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Intelligent Environmental Scanning Approach (A Case Study: the Egyptian Wheat Crop Production)

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Abstract

Policy/decision makers need to an intelligent, robust and more confidence mechanism to help them to analysis the futures impacts and overcome the future high uncertainty and complexity. Also, all environmental scanning and analysis methods in literature conduct for the current /short-term to help policy/decision makers in strategic decisions process. The core idea of our research paper is to develop an intelligent environmental scanning approach (IESA) to generate more justifiable estimation for long-term strategic view. In addition, our IESA supports policy/decision makers to reduce the future uncertainty and stimulates the domain experts to identify the major futures drivers of a specific domain. This support deals with providing new levels of awareness situation that may lead to more efficient and effective decision making process. Moreover, our IESA enhances and integrates RT-Delphi, Ontology KB, Explanation, PESTEEL, SWOT and Structural analysis methods to generate large-scale participatory approach to help policy/decision makers for long-term environmental scanning. Final, this paper builds on our research to support policy/decision makers in the Egyptian ministry of agriculture (MOA) for developing the strategic plan (2014-2035) of the Wheat crop production.

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Keywords: Intelligent Environmental scanning, Long-term view, RT-Delphi, MICMAC, SWOT, PESTEEL, Explanation, Wildcards, Egyptian Wheat production.

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1. Introduction

Long-term strategic analysis (LTSA) is an important decision making process that helps policy/decision makers to develop effective and efficiency long-term strategic view. Thus, LTSA is crucial to help for decision-making under conditions of high uncertainty and complexity [1]. Environmental scanning phase plays a fundamental role in the long-term strategic planning. In addition, it is used to identify all drivers by discovering the current internal strength and weakness, external drivers and future external opportunities and threats of a specific domain [2].

A PEST analysis is a widely used environmental analysis tool. PESTEEL stands for Political, Economic, Socio-cultural, Technological, Legal and Ethical issues. Its analysis examines the impact of each of these factors on a specific domain [2]. In addition, SWOT analysis is an important strategic planning tool used to evaluate the internal Strengths, Weaknesses, Opportunities, and External Threats involved of a specific domain. A SWOT analysis cooperates with the results of the PESTEL analysis [2, 3].

For knowledge elicitation process from the domain experts, Real-Time (RT-Delphi) Delphi technique is widely-used as a structured and controlled debate [4, 5]. In RT-Delphi, all opinions are made anonymous and the domain experts move toward consensus. it has the following 5 advantages (in comparison to traditional Delphi): Round-less approach then significantly saves time and cost, experts have instantaneous access to the website, flexibility in the number of participants and it can be easily applied to problems formulated in a matrix design[6].

The process of knowledge acquisition requires an agreement on the concepts and their attributes of a specific domain [7]. Ontology describes domain concepts and their attributes and all relationships that hold between these concepts. It is crucial in order to harmonize the meaning of concepts and provide richer relationships between them [7, 8]. This paves the way towards the knowledge acquisition process by minimizing the chances of misunderstandings when debating a certain concept or a problem. It provides for reducing the contradiction of the experts' judgments by defining a common language between domain experts and avoiding misunderstandings when talking about specific topics [8]. The explanation facilities for the knowledge-based model indeed influence policy/decision maker confidence in acceptance the consensus results [9].

Moreover, MICMAC (Impact Matrix Cross-Reference Multiplication Applied to a Classification) represents a structural analysis based on comparing the hierarchy of issues in the different classifications (direct, indirect and potential), which is a rich source of information to determine the major wildcards of a specific domain [10]. Final, most of classical environmental scanning models, in literature, provide only the short and medium term [11, 12, 13, 14, 15].

The paper structure is organized as follows: in Section 2, we discuss the problem addressed. Then in Section 3, our proposed solution is explained in details including the inputs, output and the approach itself. Also, in Section 4, we give a case study. Finally in Section 6, we conclude and suggest possible future work.

