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## An Intelligent Recommender System for Long View of Egypt's Livestock Production<sup>\*</sup>

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### Abstract

Research on the Egyptian food security, is a crucial subject of a huge studies and debates. The gap between the Egyptian domestic milk production and consumption is translated into high import costs. Also, all policy analysis and evaluation methods in literature conduct for the current /short-term policies to help policy/decision makers in strategic decisions. The core idea of our research paper is to develop an intelligent recommender system (IRS) to generate more justifiable estimates to evaluate of the suggested long-term policies. In addition, our IRS supports policy/decision makers to reduce the future uncertainty and stimulates the domain experts to anticipate the futures impacts and evaluate their suggested policies. This support deals with providing new levels of awareness situation that may lead to more efficient and effective decision making process. Final, our IRS integrates Trend Impact Analysis, RT-Delphi, Knowledge-Based, Explanation and Mathematical forecasting models to generate large-scale participatory approach to help policy/decision makers for long-term strategic planning.

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## 1. Introduction

The Egyptian agricultural domain plays an important role in the Egyptian economy as it represents more than 20% of the national GDP and employs nearly 30% of the working population [1]. In addition, the national food security has been noted to be the main goal to achieve a real development and to meet rising of the Egyptian population that expected to be more than 100 million by the year 2030. The policy/decision makers' strategy for animal production in Egypt, up to year 2035, aims to reduce the milk production gap to be less than 10% [2].

There are different national research and development efforts tried to tackle the problem of food shortage and to enhance the revenue from milk production in Egypt. The national milk production in Egypt is dependent on buffaloes, cattle, small ruminant (sheep and goats) and camels, which are the most suitable animals for Egypt [3]. In 2012, animal production in Egypt represented about 27.4% of the agricultural gross domestic product (AGDP). Milk productivity of buffaloes increased from about 1.3 ton/head/season to 1.1 ton/head/season. Fortunately, there are still large efforts to improve this milk productivity [4, 5].

Uncertainty and Complexity, which are arising from future unprecedented events/ wildcards, represent the main characteristics for long-term strategic planning process [6]. For long-term strategic planning, policy/decision maker need for two crucial activities, which are explorative futures scenarios and policy formulation and evaluation [7]. Explorative futures scenarios provide awareness situation for the wildcards future impacts. However, the policy formulation and evaluation provides justifiable recommendations for futures policies based on their expected impacts [8]. Due to the future high uncertainty and complexity, long-term policy formulation and evaluation represent unstructured processes [9].

The Delphi method is a powerful and a well structured tool for knowledge acquisition, because its anonymity process. In Delphi method the process for knowledge acquisition from domain participators is done by controlled opinion feedback for a series of questionnaires [10]. It provides the domain participators to move toward consensus [6]. Moreover, RT-Delphi is a round-less Delphi applied as an on-line tool [11]. Also, it is widely used to improve the efficiency of knowledge acquisition process from the domain experts and to create a large participatory and anonymity on-line system with between all participants (system analysts, researcher, experts, and decision/policy makers) [12].

Mathematical models provide to reduce the complexity that it composed of variables and relationships. Such models assume that the historical information contained can be extracted, analyzed, and reduced to one or more equations that can be used to forecast historical data [13]. But, this models force at work in the past will continue to hold in the future and the forecasts are surprise-free [14]. Trend Impact Analysis (TIA) is widely used instead of traditional forecasting models to generate all possible future scenarios rather than a single image for future forecast.

In development a TIA, three major steps are necessary [15]:

- Generate a surprise-free scenario based on historical data and given no unprecedented future events namely.
- Expert imagination and experiences are used to identify the major future wildcards, their impacts that cause a change in the base forecast. The knowledge acquisition process is based collection the experts' judge about the probability of occurrence and its expected futures impact. Real-Time (RT) Delphi is widely used tool for knowledge acquisition process.
- Using TIA algorithm and Monte Carlo Simulation to generate all possible future scenarios [16].

Moreover, domain ontology is major in order to provide an easy way towards the knowledge acquisition process by minimizing the misunderstandings when debating a certain concept or a problem [17]. It plays an important role for reducing the contradiction of the experts' judgments by defining a common language between domain experts. Also, it describes the domain concepts, their attributes and all relationships that hold between these concepts [18].

The core idea of our research paper is to develop an intelligent recommender system (IRS) to generate more justifiable estimates to evaluate of the suggested long-term policies. In addition, our IRS supports policy/decision makers to reduce the future uncertainty and stimulates the domain experts to anticipate the futures impacts and evaluate their suggested policies. The developed approach uses the enhanced TIA [16] as the point of departure.

