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Expert Based System Design for Integrated Waste Management

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Abstract**—**Recently, an increasing number of researchers have been focusing on working out realistic solutions to sustainability problems. As sustainability issues gain higher importance for organisations, the management of such decisions becomes critical. Knowledge representation is a fundamental issue of complex knowledge based systems. Many types of sustainability problems would benefit from models based on experts' knowledge. Cognitive maps have been used for analyzing and aiding decision making. A cognitive map can be made of almost any system or problem. A fuzzy cognitive map (FCM) can successfully represent knowledge and human experience, introducing concepts to represent the essential elements and the cause and effect relationships among the concepts to model the behaviour of any system. Integrated waste management systems (IWMS) are complex systems that can be decomposed to non-related and related subsystems and elements, where many factors have to be taken into consideration that may be complementary, contradictory, and competitive; these factors influence each other and determine the overall decision process of the system. The goal of the present paper is to construct an efficient IWMS which considers various factors. The authors' intention is to propose an expert based system design approach for implementing expert decision support in the area of IWMSs and introduces an appropriate methodology for the development and analysis of group FCM. A framework for such a methodology consisting of the development and application phases is presented.

Keywords**—**Factors, fuzzy cognitive map, group decision, integrated waste management system.

I. Introduction

DECISION problems are usually characterized by numerous issues or concepts interrelated in a complex way. They are often dynamic, i.e., they evolve through a sequence of interactions among related concepts. Feedback plays a dominant role in updating the concepts states by propagating causal influences through multiple pathways. Formulating a quantitative mathematical model for such system may be difficult or impossible due to lack of numerical data and dependence on imprecise verbal expressions. An FCM is able to represent unstructured knowledge through causalities expressed in imprecise terms [1]. FCM offers many advantages for sustainability modelling including the ability to include abstract and aggregate variables in models, the ability to model relationships which are not known with certainty, the ability to model complex relationships which are full of feedback loops, and the ease and speed of obtaining and combining different knowledge sources.

Modelling problems related to sustainability is a challenge when humans are involved [2]. In case of integrated waste management (IWMS), problems are complex, involve many parties, and have no easy solutions or right answers. However, decision must be made. A useful modelling tool for the analyzing such problems would bring together the knowledge of many different experts from different disciplines, be able to compare their perceptions and to simulate different policy options, allowing for discussion and insight into the advantages and disadvantages of possible decision [2].

Why is a cognitive map? A cognitive map can be described as a qualitative model of how a given system operates. The map is based on defined variables. These variables can be physical quantities that can be measured, such as amount of waste, or complex aggregate and abstract ideas [2].

Experts, as a mean of direct interactions with the real world, are invited to filter and disseminate their knowledge in order for the inferences to be realistic. The graphical representation of a problem facilitates the analysis of the parameters, and reveals its simplicity and effectiveness especially in the case of complex systems [3].

The process of development of IWMSs involves significant degree of social analysis, utilization of pure technical features (collection, transport, equipment, etc.), legal and institutional issues based on personal experiences, expert judgment, synthesis of conflicting opinions, etc. Although personal experiences and expert judgment tend to be subjective, their contribution is vital to the completeness of waste management system design [4].

The methodology of FCM simulation starts with an expert workshop and a content analysis procedure as these are the input data to the simulation of the system in question. This paper now focuses on presenting the methodology tool for systematic modelling and unitization of expert knowledge to support the decision making process in the field of IWMSs.

II. Literature Review

A. The Development of Methods

Many environmental problems would benefit from models based on experts' knowledge [5], among them IWMS modelling as well. Several models have been developed in recent decades to support decision making in IWMS to monitor present conditions, to assess future risks and to

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visualize alternative futures [6], [7]. According to [6], [8] and [9], early waste management models developed during the 1960s and 1970s focused on studying individual functional elements, i.e. optimizing waste collection routes for vehicles or locating appropriate transfer stations. In the 1980s, the investigation was extended to encompass waste management on the system level, minimizing waste treatment costs. In the 1990s, the waste management models focused principally on economic (e.g. system cost and system benefit), environmental (air emission, water pollution) and technological (the maturity of technology) aspects. An environmental impact assessment model, the life cycle assessment (LCA) is also often used to aid the decision-making in waste management. Numerous studies applied the LCA method to evaluate the environmental impact of waste treatment alternatives. In several strategic planning models, both costs and emissions of waste management systems have been included in the research. In some models, the whole life cycle of products has been studied instead of only the waste management system when searching for environmentally optimal waste management strategies.