2. Problem Addressed

The most of classical environmental scanning models aren’t efficient and effective enough to deal appropriately with the long-term complexity and uncertainty that vital properties of long-term future. Also, theses conventional models are depending on a limited number of anticipators. Moreover, the classical environmental scanning models have limitations in handling knowledge acquisition process, for instance: dealing with the misunderstanding of some concepts’ meaning, handling knowledge contradiction, allowing knowledge gathering from experts in different locations and having an efficient communications between experts.

3. Solution Proposed

The main purpose of this research is to develop an intelligent Environmental Scanning Approach (IESA) that efficient and effective enough to deal appropriately with the long-term complexity and uncertainty. IESA depends on domain experts' judgments, their justifications and modeling capabilities.

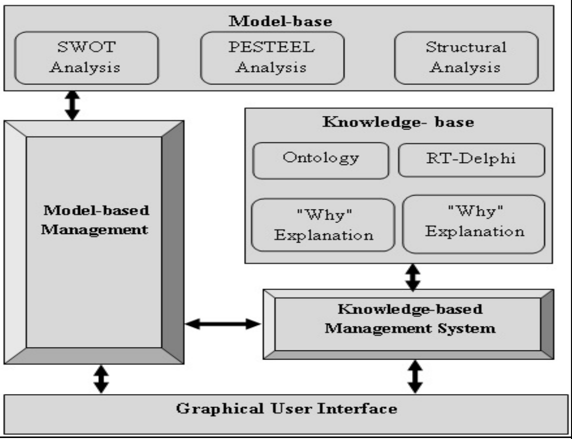

Fig.1.Conceptual framework for the IESA

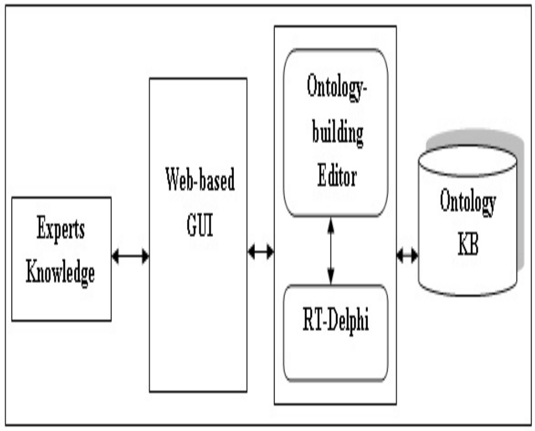

Fig.2. Phase1.Ontology Building

As shown in the previous figure, the developed IESA framework. Below we will explain methodology of the developed IESA, its inputs and output, and finally the phases' flowchart. Note that the developed IESA approach was implemented and tested using the developed IESA tool with C# programming language and XML (the reader interested in the code can email the authors).

3.1. Inputs/Outputs

The inputs of our developed approach are knowledge about PESTEEL, SWOT, Structural analysis and meta knowledge about "what" and "why" explanation (the usage of each input will be illustrated in the methodology section). The final consensus results of the developed IESA approach are the major drivers and explanation knowledge that give policy/decision makers more justifiable results.

3.2. IESA Methodology and Phases

Our methodology is based on developing an intelligent large scale participators approach for environmental scanning process. It provides the distributed interaction capabilities and helps for building and managing knowledge repositories for environmental scanning process. Different knowledge-based and model-based methods are integrated to achieve this task. In addition, we enhanced the web-based RT-Delphi model by adding visualization and explanation capabilities and integrating with an ontology KB model. The widely used environmental scanning models that are SWOT, PESTEL and MICMAC analysis, also, are integrated with the enhanced RT-Delphi to perform the environmental scanning task.

As shown in figure.1, the developed framework consists of five main components, which are model-base, knowledge-base, model-based management system, knowledge-based management system and graphical user interface components. There are different models in knowledge-base system, which are enhanced RT-Delphi, ontology building model, "What if" and "Why" Explanation. Also, SWOT, PESTEEL and Structural Analysis are the three models that represent the model base components.