## 2. Problem Addressed

Policy/decision makers, in the Egyptian ministry of agriculture, need to generate and evaluate the long-term policies that can improve the quality of their long-term strategic plan from 2014 to 2035. They need to predict the future, analysis its impacts and be confidence about benefits of the suggested policies. Classical futures analysis methods always provide analysis for the major drivers and their possible future impacts. These methods isn't quietly provides a suggestive guidance for evaluating the future policies and their impacts on minimizing the future threats and maximizing the future opportunity.

## 3. Solution Proposed

### 3.1 The Developed Framework

As shown in figure.1, the developed framework consists of three main components, which are model-based, knowledge-based and graphical user interface sub-systems. Model-based component has two sub-components, which are model base and model-base management sub-component. There are different models in model-base system, which are enhanced RT-Delphi integrated with TIA model (ERT-Delphi TIA) and Case-based model. The model-base management component provides models integration and execution. In addition, knowledge-based component has two sub-components, which are knowledge-base and knowledge-based management system. The Knowledge-base component consists of three sub-components which are ontology, explanation and policy sub-components. The explanation sub-component provides “What if” and “Why” explanation, which help for reducing the uncertainties associated with the long-term scenarios and increasing the confidence of policy/decision makers about the consensus results. Furthermore, the domain expert knowledge consists of two main categories, which are experts' judgment and its justifications that represent the core of “Why” explanation. Final, graphical user interface sub-system provides the policy/decision decision maker capabilities for reporting consensus summary information, consensus justifications and the visualization capabilities.

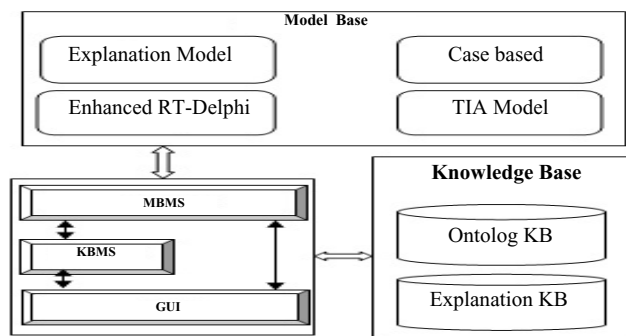


Fig. 1. 'Conceptual view of the developed framework'

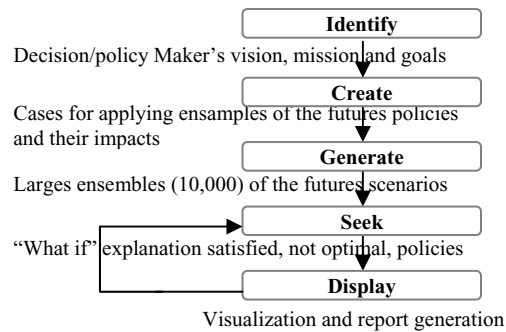


Fig. 2. Flow chart of the major phases

### 3.2. The Developed Methodology

Below, we shall explain the functions of the developed methodology illustrated in each of the following flowcharts: Our developed methodology is based on utilizing domain experts' experiences and imagination. It utilized both quantitative and qualitative futures studies' models, which are RT-Delphi, explanation, case-based enhanced TIA, forecasting and simulation modeling. Also, the future policy evaluation approach is based on its expected future impacts. In addition, there are different types of inputs, which are: experts' knowledge (experiences and imagination), policy/decision maker goals and their insights, the formulated policies, and all possible future scenarios.

In addition, it aims to help for reducing the gap between the decision maker's goals, the current state and the possible futures. As shown in figure2, our developed methodology consists of five phases of completing this task is as follows: 'Identify', 'Create', 'Generate', 'Seek' and 'Display' phases. Based on 'Identify' phase, policy/decision makers can describe about the future vision, mission and goals of his/her organization. Each policy associated with two types of evaluation factors, which are effectiveness factor and efficiency factor (Effv\_F) and (Eff\_F). The effectiveness and efficiency factors are represented in each Political, Economical, Soci-culture, Technical, Ethical, Legal (PESTEEL) issues.

'Create' phase provides policy/decision makers to generate all possible cases for futures opportunities or threats. The inputs of this phase are TIA inputs' matrices, wildcards, and expert anticipation about future impacts and the suitable policies. In addition, the outputs are different cases for wildcards impact and the proposed policies for optimizing their benefits and reducing their threats. The enhanced RT-Delphi is applied to elicit the knowledge from the domain experts. 'Generate' phase provides policy/decision makers to apply ensamples of the proposed future policies and their impacts on the domain key variables by generating all possible futures scenarios TIA algorithm is used to generate all possible futures scenarios to reflect the impacts of applied the proposed policies. In the other hand, Seek phase provides policy/decision makers to evaluate the impacts of each policy on the domain key variables, which may lead to find the satisfied policies. The comparative between the two types of the outputs' scenarios, which are case-based scenario and the benchmark TIA scenarios (basic TIA scenarios), is applied to find the satisfied polices. The values of both Min and Max scenarios are used for applying this comparative to reflect the increasing and reducing types. Finally, 'Display' phase provides policy/decision makers for different explanation, visualization and report generation capabilities.

