A Generic Software to Support Collective Decision in Food Chains and in Multi-Stakeholder Situations

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KEYWORDS

Multi-stakeholder analysis, Multi-source argument database, Collective attitude, Opinion modeling, Explainable decision, Multicriteria argumentation, *MyChoice* web-based tool, Ethical decision making.

ABSTRACT

MyChoice is a user-friendly web-based application supporting collective decision, developed by INRAE (French National Institute of Research for Agriculture, Food and the Environment). It is designed to analyse, compare and assess the acceptability of different alternatives –e.g. technologies, food processes, variants of a product, etc.-, based on explicative arguments stemming from various sources and stakeholders, regarding different criteria and aims. It is well-suited for accompanying news trends and developments in food chains, requiring the adhesion and cooperation of various stakeholders. Nevertheless, its design is generic and may also be applied to different fields. This paper presents the design concepts of the software, stemming from different disciplines –multicriteria decision, AI argumentation, database information systems, social psychology–, its features and expected future developments.

INTRODUCTION

New Developments and Practices in Food Chains

Caught in the middle between upstream production and downstream consumption, be it climatic, regulatory, economic or social, food supply chains are driven to adopt new technologies and practices. For example, from an environmental standpoint, (i) producers are dependent on global warming, the effects of which are already being felt in certain sectors (Ortiz et al. 2008); (ii) consumer demand evolves at different speeds and integrates these new environmental concerns sometimes mixed with health or ethical issues through the demand for more “natural” products -untreated, without additives, in bulk, etc.- (Siegrist and Sütterlin 2017); (iii) agricultural and food policies take measures such as environmental regulations to control this warming (Belhouchette et al. 2011), which is impacted on food supply chains. Food chains have a key role in adapting to new production conditions while satisfying the evolving consumer demand, by designing or adopting new products, processes, technologies and practices.

Collectively Assessing the Impacts of New Developments in Food Chains, a Multi-Stakeholder Issue

The food industry relies on various stakeholders, from producers to consumers, including processors, distributors, managers, professional associations, public authorities. Their objectives relate to different criteria, economic, environmental, health, sensory, technical. Their priorities may be divergent, requiring the resolution of arbitration issues for decision-making. In this context, the paper considers the possibility of developing formal methods and tools that are both intuitive and automatable to 1) analyze the compatibility of the objectives of the stakeholders involved and 2) anticipate multi-criteria consequences of their achievement. The main related obstacle is that the decision is not centralized but distributed between various interdependent stakeholders, poorly coordinated, and heterogeneous in their number, their role in the food chain and their objectives.

The Interest of Formal Multi-Stakeholder Models and Tools

Most widespread approaches in food models include both mechanistic modeling such as physical models, i.e. top-down approaches requiring knowledge of the physical laws injected into the model; and empirical models such as statistical ones, i.e. bottom-up approaches discovering the rules of the model by exploring the data (Aceves et al. 2018). Both provide tools for controlling the structure and function properties of the products and processes studied. However, they seldom provide information on the compatibility of products and processes with the technical, economic or social constraints of the food chain stakeholders. This is the issue dealt with in this paper. Information sources that provide clues on stakeholders’ concerns go from websites, project meetings, expert interviews, scientific articles, and manufacturing practices to consumer patterns, opinions, preferences, and choices, available through online forums, to sales statistics, new marketing trends, and the list goes on (Bourguet et al. 2013).

Structure of the Paper

Next sections introduce, respectively: the model description including purposes, design concepts and detailed features; the software implementation presenting the technologies used, the inputs and the outputs; discussion on the resulting novelties; the future stages.

MODEL DESCRIPTION

Purposes

The *MyChoice* tool is based on the analysis of arguments expressing the knowledge and opinions of different types of stakeholders concerning the advantages and disadvantages of a number of alternatives considered, for different criteria. It aims to reflect stakeholders' attitudes regarding these alternatives, to measure the acceptability of the alternatives for stakeholders and to support collective decision.
Examples of alternatives are animal versus vegetal diets, white versus whole-grain bread, high-speed detection technologies versus classic ones, etc.