The increasing demand for types of models which combine environmental, economic and further aspects (like social, technological aspects) has led to the development of a latest generation of computerized models, which are similar to the LCA-based models, but include additional cost effects and/or social effects. In this case, cost effects can be regarded as an additional impact category. Examples of this type of models are GABI and Umberto [10], well known computerized tools especially in the German speaking community. From both methodological and practical point of view, it is a complex task to compare alternatives with respect to environmental effects, costs and social aspects. In most cases, the antagonistic targets of cost minimization, reduction of environmental effects and high convenience for the user (mainly of the waste collection scheme) cannot be met by one single scenario. It is increasingly likely that a scenario in which high costs are linked with high environmental standards and high convenience will be involved, whereas low-cost scenarios prove to be less environmentally friendly or less convenient.

B. The Evolution of Factors

In the preliminaries of this research we investigated the conditions and driving factors of sustainability of IWMS and determined its main aspects based on various authors. The concept of ‘key drivers’ are defined as factors that change the status quo of an existing waste management system (in either positive or negative direction), be it legislation that encourages an integrated approach to waste management or change of public perception in an IWMS. A large body of literature on factors that influence municipal waste management systems is available. According to the development of methods investigating urban waste management systems, the number of factors influencing system element increased dramatically worldwide. In the 1990s, the factors considered in municipal waste management models were principally economic (e.g. system cost and system benefit), environmental (air emission, water pollution) and technological (the maturity of technology) [8]. In the late 1990s, to compare different waste treatment and disposal scenarios, and rank them (from the `best' to the `worst'), the authors [9], [11], [12] investigated technical data (number of treatment/disposal technologies and available plants, relative capacities, geographical data), social progress (demography), environmental aspects (protection of the environment, use of natural resources, greenhouse gas load, acid load) and economic variables (maintenance of economic activity) [13]. In some studies [14]-[16] examining the situation of waste management in the developing countries, the authors introduced six principles: technical/operational, environmental, financial, socio-economic, institutional/administrative and policy/legal ones.

In the early 2000s, the development of factors continued. In the European Union [17], the role of policy, management and institutional structure (local and regional politics and planning strategy); operational demands (infrastructure and waste disposal, security, waste stream composition and change); economic and financial factors (available funding and subsidies, cost of current system and other option); legislation (prescriptive or enabling legislation, international, national and regional legislation) and social considerations (public opinion and support) came to the front. In the middle of the 2000s, more factors and subsystem elements were involved in the newly developed methods, such as savings from energy generation [18], habitats diversity [8], and also the social factors such as human well-being and motivation received bigger attention (since the separation of waste is undertaken by the inhabitants of a considered city, the citizens’ behaviour is the key influencing factor) [19], life-cycle analysis for production and consumption of energy and full-cost accounting [20]. In some cases, the weight of factors is determined by stakeholders using questionnaires to obtain stakeholder opinions to develop fuzzy criteria weights [6].

Over recent years, the method of development of factors and subsystem elements has been refined. In the developing countries where the realization of sustainable waste management is still an urgent challenge, researches [14], [21]-[23] focus on among others the involvement and participation of all the stakeholders, features of existing infrastructure, seasonal and daily variations of waste generation, etc. Therefore the key factors here are: environmental (regulations, standards, monitoring and enforcement); policy (guidance with long-term view in allocating resources, poor awareness about the benefits of proper waste management); public (participation in decision-making, the income of households, family size, education, profession); NGOs (mobilizing community); private sector (searching and implementing appropriate actions); media (environmental awareness, focus on real local priorities); scientific community (focus on needs of vulnerable population and communication); financial (institutions supporting environmentally sound developments); technical (presence/lack of infrastructural capacity, failure to adequately utilize modern waste management and processing technology, the absence of an integrated waste management system).

The so called horizontal factors describe the processes of interchanges between different waste types (shifts between residual waste, bulky waste, recyclable waste and illegally disposed waste), and vertical factors are due to changes of the total sum of all waste streams depending on demographic, economic, social and technical development (mass-related data and monetary data) [24].

On the basic of the above review, we can conclude that there is a wide consensus in the related literature that a typical IWMS includes at least the following six key factors: environmental, economic, social, institutional, legal and technical. These factors are the 'key drivers' of a sustainable IWMS that determine why the system operates as it does [16], [17], [19], [20], [25], [26].

In Table I the main factors and some examples of their respective subsystems are introduced.