#### 4. Case-study: The Future of the Egyptian Milk Production

The historical data has been sourced from FAO annual reports and the Egyptian governmental agencies. The percentage of milk production gap data was available from 2000 to 2013 [19, 20]. The available historical data contains only 14 points. To explore all possible futures, it is required to build a mathematical forecasting (surprise-free) model for 22 years ahead. Based on the Simple Regression Model and assuming the relationship between the gap milk and the time is linear; the mathematical formulation can be calculated by:

$$Y (\text{Gap value}) = a + b X (\text{Year}) + E$$

Least square is popular used to estimate the value of a and b and based on MINITAB13 software, the value gap percentage can be estimated using the following equation:

$$\text{Gap Value} = 1750 - (0.86 * \text{Year})$$

$$\text{With Mean Square Error (MSE)} = 11.75\%$$

Experts' knowledge explains how would World financial crises (E1), Dissemination of the epidemic diseases (E2) Bad weather conditions (E3) and High inflation of the animal feeding prices (E4) wildcards affect on milk production gap in the future, if they were said to occur. Should any of these events occur, (E2 and E3) have negative impacts (increasing the gap value) whereas the (E1 and E4) have a positive impact (decreasing the gap value). There are 10,000 scenarios are generated and the study is for 22 year ahead. The generated scenario results show that the world financial crises (E1) wildcard has a positive impact (decreasing the gap value). Experts' consensus expected its occurrence, with different severities, from 2014 to 2021.

Experts explain how E2 has the highest maximum impact on the gap and how its behavior is a high speed of disseminations due to lack of the powerful extension in all Egyptian governorates, directorates and villages. E2 has a probability of occurrence with a high severity for separated seven years. Also, the bad weather conditions (E3) wildcard has negative impacts (increasing the gap value). Experts have a consensus about its probability of occurrence with a high severity from 2020 to 2030.

Table.1 displays the Base Forecast, Median, Max, Median and Percentile scenarios. The generated future scenarios are very insightful and provide policy/decision makers for anticipating the future and hence properly plan for it. From table.1, policy/decision makers can notes three main observations, which are:

- The best interval time is expected to be from the year 2014 to 2021. This gap decreasing is due to the positive impact of “the world financial crisis” wildcard.
- The critical time interval, which has the highest impact of the negative wildcards, is expected to be during 2028 to 2034. The gap value will be increased by 10% compared with the base forecasting value.

Table. 1. The numerical values of the generated futures scenarios

Benchmark Scenarios									
Years	Base	Max	Min	Median	Mean	95%	75%	25%	5%
2014	21.40	21.15	19.4	21.02	21.02	21.02	20.37	20.42	20.37
2015	20.53	20	18.34	19.87	19.87	19.87	19.2	19.26	19.21
2016	19.67	18.88	17.32	18.76	18.76	18.76	18.18	18.13	18.13
2017	18.81	17.78	16.31	17.67	17.67	17.67	17.12	17.08	17.07
2018	17.95	16.7	15.32	16.6	16.6	16.6	16.0	16.09	16.04
2019	16.09	15.65	14.35	15.55	15.54	15.55	15.02	15.07	15.03
2020	15.23	14.61	13.4	14.51	14.51	14.51	14.02	14.06	14.03
2021	14.36	14.31	13.16	13.89	13.84	14.16	13.63	13.25	13.21
2022	13.50	14.81	13.3	14.15	14.03	14.6	13.75	13.67	13.33
2023	12.64	15.15	13.91	14.79	14.58	15.07	14.36	14.01	13.98
2024	11.78	15.88	14.24	15.19	15.06	15.7	14.74	14.66	14.28
2025	10.92	16.39	14.89	15.76	15.67	16.14	14.85	15.32	15.13
2026	9.06	16.93	15.62	16.29	16.2	16.69	15.39	15.81	15.35
2027	8.20	17.95	15.76	16.97	16.87	17.56	16.61	16.45	16.01