The model-based and knowledge-based management systems components provide the integration and execution of all models. Final, graphical user interface sub-system provides the policy/decision decision maker capabilities for reporting consensus summary information, explanation and visualization capabilities. In the following, the methodology of the IESA will be illustrated in each of the previous flowcharts:

The enhanced RT-Delphi model is used as a knowledge acquisition tool for ontology building. It cooperates with ontology building editor, as shown in figure 2, to generate a domain ontology KB. The developed ontology KB consists of four sub-ontologies: model drivers, model variables, participators, questionnaires which are consist of different concepts. Moreover, each sub-ontology consists of different concepts' prosperities (name, description, weight ranking and its impact).

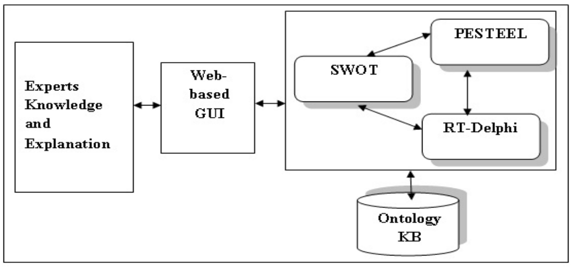

Fig.3. Phase2. Identification Phase

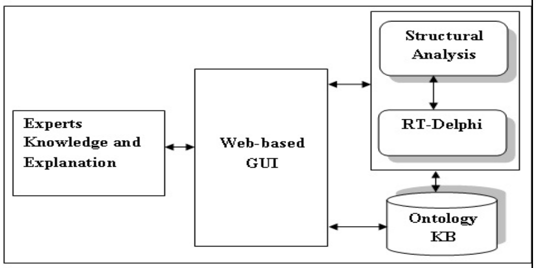

Fig.4. Phase3. Structural Analysis Phase

Figure 3 explains the identification phase. It plays a fundamental role in environmental scanning. It is used to identify all drivers by utilizing experts' knowledge and their imaginations. This phase provides to identify the external drivers and current internal strength and weakness. In this phase, we enhanced the web-based RT-Delphi model by adding visualization and explanation capabilities. Also, the widely used environmental scanning models that are SWOT, PESTEL are integrated with the enhanced RT-Delphi to perform the environmental scanning task. Figure 4 shows the integrated ERT-Delphi with SWOT and PESTEEL analysis.

Figure 6 explains the structural analysis phase. Based on integrating two futures studies methods, which are MICMAC and the enhanced RT-Delphi (ERT-Delphi) method, MICMAC E-RT-Delphi will be used to identify the major drivers, which are essential to the system's development. As shown in figure7, the knowledge acquisition process of structural analysis is based on the RT-Delphi numerical questionnaires. The knowledge acquisition screens are classified as two types: the first is a guide-knowledge that contains for each question median response of the domain experts group, the number of responses made, justifications that others have given for their responses, and finally, the related links for the questionnaires' types. Also, the second type is the judgment- knowledge that allows the domain exerts to add new respondent's numerical answer and type their justifications for their own answer(s). A large-scale of the domain experts can fill in the MICMAC E-RT-Delphi matrix over a specific period of time determined by the domain analysts. When the relationship between domain drivers is direct influence, the filling-in direct influence is low (1), medium (2) or high (3). In addition, zero value (0), appears if there is not a relation.

After the knowledge acquisition process is finished, the system runs MICMAC algorithm raising the structural analysis matrix to the power of successive values (power seven is widely used in literatures) to find the indirect relations between each pair of drivers. After that, the final matrix is normalized, summation process for both rows and columns are applied. The visualization and report generation components are used for generating a consensus report for policy/decision makers.

4. Case Study: The Egyptian Wheat Crop Production

Egypt represents the world's largest wheat importer, and high global prices are feeding into domestic prices. In addition, the products of the Wheat crop are crucial food for most Egyptian people [16, 17, 18].