TABLE I
'KEY DRIVERS' OF IWMS AND THEIR RESPECTIVE SUBSYSTEMS

Factors	Subsystem elements
Environmental factors	Emissions; Climate change; Land use; Recovery and recycling targets; Depletion of natural resources; Human toxicity
Economic factors	Efficiency at subsystem level; Efficiency at system level; Available funding/subsidies; Equity; System costs and revenues; Pricing system for waste services, Secondary materials market
Social factors	Public opinion; Public participation in the decision making process; Risk perception; Employment; Local demographics – population density, household size and household income; Public resistance (NIMBY – Not In My BackYard, LULU – Locally Unacceptable Land Use)
Institutional factors	Local and regional politics and planning; Managerial conditions and future directions; Institutional and administrative structure of waste management
Legal factors	Relevant legislation (international, national, regional and municipal)
Technical factors	Collection and transfer system; Treatment technologies; Waste stream composition and change

III. METHODS APPLIED

A. Fuzzy Cognitive Map Approach

Complex processes are characterized by high dimension, comprised of subsystems that are strongly interconnected and mutually dependent. For such systems soft computing modelling techniques are proposed to address uncertainty issues. A large number of complex processes are not well understood and their operation is "tuned" by experience rather than through the application of pure mathematic principles. Capturing and utilizing the expert's knowledge effectively and efficiently, promises to improve complex system models.

Fuzzy Cognitive Map (FCM) is an illustrative causative representation of the description and modelling of complex systems. FCM draws a causal representation, which intends to model the behaviour of any system. FCM is an interactive structure of concepts, each of which interacts with the rest showing the dynamics and different aspects of the behaviour of the system. The human experience and knowledge on the operation of the complex system is embedded in the structure of FCM and the FCM developing methodology, i.e. using human experts that have observed and known the operation of the system and its behaviour under different circumstances. The FCM model of the whole system is illustrated by a graph showing the cause and effect along the concepts. The development of FCM is based on using words to describe worlds. FCM represents knowledge and relates states, variables, events, inputs and outputs in a manner, which is analogous to that of human beings. This soft computing methodology could help humans to construct sophisticated systems, as it is generally accepted that the more symbolic and fuzzy representation is used to model a system the more sophisticated the system is.

FCM consists of nodes and weighted arcs, which are graphically illustrated as a signed weighted graph with feedback. Nodes of the graph stand for the concepts describing behavioural characteristics of the system. Signed weighted arcs represent the causal relationships that exist among concepts and interconnect them. This graphic display shows clearly which concept influences which concept and what this degree of influence is. Concepts represent conceptual characteristics of the system and weight W_{ij} represents the cause and effect influence of one concept on another. In general, concepts represent key-factors and characteristics of the modelled system and stand for inputs, outputs, variables, states, events, actions, goals, and trends of any system. Concepts correspond to features of the system that experts use to describe its operation in terms of linguistic expressions, such as the performance of a system. Concepts take fuzzy values that are represented by value A_i, which results from the transformation of the real value of the system's variable for which a concept stands for, in the interval [0, 1]. The relationships between concepts are described using a degree of causality. Experts describe this degree of influence using linguistic variables for every weight; so weight W_{ij} for any interconnection can range from [-1, 1].

In the FCM structure the degree of causal relationship between different factors of the FCM can have either positive or negative sign and values of weights express the degree of the causal relationship. Linkages between concepts express the influence one concept on another. There are three possible types of interaction. Interaction can express

- either positive causality between two concepts ($W_{ij} > 0$) when the increase on the value of the ith concept causes an increase of the value of the jth concept;
- negative causality ($W_{ij} < 0$) when the increase on the value of the ith concept causes a decrease of the value of the jth concept;
- no relationship ($W_{ij} = 0$) between the ith concept and the jth concept.

The method that is used to develop and construct the FCM has great importance for its potential to sufficiently model a system. The method is depending on the group of experts who operate, monitor and supervise the system and develop the FCM model.

The FCM modelling approach is symbolic, presenting abstract knowledge and is based on human expert experience and knowledge. FCM models the behaviour of a complex system and offers an opportunity to produce new knowledge based system applications, addressing the need to handle uncertainties and inaccuracies associated with real problems [27]-[30].

B. Expert Workshop Design Principles

Stakeholder participation is a major aspect in many integrated projects. Stakeholders are often asked to participate in the system development. The reason for participation and the quality of the results of workshop are related [31]. Integrated approaches to environmental planning with proper stakeholder involvement offer a possible way forward. Such an approach needs to facilitate communication within multidisciplinary research teams. Furthermore, it must encompass participatory management schemes which promise a substantive change in the exploitation of local knowledge. By enhancing stakeholder involvement, participatory management strengthens policy relevance, diminishes uncertainties, improves monitoring and raises enforcement rates. Participatory (or deliberative) approaches to sustainable waste management are usually grouped under the general term of stakeholder analysis. Stakeholder analysis in turn can be divided into what we opt to call macro-stakeholder and micro-stakeholder analysis. The former category includes all those qualitative approaches that refer to the interaction of social groups and their dynamics: social networks analysis, analysis of conflicts, and actor analysis. The latter category refers to qualitative or semi-quantitative approaches, which explore individual perceptions, values and attitudes. These include: FCM of social perceptions and values [32].