Design Concepts

Social psychology.
Several types of approaches can be referred to as methods for compromise computation. Historically, the first was probably the social choice approach. Its utility value in food-related applications has recently been explored (Bisquert et al. 2017). It is premised on the principle that the food design process should internalize the opinions of all categories of food chain actors, and, so, actors' opinions are computed as votes. In this paper, voting is not strictly speaking applied. Although counts of arguments play an important role in the analysis, an argument does not represent a vote, since it is is associated with the general type of stakeholder who expressed it (e.g. producer, processor, consumer, etc.). Technically, each individual participant can provide several arguments, and a given argument may be repeated by different participants and stakeholders.
Nonetheless, a different feature, stemming from social psychology, is explored in the paper. Indeed, social psychological variables have been shown to influence food-related choices. In the expectancy-value theory (Fishbein 1967), which is a general model of human decision-making widely applied to understanding food-related choices, individuals are assumed to make the choice associated with the most desirable outcomes, i.e. the one evaluated most positively. This global evaluation, denoted as "attitude", is derived from the perceived likelihood that the choice is associated with a number of key outcomes, weighted by the evaluation of those outcomes. Formally, the attitude is computed by:

$$\text{Attitude} = \Sigma_i\, b_i.e_i \qquad \text{for } i \in [1;n]$$

where b refers to the outcome belief and e refers to the evaluation of that belief.
In the present paper, the following concepts are retained:
- Choices (denoted by "Alternatives").
- Outcomes (denoted by "Aims").
- Attitude (denoted by "Acceptability").

We propose **a practical way of computing b and e**, which is an innovative research result introduced in this work:
- e_i is computed as the proportion of arguments claiming the considered alternative allows reaching the aim i, within all arguments (pro and con) concerning the achievement of aim i for the considered alternative.
- b_i is computed as the proportion of arguments related with aim i in the whole debate, i.e. for all alternatives.

Multicriteria decision.
The second type of approach, called multi-criteria decision (Belton and Stewart 2010), addresses evaluation issues, in which a set of pre-defined alternatives is to be evaluated according to various criteria (environment, cost, etc.), based on attributes describing the alternatives.
In the present paper, the following concepts are retained:
- Alternatives (see section "Social psychology" above).
- Criteria. The Aims mentioned in the above section can be considered as refinements of these criteria. For instance, "Generating employment" is an aim refining the general "Economic" criterion.
- Attributes (denoted by "Properties").

AI Argumentation.
A recent concern in multi-criteria decision and other fields of computer science is the need to explain and trace the conclusions obtained. Why was a given alternative chosen? Which criteria were best satisfied, and which were left aside? What arguments served for or against each alternative? This way of reasoning is central to the argumentative approach (Dung 1995), which has also been explored in food applications (Thomopoulos 2018).
Various formalisms have been proposed, from abstract to logical ones. In this work, "Argument" means the expression of an opinion by a stakeholder, in favor or against an alternative, pursuing a particular aim (e.g. consuming a balanced diet) itself linked to a more general criterion (e.g. nutritional, sensory, economic, social, ethical, etc.). This opinion is justified by a property of the alternative supported or rejected (e.g. its price, its protein content, etc.) which is declared to take on a certain value (e.g. high, balanced, etc.).
An argument in this paper can thereby be defined as a tuple composed of an id, a stakeholder who expressed the argument, an alternative considered, a type pro or con, etc. The detailed structure is represented in the database schema provided in the "Implementation" section (see Figure 2).

Beyond state-of-the-art.
Several novelties are worth being highlighted:
- The **acceptabilities** of alternatives are computed as attitudes with the meaning of social psychology.
- The concept of **Stakeholder** is explicitely introduced in the model, allowing for multi-stakeholder analysis. Questions such as "Do all stakeholders benefit equally from the solution?", "How did possible compromises emerge from them?" can be tackled.
- **Contradictions** between arguments are not declared but deduced.
- **Preferences** regarding criteria and aims are not declared but deduced.
- The list of criteria and aims considered is not determined in advance, but dynamically complemented **without a priori**.

