Selection of the best-fitting candidate migrant fishermen for aquaculture training, using a Multi Attribute Decision-Making approach

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I. INTRODUCTION

The project undertaken by ANCE under the title *"Migrant skills transfer in the aquaculture industry: The case of Greece and Egypt"* is part of the EC-UN Joint Migration and Development Initiative (JMDI) which supports civil society organizations and local authorities to implement pilot-project proposals linking migration with development. In the respective project we engage on migrant skills exchange between sending and receiving countries and we focus our effort on the improvement of the migrants' skills during their stay in the receiving country.

The Egyptian migrant workforce employed in Greek fisheries serves as our target group. In compliance with the above EC-UN initiative prerogatives linking migration and development, our approved project offers to a selected number of Egyptian fishermen the opportunity to be on-the job trained in aquaculture within volunteering Greek aquaculture Industries and Institutes. We have purposefully focused our "up-skilling" project simultaneously on a priority-development field in Egypt and on an Egyptian migrant group – *open sea fisheries workers* – familiar with several aspects of the product/market in order to maximize the chances for a rapid acquisition of the requested supplementary skills needed. This way, we believe we can effectively assist the targeted migrants to engage in a promising productive activity with a known shortage in skills, upon their future return to Egypt.

For the purpose of the project, we have designed and submitted a structured questionnaire to a number of 400 Egyptian fisheries workers widely distributed along the Greek space. To select the most suitable among them for the designed training, we were in need of a "ranking" process that would enable us to dress list of Egyptian fishermen among which we can select progressively and orderly and as much as objectively. For this purpose, we have employed as a primary selection mechanism, an evaluation scheme using data from the questionnaires and have treated these data by employing a scientific approach to decision making. The next step in our selection process includes a personal interview with the top-listed/ranked fisheries workers, through which we first validate/control the accuracy of key answers contained in the filled questionnaire then we acquire a direct and more definitive opinion on their appropriateness for participation in the up-skilling training program.

II. SELECTING THE MOST SUITABLE WORKERS FOR AQUACULTURE SEMINARS

The evaluation process is using the data collected through field questionnaires designed to register the skills and knowledge levels of the selected sample of the Egyptian migrant workforce employed in Greek fisheries. Although the questionnaire was exhaustive with regard to its purposes, comprising of a number of 42 questions addressing fields such as personal information (*age, family status, place of birth e.t.c.*), contact details, educational level, working skills and experience, networking in the work field, aquaculture related information (*previous work experience, intention to work in the field, attitude towards the aquaculture industry etc*.), we have made use for the purpose of their ranking, of only those data considered relevant to the personal competences and attributes of the fisheries workers that were supportive to our current task of selection for training.

In particular the workers' attributes retained for the evaluation process were the following:

- Age
- Family status
- Level of education
- Language use (Greek, Arab and English)
- Computer literacy
- Number of years working in Greek fisheries
- Number of additional years intended to stay in Greece
- Previous experience in any aquaculture related activity
- Preference for working in the aquaculture industry

To dress the "short-list" of the most suitable workers to be selected for participating in the aquaculture training, we employed certain methods derived from the scientific discipline of Multi Attribute Decision Making (MADM) or Multi-Criteria Decision Analysis (MCDA). In the present context we used two different scoring methods for evaluating the appropriateness of the Egyptian fisheries workers registered in our database for participating in the "up-skilling" process through the respective on-the-job training.

III. METHODS FOR MULTI ATTRIBUTE DECISION MAKING

There exists a significant number of MADM methods all of them addressing the central problem in this scientific discipline, i.e.: *"how to evaluate a set of alternatives in terms of a number of criteria"*. A detailed description of the most important and frequently used of these methods can be found in [1], [2] and [3].

We have selected two of these methods, best adapted to our case: the Simple Additive Weighting (SAW) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Their use is described in detail in the following sections.

All the methods share a common number of steps:

1. Determine the alternatives to be evaluated. That is, determine the set of questionnaires (i.e. workers) that have been completed in an acceptable manner i.e. those where the relevant questions are answered in total and when this is not the case determine some acceptable modification.

2. Selection and definition of attributes-criteria (we prefer the use of the term attribute instead of criteria as it better describes the fact that we are dealing with real world attributes of the workers under evaluation). The attributes used are the workers attributes

that are presented in chapter II. The values used are derived from the answers given to each of the questions set out in the questionnaire.