The construction of a FCM requires the input of human experience and knowledge on the system under consideration. Thus, FCMs integrate the accumulated experience and knowledge concerning the underlying causal relationships amongst factors, characteristics, and components that constitute the system [32].

The design of a fuzzy cognitive map is a process that heavily relies on the input from experts and/or stakeholders. This methodology extracts the knowledge from the stakeholders and exploits their experience of the system's model and behaviour. FCM is fairly simple and easy to understand for the participants, which opens up the possibility for involving lay people as well as planners, managers and experts [33].

At the beginning of the methodology, the group of experts determines the number and kind of concepts that comprise the FCM. An expert from his/her experience knows the main factors that describe the behaviour of the system; each of these factors is represented by one concept of the FCM. Experts know which factors of the system influence other elements; for the corresponding concepts they determine the negative or positive effect of one concept on the others, with a fuzzy degree of causation. In this way, an expert decodes his/her own knowledge on the behavioural model of the system and transforms his/her knowledge in a dynamic weighted graph, the FCM. With this method experts are forced to think about and describe the existing relationship between the concepts and so they justify their suggestion [27]-[30].

C. Workshop Techniques

In this application we were interested in investigating how the experts perceive the future prospects and risks of the IWMS with regard to the environmental, social, legal, technical, etc. issues; creating and analyzing an FCMs this can be achieved.

As with many other workshop techniques, it is helpful to produce systematic guidelines describing the single steps of FCM before starting with the moderation of the workshop. These workshop guidelines [33] should function as a guidance for how to moderate the workshop, and how to create FCMs over the case study areas. In this section the author summarize the practical steps needed to design and conduct a FCM design workshop.

At first, how to draw a FCM must be explained to the participants using a cognitive map and its related FCM as an example. Once the stakeholders understood the process of constructing FCM, then they are able to draw collectively the map of the issue.

The process involved four steps in the present case: (1) literature surveys to identify the major components of the IWMS; (2) description of specific concepts in the system format using expert knowledge and perception; (3) linking variables and drivers in the map attaching weights; and (4) develop the connection matrix as an input data for FCM simulation of IWMS [33].

During the workshop, the authors used four steps to generate FCMs, each guided by a question:

- What are the determining factors of the IWMS that expert and stakeholders distinguish?
- How can we understand the structure of each factor, i.e., its relations with the main factors?
- How do experts perceive the effects of particular factors on the other (sub)factor?
- Where do particular hazards or unclear boundaries affect the constituting factors of the IWMS? What consequences does this have for the entire system?

1. Research Process

The research process proceeded through four main stages.

Based on specific guidelines, the expert workshop was organized in the building of the Széchenyi István University during the spring semester of 2014 with the participation of the representatives of the six related fields: operators of different waste management systems in the country (technical), environmental lawyers (legal), economic specialists (economic), environmental expert (environmental), authority experts (institutional) and representatives of the public (social). The workshop lasted for six hours.

2. Workshop Protocol

Stage 1: Formal Introduction

- What is the aim of the workshop?
- What is cognitive mapping methodology?

Stage 2: Definition of sub-factors and creation of FCM

- Which sub-factors come into your mind spontaneously if I mention to you the main factors of IWMS as a system where various components interact with each other?
- Is there any positive or negative relationship between these factors? How strongly a factor A influences another factor B? A scale having 11 grades capable to describe any kind of relationship between two things is given.

Stage 3: Conclusion

- Strong words/phrases they used, general comments of the workshop.

IV. Results

As the six main factors had been determined on the basis of the relevant literature, these were the starting point of the FCM design during the workshop. The participants were asked to form groups according to the six areas they represented. Then, they were requested to identify 5-7 sub-factors in their field of specialty which come to their mind when they are asked about the sustainability of IWMS. Describing the properties of the sub-factors is very important as they have to fulfil certain criteria. When creating a FCM, it is important to consider that the concepts must be quantifiable in order to be able to be affected by other concept. It is important for the understanding of the map that the concepts are clearly described in a manner which makes the FCM work [34].

During the workshop participants defined altogether 33 sub-factors as critical variables of the IWMS (see Table II and Fig. 1).

After determining the sub-factors, all the stakeholders cooperatively assessed the existence and type of the causal relationships among the 33 sub-factors, furthermore evaluated the strength of these using a predetermined simple scale, capable to describe any kind of relationship between a pair of factors, both positive and negative ones. This phase was implemented 11 grades scale, numbering from -5 to +5, capable to describe any kind of relationship between two factors, positive and negative After explaining to the participant the fundamental features of FCM, they understood the underlying basic information and were able to assess the value of the connections. Table III and IV illustrate the produced connection matrix of the FCM for further assessment.

