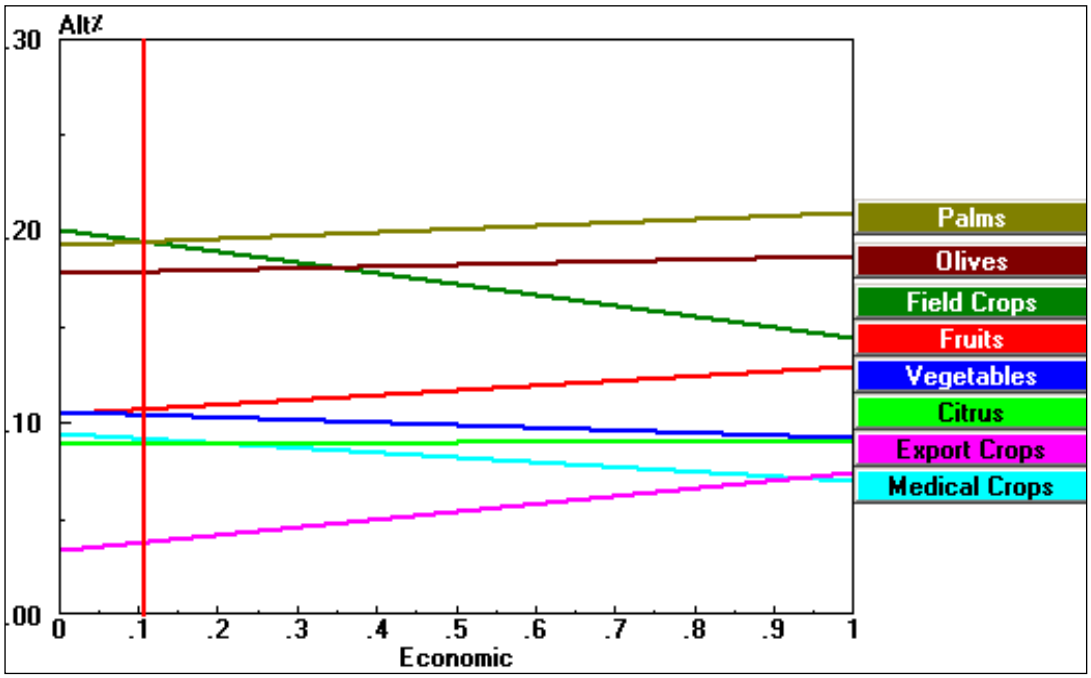

Figure (5): *Gradient Sensitivity Analysis for Economic Criteria under Resistive Economy Condition.*

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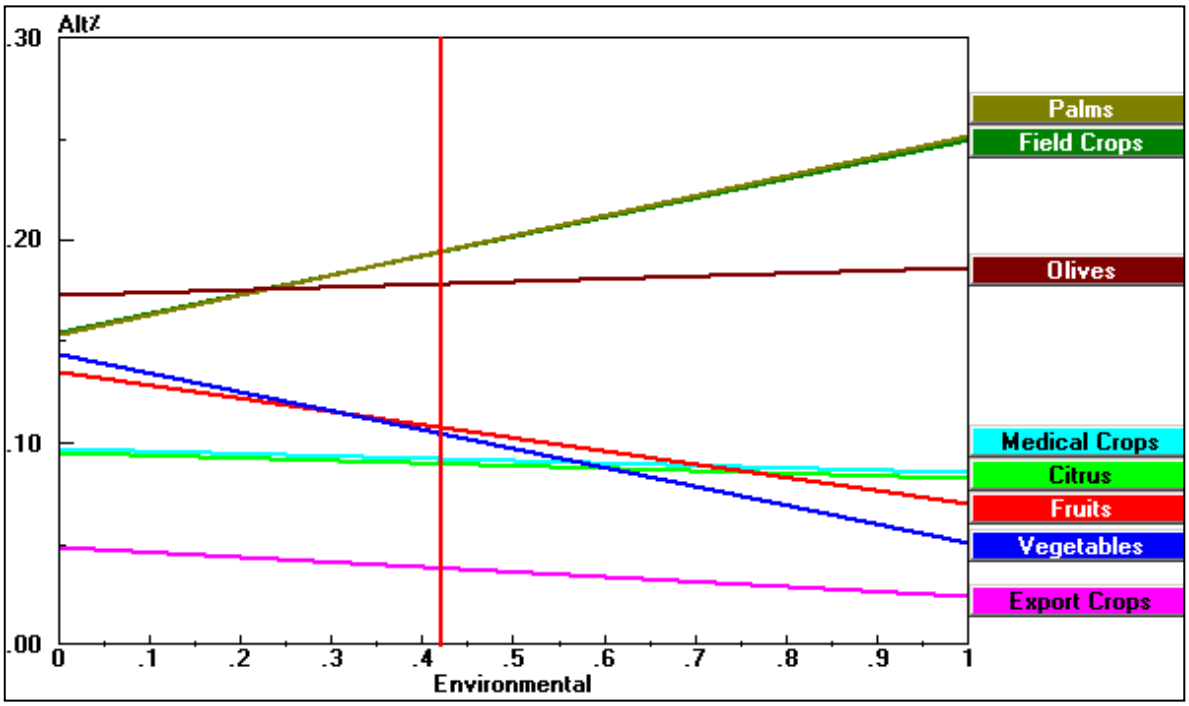