2028	7.33	18.15	16.75	17.41	17.34	17.87	16.42	16.94	16.46
2029	6.47	18.21	15.07	17.53	17.46	18.7	17.33	16.66	15.4
2030	5.61	18.58	15.29	17.64	17.6	18.26	17.15	16.66	15.4
2031	4.75	17.82	14.7	16.93	16.92	17.52	16.45	15.95	14.8
2032	3.89	16.58	13.65	15.74	15.74	16.3	15.31	14.82	13.77
2033	3.03	15.17	12.15	14.16	14.17	14.79	14.06	13.48	12.46
2034	2.16	12.76	10.2	11.88	11.9	12.43	11.83	11.3	10.43
2035	1.30	8.86	7.29	8.34	8.39	8.17	8.7	7.92	7.34

Table. 2. The numerical results for the optimization on-case scenarios Case-based scenarios

Benchmark Scenarios									
Years	Base	Max	Min	Median	Mean	95%	75%	25%	5%
2014	21.40	20.01	18.12	19.02	19.02	19.04	19.4	18.47	18.06
2015	20.53	18.37	16.376	18.06	18.06	17.8	17.43	17.12	17.21
2016	19.67	16.89	15.32	16.26	16.19	16.38	16.81	16.13	16.13
2017	18.81	15.38	15.04	15.12	15.67	15.67	15.67	15.08	15.07
2018	17.95	14.37	13.32	14.6	14.6	14.6	14.09	14.04	14.04
2019	16.09	13.75	13.75	13.25	13.25	13.54	13.14	13.03	13.02
2020	15.23	14.61	13.4	14.51	14.51	14.52	14.0	14.03	14.02
2021	14.36	12.68	12.02	12.84	12.58	12.60	12.51	12.19	12.15
2022	13.50	14.81	13.3	14.02	14.17	13.71	14.6	13.33	13.67
2023	12.64	15.15	13.91	15.07	14.79	14.36	14.55	14.01	13.98
2024	11.78	15.88	14.7	15.05	15.10	15.7	14.66	14.28	14.24
2025	10.92	16.39	15.13	15.66	15.74	16.14	15.31	14.88	14.85
2026	9.06	16.93	15.62	16.69	16.27	16.19	15.8	15.38	15.35
2027	8.29	17.94	16.05	16.43	16.95	17.54	16.85	16.81	15.76
2028	7.33	18.15	16.42	17.33	17.41	17.86	16.75	16.93	16.46
2029	6.47	18.7	15.07	17.44	17.45	18.2	17.35	16.6	15.45
2030	5.61	18.58	15.29	17.59	17.57	17.15	16.59	18.25	15.39
2031	4.75	16.9	14.7	17.82	16.86	17.49	16.45	15.93	14.8
2032	3.89	16.58	13.68	15.73	15.69	16.28	15.31	14.82	13.77
2033	3.03	15.17	12.15	14.06	14.015	14.75	14.11	13.37	12.46
2034	2.16	12.76	10.2	11.88	11.82	12.12	11.22	11.83	10.45
2035	1.30	8.86	8.17	8.39	8.35	8.7	7.9	7.34	7.29

The consensus results show that the number of the political drivers is five, the number of the economical drivers is eight, the number of the soci-cultural drivers is two, the number of the technological drivers is two, the number of the ethical driver is one, the number of the environmental drivers is three, the number of legal drivers is 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. In addition, the consensus results show, also, 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.

By comparing between the numerical values of table.3 (bench mark scenarios) and table.5 (optimization case-based scenarios), policy/decision makers can notes the suggested policies expected to increase the positive impact for WFC wildcard, which can reduce the gap value. From 2014 to 2021, the impacts of the ensamples policies can be measured by decreased between 1% and 3.6%. Final, 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 ministry of agriculture in anticipating the most important future drivers and enhance the quality of future strategic plan.

## 5. Concluding remarks and future work

Complexity and uncertainty of the long-term futures are the major challenges to develop more justifiable estimates for the quality of long-term policies. To summarize, in this paper, we can summarize, in this paper, we develop an intelligent recommender system (IRS) to help policy/decision maker for more justifiable estimates to the efficiency and effectiveness of the suggested policies for the long-term strategic planning. The developed IRS is based on integration of scenario-based, knowledge-based and explanation modeling capabilities. To illustrate the developed IRS, a case study is provided concerning the impact of external wildcards on the milk production gap in Egypt. In this case, our IRS supports policy/decision makers in the Egyptian ministry of agriculture for developing the strategic Plan (2014-2035) of the national livestock production. This support deals with providing new levels of awareness situation that may lead to more efficient and effective decision making process. Our future work could be extended by integrating the proposed approach with the interval based/fuzzy based TIA. Also, data-mining techniques can be used as powerful tool for automated ontology building. It could be used to speed up and improve the process of creating a formal ontology of a specific domain.

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