Thus, the connection matrix for the collective FCM was established presenting the main factors and the sub-factors and the relationships among them illustrating the common perceptions about the future prospects and the risks about the IWMS.

TABLE II
THE IDENTIFIED SUB-FACTORS OF THE MAIN FACTORS AND THE CONCEPT IDS (CID) OF THEM

Main factor	Sub-factor	CID	Main factor	Sub-factor	CID
Technology (C1)	Engineering knowledge	C1.1	Society (C4)	Public opinion	C4.1
	Technological system and its coherence	C1.2		Public health	C4.2
	Local geographical and infrastructural conditions	C1.3		Political and power factors	C4.3
	Technical requirements in the EU and national policy	C1.4		Education	C4.4
	Technical level of equipment	C1.5		Culture	C4.5
Environment (C2)	Impact on environmental elements	C2.1		Social environment	C4.6
	Waste recovery	C2.2		Employment	C4.7
	Geographical factor	C2.3	Law (C5)	Monitoring and sanctioning	C5.1
	Resource use	C2.4		Internal and external legal coherence (domestic law)	C5.2
	Wildlife (social acceptance)	C2.5		General waste management regulation in the EU	C5.3
	Environmental feedback	C2.6		Policy strategy and method of implementation	C5.4
Economy (C3)	Composition and income level of the population	C3.1	Institution (C6)	Publicity, transparency (data management)	C6.1
	Changes in public service fees	C3.2		Elimination of duplicate authority	C6.2
	Depreciation and resource development	C3.3		Fast and flexible administration	C6.3
	Economic interest of operators	C3.4		Cooperation among institutions	C6.4
	Financing	C3.5		Improvement of professional standards	C6.5
	Structure of industry	C3.6			

The generated connection matrix contains 1056 (33*32) connection. Since the representation and interpretation of such a complex model is rather difficult, only the most important connections are represented in Fig. 2 with the help alpha-cuts.

Results show that the tool provides a structured, semi-quantitative understanding of the system perceptions of a group of stakeholders. Experts perceived the method as easy to understand and easy to use in a short period of time.

V. Summary and Conclusions

The aim of this paper was to show a possible design for IWMS to bridge the gap between computer simulation and expert knowledge. In this paper, a workshop approach was presented as a tool to generate input data for FCM modelling. A cognition model, like FCM, represents a system in a form that corresponds closely to the way humans perceive it. Therefore, the model is easily understandable, even by a nonprofessional audience and each parameter has a perceivable meaning. The model can be easily altered to incorporate new phenomena, and if its behaviour is different than expected, it is usually easy to find which factor should be modified and how. FCM is not able to make predictions but work as a tool for gaining an understanding of the system. In this sense, a FCM is a dynamic modelling tool in which the resolution of the system representation can be increased by applying a further mapping.