This paper builds on our research to support policy/decision makers in the Egyptian ministry of agriculture (MOA) for developing the strategic Plan (2014-2035) of the national crop production. In this case-study, we help policy/decision makers in MOT to generate more justifiable estimates for the major drivers in the national wheat production during the next 13 years. In addition, we may support to reduce the future uncertainty and complexity and stimulates the Wheat production experts and futurists in Egypt to anticipate the futures threats and opportunity for this crucial domain in Egypt.

Based on PESTEEL, SWOT, Structural Analysis and ontology-based RT-Delphi, more than 18 domain experts/futurists participate to help policy/decision makers by providing new levels about the major domain drivers and their relations. In the following we illustrate the consensus results:

4.1. The summary of the Identification phase can be described as the follows:

- PESTEEL Analysis:
The consensus results show that the numbers of the political drivers are five, the numbers of the economical drivers are eight, the numbers of the soci-cultural drivers are two, the numbers of the technological drivers are two, the numbers of the ethical driver is one, the numbers of the environmental drivers are three, the numbers of legal drivers are two. All of the selected drivers are evaluated by weights with median values between 70% and 93%. Also, more than 12 domain experts have to agree about the evaluated major driver.
- SWOT Analysis:
The consensus results show that the number of strengths items is five, the number of weaknesses items is twenty two, the number of opportunities items is five, and the number of threats is twelve. All of the selected items are evaluated by weights with median values between 72% and 87%. Also, more than 12 domain experts have to agree about the evaluated items.

4.2. The summary of the structural analysis consensus results:

In structural analysis phase, there are three major steps that are listing the wildcards, describing the relationship between them and identifying the keys.

- StepA. Listing the Wildcards:

In this step, all wildcards that is coming from the PESTEEL and SWOT analysis is listed. There are important twelve wildcards, which are: Global temperature, Global economic goes up, World financial crises, Economical instability in Egypt, Dissemination of the Epidemic diseases, Major overseas transportation accidents, Major natural catastrophic events, Significant pollution increasing, Bad weather conditions, Climatic change in the Egyptian Delta, the Governmental view for the self-sufficiency of the Wheat production, and Water scarcity. These drivers/wildcards take consensus weights from 75% to 95% in the PESTEEL analysis.

- StepB.Relationships Description

The MICMAC E-RT-Delphi attempts to discover the relationships among wildcards. The following table shows the input matrix of this step. Note: (high relation = 2, low relation =1 and no relation= 0).

- StepC.Key Drivers Identification

This step consists of identifying the key wildcards, which are essential to the Wheat production development, first by using direct classification (easy to set up), then through indirect classification by RT-

Delphi MICMAC model. This indirect classification is obtained after increasing the matrix power in to the power7 (based on the literature). The consensus results of the structural analysis that shows that: Water scarcely, Governmental view for the self-sufficiency of the Wheat production, the Climatic change in the Egyptian Delta; the World financial crises are the key wildcard events for future of the Egyptian wheat production. Displaying the futures scenarios numerical report and figures may help policy/ decision makers in MOT in anticipating the most important future drivers and enhance the quality of future strategic plan.

5. Concluding Remarks and Future Work

- The developed IESA deals creating an efficient large scale participation network. It provides the policy/decision makers for reducing uncertainty and complexity and improving the quality of future decision making. Different knowledge-based methods (E-RT-Delphi, SWOT, PESTEL, Explanation and ontology building) integrated with model-based methods (MICMASC) to help for building and managing knowledge repositories for environmental scanning process.
- We applied the developed framework and its represented web-tool to help policy/maker for addressing the major futures drivers in the Egyptian Wheat crop production during the next 13 years.
- Our future work could be extended by integrating the proposed approach with the interval based/fuzzy based TIA to anticipate futures impacts of the major drivers. Also, data-mining techniques can be used as powerful tool for automated ontology building.

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