3. Attribute values (i.e. questionnaire answers) should be quantified in a manner conforming to the specific MADM method used. Bare in mind that attributes are measured in different units while some of them have a nominal and others a cardinal character. These differences must be compensated for.

4. Rank and obtain weights for the attributes in order of relative importance. Each attribute is assigned a weight that expresses the importance of each of the worker's attribute to the decision making process.

5. Score each attribute of each alternative.

6. Ranking the alternatives. A total score for each alternative is calculated, with the mathematics involved determined by the specific method used.

7. Perform post-evaluation analysis, aggregating the results of each method used and then decide on the final ranking of each of the alternatives.

Implementation of steps 1 and 2 are indifferent of each of the methods. Keep in mind that questions in the questionnaire correspond for attributes in the decision making process, questionnaire answers correspond to attribute values and each separate questionnaire corresponds to an alternative for the MADM process. By collecting our data from the questionnaires, at a first stage we end up with a matrix *X* having as rows each of the alternatives and as columns each of the attributes with the entries being the attribute values.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix}$$

For example x_{11} is the answer given from the first worker on the first question in the questionnaire.

To allow for the rejection of questionnaires that were not completed in a satisfactory way, the questionnaires that had more than 2 of the relevant questions unfilled were rejected. In the few cases where a question was not filled in (there existed no attribute value) we substituted the empty value with the mean value of the total of the answers that was calculated by:

$$X_m = \frac{\sum_{i=1}^{N} X_i}{N}$$

where X_m the mean value of the list of the answers in a specific question, X_i the answer's value derived from the ith questionnaire and *N* the total number of questionnaires with a filled answer for the specific question. For example if a worker had not answered a question, he was assigned the mean value of the answers to the same question acquired from the sum of the questionnaires. This stands true for attributes that are expressed with cardinal values. If the attribute had a nominal value (such as yes or no, good or little) we tackled the problem in a way that will be described later within the presentation of the MADM methods employed.

The SAW and TOPSIS methods belong to the set of MADM methods characterized as linear additive models. The models require the preferential independence of the attributes-criteria in order to be applied [8], a prerequisite valid in our case. What follows is a presentation of each of the different MADM models used for the evaluation starting with the process of weight assignment to each of the attributes.

IV. ASSIGNING WEIGHTS TO THE ATTRIBUTES

Weighting the attributes precedes the application of each of the separate models as the same weighting will be applied to each model. In order to weight the attributes we had to decide on their relative importance. This implies that a preference rating must take place in order to give priorities among the different attributes. We actually used three different techniques for calculating the weights.

a) Direct Estimation.

We assigned each of the attributes a weight value between 0 and 100 in a proportional way to their importance. The most important attribute was given the weight value of 100 and the remaining attributes were given weights in an analogous manner considering their relative importance to the leading attribute. In this way, the use of the Greek language was graded with 100, the educational level with 90, while the least important family status was rated with a 20. This method postulates a very accurate realization of the required "profile" of a prospective worker to be trained in the seminars.

b) The rank reciprocal weights method

With this technique one assigns 1 to the most important attribute and *n* (the number of attributes at hand) to the least important, so the cardinal weights can be obtained by

$$w_j = \frac{\frac{1}{r_j}}{\sum_{k=1}^{n} \frac{1}{r_k}}$$

where r_j is the rank of the j^{th} attribute. The ranking of the attributes that we followed is shown bellow:

1- Speaks Greek
2- Total Years of Education
3- Tertiary education in a relevant field (i.e. logistics, business, marine technology)
4- Reads Arab
5- Computer Use
6- Writes Arab
7- Previous experience in aquacultures
8- Total years working in Greece
9- Speaks English