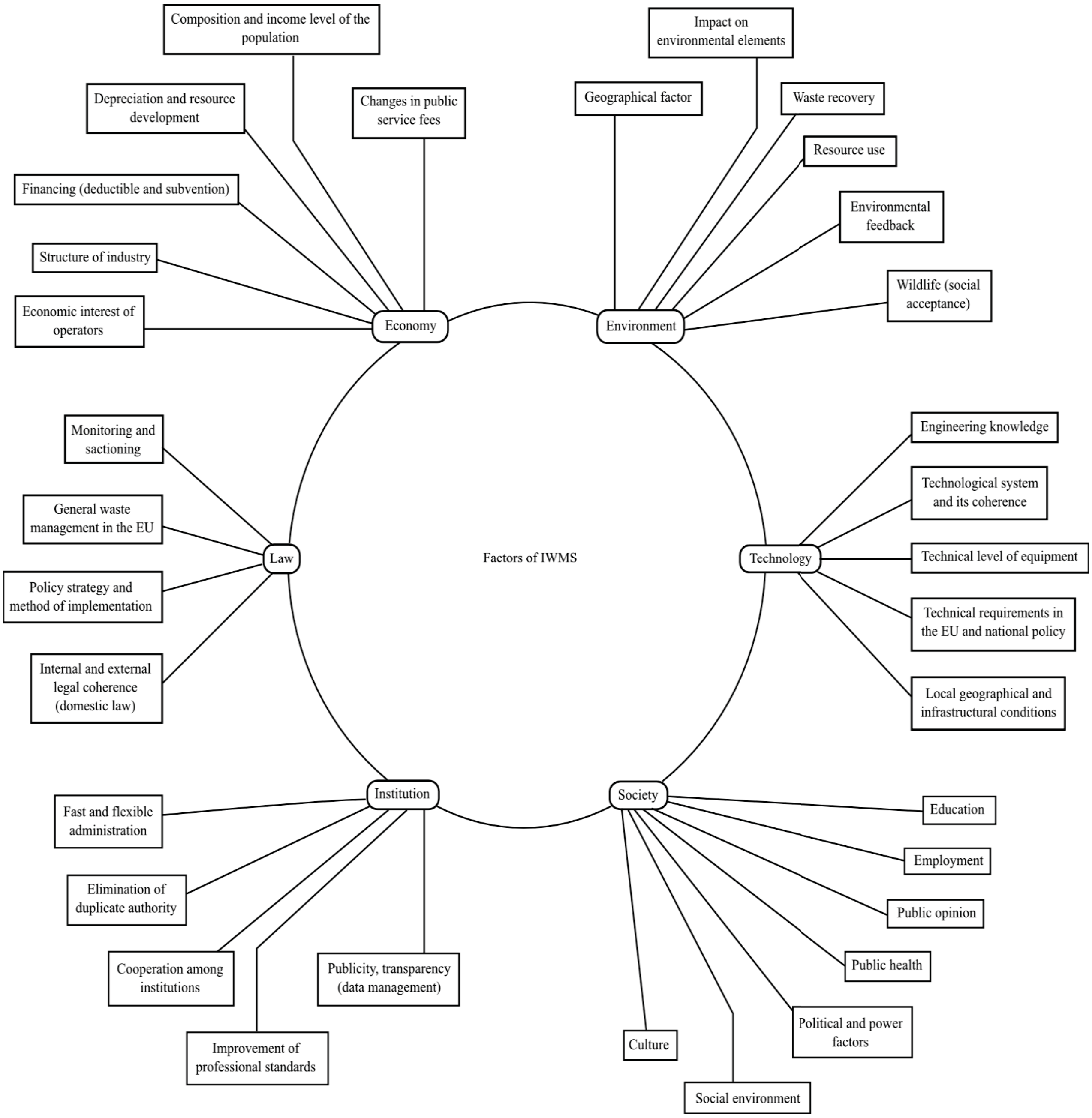

Fig. 1 The Thirty-tree Sub-factors of the IWMS Model

TABLE III
CONNECTION MATRIX CREATED BY EXPERTS AS A RESULT OF THE WORKSHOP, PART 1

CID	C1.1	C1.2	C1.3	C1.4	C1.5	C2.1	C2.2	C2.3	C2.4	C2.5	C2.6	C3.1	C3.2	C3.3	C3.4	C3.5	C3.6
C1.1	0	0.2	0	0.6	0.4	0.6	0.2	0	0.8	0.2	0.6	0.4	0.8	0.4	0.8	0.4	0.4
C1.2	0.4	0	0.4	0.4	0.6	0.2	0.2	0	0.4	0.2	0.4	0.6	0.8	0.6	0.6	0.6	0.6
C1.3	0	0.2	0	0.2	0	0	0	0	0.2	0	0.4	0.6	0.6	0.6	0.6	0.4	0.4
C1.5	0.8	0.2	0	0.8	0	0.4	0.2	0	0.4	0.4	0.6	0.6	0.8	0.6	0.6	0.6	0.6
C2.1	0	0	0.6	0.2	0	0	0	0	0.2	0.4	-0.6	0	0.2	0	0	0	0
C2.2	0	0.2	0	0	0.2	0.4	0	0.6	-1	0	-0.6	0	-0.4	0.4	0.8	0.6	1
C2.3	0	0	0.6	0	0	0.4	0.4	0	0.4	0	0	0	0.2	0	0	0	0.6
C2.4	0	0.2	0.4	0	0.6	-0.6	-0.8	-0.6	0	-0.4	-0.6	0	-0.2	0	0	-0.2	0.2
C2.5	0	0	0	0.6	0	0.4	0	0.4	0	0	0.4	0	0	0	0.2	0	0
C2.6	0	0.6	-0.8	0.6	0.6	-0.8	0.6	0	0.6	-0.8	0	-0.6	0.2	0	0	0	0.2
C3.1	0	0.2	0	0	0.2	-0.8	0.4	0	0	0.2	0.2	0	0.8	0.8	0.6	0.6	0
C3.2	0	0.6	0	0	0.6	-0.6	0.4	0	0.6	0	0.4	0	0	0.6	0.8	0.8	1
C3.3	0	0.6	0	0.2	0.4	0.4	0.4	0	0.2	0.2	0.2	0	0.6	0	0.4	0.8	0.8
C3.4	0.8	0.8	0	0.2	0.8	-0.6	0.8	0	-0.2	0.2	0.2	0	1	0.6	0	0.6	0.4