Figure (6): *Gradient Sensitivity Analysis for Environmental Criteria under Resistive Economy Condition*

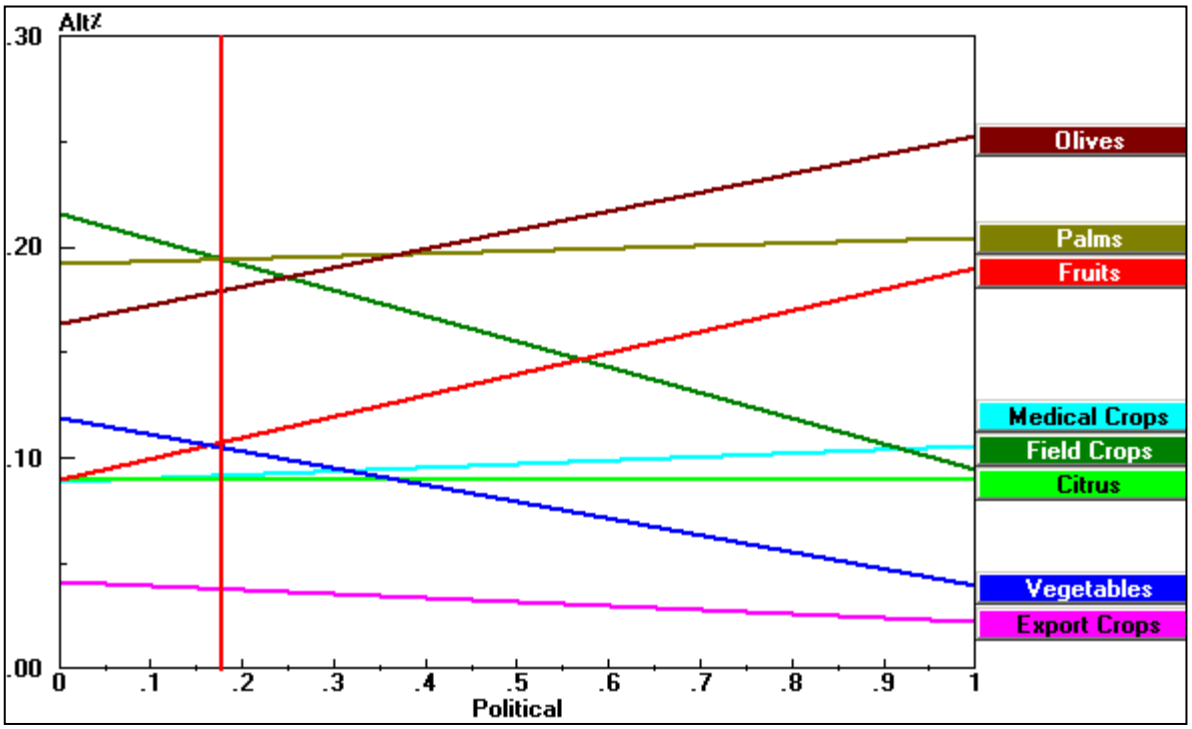

Figure (7): *Gradient Sensitivity Analysis for Political Criteria under Resistive Economy Condition.*