10- Age

11- Extra years intended to stay in Greece

12- Family Status

c) Paired Comparisons

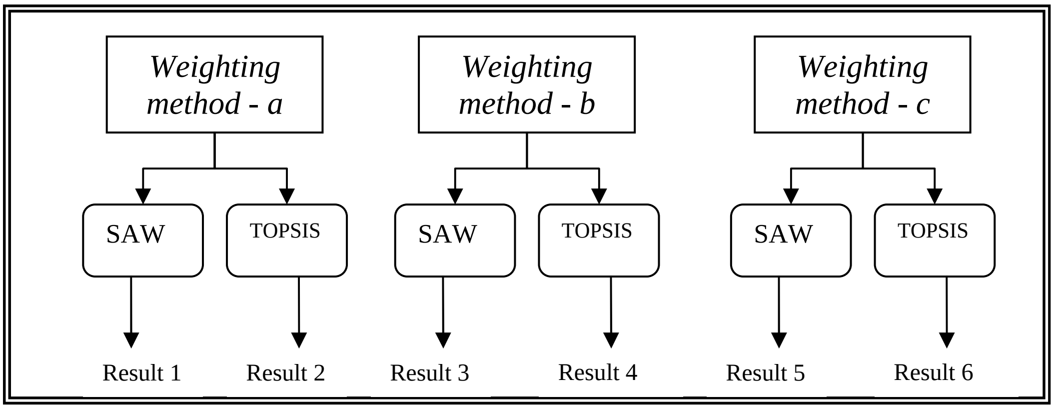
For each of the pair of attributes *k,l* where attribute *k* is considered more important than attribute *l*, we are asked to determine their degree of differential importance ($d_{k,l}$) using a scale that has its origins to the Analytic Hierarchy Process proposed by Saaty in the 80's [3]. That scale of relative importance is the following:

Intensity of importance	Definition
1	Equal importance
3	Weak importance of one vs the other
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate values when a compromise between odd values is needed
Reciprocals of above numbers	If attribute *k* has one of the above numbers assigned to it when compared with attribute *l*, then *l* has the reciprocal value when compared with *k*

We construct a matrix *D* where the element $D_{k,l}$ is the result of the comparison between attribute *k* and *l*. The relationship $D_{l,k} = 1/ D_{k,l}$ also holds true. For calculating the weights we utilize the geometric mean g_k of each of the row of the matrix *D*.

$$g_k = \left(\prod_{1}^{l} D_{k,l} \right)^{1/k}$$

After calculation of the weights with each of the above methods we utilized the MADM models with the three weighting scenarios separately, reaching out to a final result of six different ranking schemes according to the table bellow.



The MADM models are described in the next section.

V. SIMPLE ADDITIVE WEIGHTING (SAW) MODEL.

The model is one of the best known and easy to implement while it is widely used in a variety of cases [4], [5].The model assigns a value to each alternative using the following equation:

$$R_i = \sum_{n=1}^{j} w_j x_{ij}$$

where R_i is the score of the i^{th} alternative (worker), w_j is the weight assigned to the j^{th} attribute and x_{ij} is the actual value of the i^{th} alternative in terms of the j^{th} attribute. In order for the above sum to be applied, the attribute values must be quantified and normalized first. These procedures serve the purpose of transforming attribute values to a compatible scale.

In our case we initially transformed nominal level answers into cardinal ones. We had a number of questions that the worker needed to answer in order to provide us with his level of use of a specific language by choosing between three levels, *no use, little use* and *good use*. We gave arithmetic values to each of the answers according to the next table.

Answer	Value Given
No	0
Little	0.5
Good	1

Where there were two possible choices for an answer, we gave the values 0 and 1 for each of the answers. The choice of having values between 0 and 1 was taken because the normalization process that follows will provide us with values between 0 and 1 for each of the attributes.

The normalization procedure we followed is the Linear Scale Transformation (Max Min Method). This method considers both the maximum and minimum ratings of attributes. For benefit attributes (attributes that add preference to our selection) the normalized value r_{ij} is obtained by

$$r_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}}$$

while for cost attributes r_{ij} is obtained by

$$r_{ij} = \frac{x_j^{\max} - x_{ij}}{x_j^{\max} - x_j^{\min}}$$

Benefit attributes where the following:

- An age level between 25 and 50 (workers were assigned a value of 1 in the case were their age was between these limits and a value of 0 in the opposite case)
- Total years of education
- Level of use for a language (Greek, Arabic, English)
- Computer use
- Years working in Greek fisheries
- Previous experience in aquaculture

Cost attributes were

- Family status (being married was considered a drawback)
- Extra years intended to stay in Greece (we favored Egyptian migrants who wish to return soon to their home country)

After the normalization took place, we applied the weights of each of the weighting methods and ended up with 3 different rankings under the implementation of the SAW model. The equation used for ranking the workers is the SAW model equation that is presented in the beginning of the chapter.

V. THE TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO THE IDEAL SOLUTION (TOPSIS)

The model was developed by Hwang and Yoon [6]. It considers that the preferred alternative is the one with the least geometrical distance from the ideal solution and at the same time with the longest distance from the negative-ideal solution.