C3.5	0	0.4	0	0	0.6	0.4	0.8	0	0.6	0	0	0	0.6	0.6	0.6	0	0.8
C3.6	0	0.6	0	0	0.8	0.6	1	0.8	-0.8	0.4	0.4	0	0.4	0.2	0.6	0.4	0
C4.1	0.2	0.2	0	0.6	0.6	0.8	0.6	0.4	0.8	1	0.6	0.2	0.6	0.4	0.6	0.4	0.4
C4.2	0.4	0.2	0.2	0.6	0.6	0.6	-0.2	0.2	0.8	0.8	1	0.6	0.4	0.4	0.4	0.4	0.4
C4.3	0	0.8	0	0.4	0	0	0	0	-0.2	0.4	-0.2	0.6	1	0.8	0.6	0.8	0.4
C4.4	0.2	0	0	0.2	0.2	0.4	0.2	0	0.6	0.6	0.6	0.8	0.2	0.2	0.2	0.2	0.2
C4.5	0.2	0	0.4	0.6	0.8	-0.2	0.6	0.2	0.4	0.8	0.6	0.2	0.2	0.2	0.2	0.2	0.2
C4.6	0	0	0.4	0.6	0.4	0.2	0.6	0.2	0.4	0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.2
C4.7	0	0	0	0.2	0	0	0.4	0	0.6	0.4	0.4	0.6	0.2	0.6	0.4	0.2	0.4
C5.1	0	0.4	0	0	0.4	0.2	0.2	0	0.2	0.2	0.2	0	0	0.6	0.2	0	-0.4
C5.2	0.4	0.6	0	0	0.4	0.8	0.8	0.6	0.6	0.6	0.8	0	1	0.6	0.6	1	0.6
C5.3	0.2	0.4	0	0.4	0.4	0.8	0.8	0.6	0.8	0.6	0.8	0	0.4	0	0.2	0.8	0.6
C5.4	0.2	0.6	0	0	0.8	0.8	0.6	0	0.6	0.6	0.6	0	0.8	0.2	0.2	0.2	0.4
C6.1	0	0.6	0	0.4	0	0.2	0	0	0.4	0.2	0.4	0.4	0.6	0.6	0.6	0.8	0.2
C6.2	0	0.4	0	0	0	0	0	0	-0.4	0	-0.2	0.4	0.6	0.8	0.8	0.6	0.4
C6.3	0	0.4	0	0	0	0	0	0	0	0	0.4	0.8	0.8	0.6	0.8	0.6	0.6
C6.4	0	0.4	0	0.4	0	0.2	0	0.2	0.2	0	0.6	0.6	0.8	0.4	0.4	0.4	0.8
C6.5	0.4	0.2	0	0.6	0.2	0.2	-0.2	0	0.6	0.4	0.8	0.6	0.6	0.8	1	1	1

