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ScienceDirect

Procedia Computer Science 120 (2017) 430–437

Procedia Computer Science

www.elsevier.com/locate/procedia

9th International Conference on Theory and Application of Soft Computing, Computing with Words and Perception, ICSCCW 2017, 24-25 August 2017, Budapest, Hungary

Fuzzy cognitive model development for monitoring of results and reporting within the UN FAO food security program

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Abstract

A fuzzy cognitive model was developed and described for assessing the level of food security for countries where there is no guaranteed regular access of the population to high-quality food necessary for an active and healthy lifestyle. As a basis it was chosen a cognitive map covering a rather wide range of food security influences, approved in the FAO Strategic Program for 2014-2017. To formalize the appropriate cause-effect relationships between these influences, bounded sets of fuzzy logic rules are used.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.

Keywords: Food security; cognitive map; fuzzy cognitive model; fuzzy inference;.

1. Introduction

Global trends and major challenges in terms of food and agriculture was formulated by IR (2017) for 2014-2017. These trends and challenges imply a significant increase in demand for foodstuff, prolonged food insecurity, malnutrition, including continuing spread of obesity among the population, poverty in rural areas, the complexity of agricultural production systems and food production, more dynamic flows in trade by agricultural products and changing rules for their regulation, climate change, as well as the need for better management under increasing complexity of the agricultural development process. At present, the UN FAO is implementing the institutional actions

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1877-0509
Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.
10.1016/j.procs.2017.11.260

aimed at completing the transition from the formulation of results based on the so-called static matrix approach to a more strategic approach based on "concrete results directed management". According to this approach, it becomes possible to concentrate efforts around the actions necessary to achieve the desired results at all levels, which in turn requires the existence of a scientific basis for operating efficiency management, reporting on results and using information to improve decision making. As a base of FAO operating efficiency management it is possible to use a model for the integrated assessment of the interim (tactical), strategic and global solutions in the field of food security, components of which should be the indicative results of the FAO. Therefore, in order to improve the monitoring of results and corresponding reporting it is necessary to form the appropriate system of integrated assessment (SIA) of indicators for FAO strategic goals (development results), organizational results and outcomes.

As any organizational and technological system, SIA is a humanist-type system, i.e. according to Zadeh (1973) the system in which an essential role belongs to the judgments and knowledge of parson. Unlike mechanistic systems whose behavior allows a numerical description, humanistic systems are weakly structured and much more complex. Therefore, the adequate SIA management is a very complex, weakly structured and, accordingly, difficult to formalize procedure. Existing developments of such systems involve the use of a systems approach that allows to consolidate the different processes occurring of the information system. Nevertheless, one of the most successful tools for describing and investigating of weakly structured systems (WSS) is cognitive modeling, which is actively used in the projecting of decision-making support systems under uncertainty. At the same time, according to Prangishvily (2005) the main advantage of the mathematical apparatus of cognitive analysis is the possibility of adapting the modeled system to possible changes in the external environment. The definition and comprehensive assessment of indicators for FAO strategic goals (SG), organizational results (OR) and outcomes (OC) has not only an objective, but also a subjective component, since in the last analysis such assessments are carried out by the parson. This is a rather important factor that necessitates the use of qualitative categories for the evaluation of solutions, i.e. terms of linguistic variables, which are the basic structural units of the natural language of the agent of management. As a consequence, given paradigm explains the need to apply the mathematical apparatus of fuzzy logic. Ultimately, the subjective thinking of the decision-maker becomes the reason for the emergence of a range of so-called "conditional acceptability" in the scale of assessments of target indicators, organizational results and FAO outcomes.

2. Problem statement

The principal steps towards the projecting of SIA are: foresight, prevention, localization and elimination of wrong decisions. At the same time, the definition and assessment of indicators of SG, (OR) and (OC) is always relative, and the desire to assign a numerical value to them is unacceptable from the point of view of further interpretation of complex results. FAO SIA is a complex concept and cannot be viewed as a simple aggregate of its interrelated and/or mutually dependent components, i.e. each of them is critically important. Therefore, in integrated assessment of results and reporting the numerical description (or averaging) of composite indicators is completely unacceptable. Distinctive features that must be taken into account during projecting of SIA are: 1) the incompleteness and uncertainty of the initial information on the content and nature of the influence that determine the SG; 2) the existence of multicriterion problems of alternative related to the need to considerate a large number of factors determining the SG; 3) the existence of a large number of qualitative indicators that must be considerate during solving the problems of developing and implementing of systems of integrated estimation of the factors determining the SG; 4) impossibility of using classical optimization methods. Therefore, taking into account above requirements it is necessary to develop such model for the integrated assessment of the tactical, strategic and global solutions in the field of food security, components of which should be the approximate desired results of the FAO.

3. Cognitive map for the projecting of FAO SIA

Let us consider a fuzzy cognitive model (FCM) on the base of a trivial example of a cognitive map, which allows generally to analyze the problem of monitoring tactical, strategic and global solutions of UN FAO in the field of food security (FS) when processing data using computer facilities. As can be seen from Fig. 1, this problem in a simplified form is described as an incompletely connected structure consisting the factors (influences) A, B, C, D, E, F and G, reflecting the corresponding cause-effect relationships between individual of them. In this case it is a signed graph in