As a first step we quantify the nominal level variables in a way similar to the one used within the SAW model. Next we construct the normalized decision matrix *R* with each element calculated by

$$r_{i,j} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$$

where x_{ij} the value of the alternative *i* to the *j* attribute and *n* the number of alternatives.

Next we construct the weighted normalized decision matrix *D* as follows

$$D = \begin{bmatrix} r_{11} * w_1 & \dots & r_{1m} * w_m \\ . & . & . \\ . & . & . \\ . & . & . \\ r_{1n} * w_1 & \cdots & r_{mn} * w_m \end{bmatrix}$$

In our case the number *n=400* was the number of questionnaires assessed and the number *m=12* was the number of attributes used.

We then determine the ideal and negative ideal solutions:

$$A^{+} = \max_{j}[d_{ij}] = [\overset{+}{d}_{1}, \ldots \overset{+}{d}_{m}]$$

$$A^{+} = \min_{j}[d_{ij}] = [\overset{-}{d}_{1}, \ldots \overset{-}{d}_{m}]$$

The distance between each alternative and the ideal and negative-ideal solution is respectively:

$$S_j^{+} = \sqrt{\sum_{i=1}^{m} (d_{ij} - \overset{+}{d}_{i})^2}$$

$$S_j^{-} = \sqrt{\sum_{i=1}^{m} (d_{ij} - \overset{-}{d}_{i})^2}$$

Finally we calculate the relative closeness to the ideal solution by:

$$C_j = \frac{S_j^{-}}{S_j^{-} + S_j^{+}}$$

and rank the alternatives by decreasing order of C_j.

By using this method each time with a different weighting approach, we ended up with three separate rankings of the workers under evaluation.

VI. AGGREGATING THE DIFFERENT RANKING RESULTS.

After applying all the models to our data, we resulted with an output of 6 different ranking outcomes, through the 2 models applied with each one employing 3 weighting approaches. Our goal was to make use of each of the resulted rankings for retrieving a final ranking order of the selected workers that would be qualified for aquaculture seminar attendance.

In order to do so we have taken a simple approach. We summed up the ranking order numbers of each worker from each of the six outcomes and divided this number with the total number of outcomes.

$$FR_i = \frac{\sum_{k=1}^{6} R_{i,k}}{6}$$

where FR_i is the final ranking of the *ith* alternative (worker), $R_{i,k}$ the ranking of the *ith* alternative in the *kth* output of each of the 6 ranking outputs.

In this way we ended up with a final ranking for all of the workers that participated in the evaluation procedure. An interview with the first-ranked among them will take place in order to assess all the necessary information for making a correct and sound selection for the training that will substantiate the up-skilling process.

VII. CONCLUSIONS

The MADM methods have been applied using MS Excel 2003. We took care for the choice of the "***best-fitting candidate migrant fishermen to train***", to be performed and arrived at, through a sound method making appropriate and concrete use of the variety of information we have obtained for each of the subjects. The need to adopt such a method came from the fact that for an up-skilling program to be effective, we must take into account the existent qualifications and attributes of the persons to be trained. Our goal was to give this training/up-skilling opportunity by priority to those fisheries workers that gather in their profile the characteristics / attributes maximizing the chances that they shall make use of the benefits of this training when back in their country where Aquaculture is a growing and promising field of activity and the need for a trained and specialized labor force enters into reality.

One should clarify here that a candidates' good response to such 'objective' criteria as used above, is viewed as a constellation of attributes necessary to secure their first level adequacy for the purpose of the project. But such attributes are not sufficient by themselves in order to secure that the candidates' choice is the best. Other behavioral and subjective attitudes of the candidates can significantly add to the sufficiency prerogative when it comes to the 'best' choice of our candidates. Parameters that have to do with the entrepreneurship attitudes of the candidate, his level of expectations, his attitude towards social and spatial mobility, the accumulated migrant's remittances wealth and their degree of immobilization versus liquidity, are among few of the more important additional factors to be considered prior to the ideal/final choice of a candidate. Some of these parameters can be defined within the remaining answers to our questionnaire and for some others we may be fortunate to get an answer during the personal interview process. Yet most unfortunately, only after the evaluation of the trainees' practical attitude and performance during the training process as well as following the appreciation of his final opinion on the worth of this up-skilling effort, one can shape a more definitive opinion on the right choice of the candidate.

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