TABLE IV
REFINED CONNECTION MATRIX CREATED BY EXPERTS AS A RESULT OF THE WORKSHOP, PART 2

CID	C4.1	C4.2	C4.3	C4.4	C4.5	C4.6	C4.7	C5.1	C5.2	C5.3	C5.4	C6.1	C6.2	C6.3	C6.4	C6.5
C1.1	0	0	0	0.4	0	0	-0.6	0	0.4	0.4	0.4	0	0	0	0	0.2
C1.2	0	0.2	0.2	0	0	0.2	-0.2	-0.6	0.6	0.2	0.6	0.8	0.4	0	0.6	0.4
C1.3	0	0.2	0	0	0.4	0.2	0	0	0	0.2	0	0.2	0	0	0	0.2
C1.4	0.2	0.6	0.4	0.2	0.2	0	0	0.2	0.2	0.6	0	0.4	0	0.2	0	0.6
C1.5	0	0.2	0	0	0.4	0.2	-0.2	0.6	0	0.2	0.4	0	0	0	0.2	0.8
C2.1	0.4	0.8	0	0.2	0	0	0	0.6	0.4	0.4	0.2	0	0	0	0.2	0
C2.2	-0.6	0.4	0	0.2	0	-0.2	0.4	0	0	1	0	0	0	0	0.4	0.4
C2.3	-0.6	-0.6	0	0	0	0.2	0.4	0	0	0	0	0	0	0	0	0
C2.4	0.2	-0.6	0	0.2	0.2	0.4	0.4	0	0	0	0.4	0	0	0	0	0.2
C2.5	0.6	0.4	0	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0
C2.6	0.8	0.4	0	0.2	0	0.4	0	0.6	0.2	0.8	0.8	0	0	0	0.2	0
C3.1	1	0.4	0	0.6	0.6	0.8	0	0	0	0.2	0	0.2	0	0.6	0	0
C3.2	1	0	0	0.2	0	-0.4	-0.4	0	0	0	0	0	0	0	0	0
C3.3	0	0	0	0.6	0	0	0.4	0	0	0	0	0	0	0	0	0.2
C3.4	0.4	0	0	0.2	0	0	-0.4	0	0	0	0	0.2	0	0	0.6	0
C3.5	0	0	0	0.2	0	0	0.4	0	0	0	0	0.2	0	0	0	0.2
C3.6	-0.4	0	0	0.4	0	0	-0.6	0	0.6	0.6	0.6	0	0	0	0	0.8
C4.1	0	0.8	0.4	0.6	0.8	0.8	0	0	0.8	0.4	0.4	0.6	0	0.2	0.4	0.2
C4.2	0.8	0	0.2	0.4	0.8	0.8	0	0.6	0.8	0.6	0.4	0.4	0	0	0	0
C4.3	0	0	0	0	0	0	0	0	0.2	0	0.6	0.6	0.8	0.2	0.8	0
C4.4	0.4	1	0.2	0	0.6	0.6	0	0.2	0.4	0.4	0.4	0	0	0	0	0
C4.5	0.6	0.4	0.2	0.8	0	0.6	0	0.4	0.4	0.4	0.4	0.2	0	0	0	0
C4.6	0.8	0.4	0.2	0.8	1	0	0	0.2	0.2	0.2	0.2	0.2	0	0	0	0
C4.7	0	0	0.4	0	0.2	0	0	0.2	0	0.2	0.2	0.4	0.4	0.6	0.4	0
C5.1	0	0.4	0	0	0	0	0	0	0.2	0.2	0.2	0	0	0	0	0
C5.2	0.6	1	0	0.6	0.4	0	0.2	0.8	0	0	0.6	0.8	0	0	0	0
C5.3	0.4	0	0	0.4	0.2	0	0	0.4	1	0	0.4	0.2	0	0	0	0
C5.4	0	0.4	0	0.4	0	0	0.2	0.8	0.8	0	0	0	0	0	0	0.4
C6.1	0.2	0.8	0.4	0.2	0	0.6	0	-0.4	0.4	0	0.8	0	0.8	0.4	0.6	0
C6.2	0	0	0.2	0	0	0	0	-0.2	0.4	0	0.8	1	0	0	0.4	0
C6.3	0	0	0.2	0	0	0.4	0	-0.6	0.4	0	0.8	0.8	1	0	0.4	0

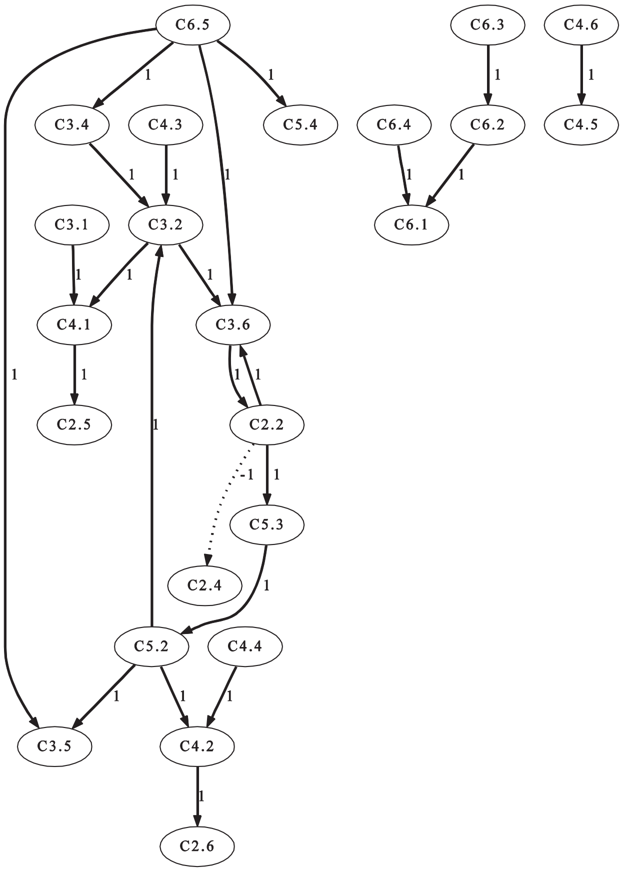

Fig. 2 The Most Important Connection (-1 and 1) of the Factors are Represented with the Help of Alpha-cuts

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