Detailed Features

Visualizing the arguments.

A web interface allows project participants to:

- View the table of arguments expressed for or against the alternatives.
- Visualize the arguments grouped by criterion (economic, nutritional, etc.) and, within each criterion, by aim (e.g. consuming a balanced diet, etc.) and by property (e.g. price, risk of contamination, etc.).
- Obtain the details of an argument: source, date, claim, explanation, type of stakeholder (e.g. consumer, researcher, etc.) who expressed it.
- Select stakeholders, criteria, aims.

Analysis by color code.

A color code (green, orange, red) is proposed in order to:

- Identify the "controversial" properties, i.e. those that are mentioned both positively and negatively for a given aim.
- Distinguish the aims unanimously satisfied by all arguments from those that are not.
- Distinguish the criteria satisfied for all aims from those that are not.
- Distinguish the alternatives judged satisfactory for all criteria from those that are not.

Acceptability of the alternatives.

A degree of acceptability is computed for each alternative as a numerical value between 0 and 1. It expresses to what extent the alternative meets the aims expressed. It is computed as an attitude, as described in the section "Design Concepts" above. In the particular case where no argument is expressed for a given aim, the proportion of pro arguments is assumed to be 0.5, which is considered as a neutral value. This is based on the assumption that the absence of arguments can be interpreted as if 2 arguments were in presence, a positive one claiming "nothing wrong to highlight" and a negative one claiming "nothing great to highlight". This assumption is comparable to handling missing values.

Different modes to filter the arguments.

Selections of arguments can be used for different analyses. The default case is the **Consensus** mode in which all arguments are retained. The **Expertise** mode only considers the arguments belonging to the expertise criteria of their authors. This information is stored in a database (see "Implementation" section below). The **Data reliability** mode selects arguments whose source type is associated with a high fiability level, which is reserved to peer reviewed information sources. The **Prospective** mode only considers arguments which envision possible future developments. The **Interplay** mode retains the arguments that make the focus on a property mentioned in several aims. For instance, the "cooking" property is involved both in the "Improving digestibility" and "enhancing food preservation" aims.

IMPLEMENTATION

Technologies

The *MyChoice* software is a web application based on a client-server architecture. The client user interface is developed in javascript with Vue.js. It relies on services provided by the server, which is implemented in java. The exchanges between the client part and the server part are done through the HTTP protocol, using JSON as exchange format. The workflow and the client-server architecture are illustrated in Figure 1.

Inputs

The input of the software is a relational database conforming with the schema described in Figure 2.

Alternatively, a spreadsheet format as well as a csv format are provided for data inputs. A screenshot of the spreadsheet template used to generate the csv file is shown in Figure 3.

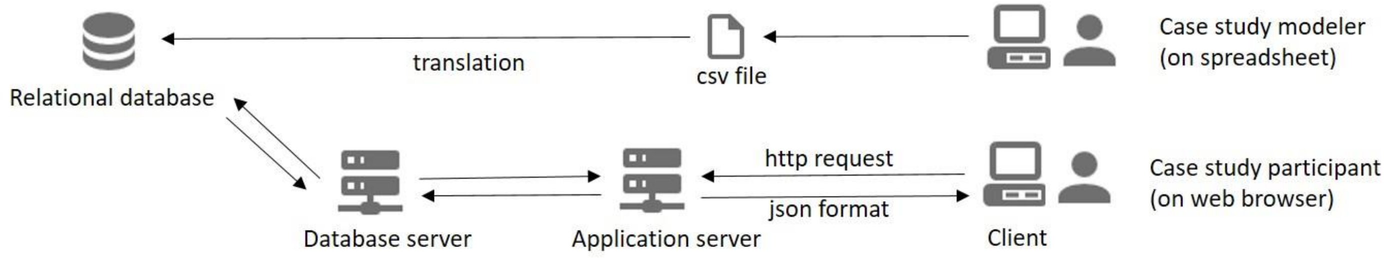


Figure 1: Workflow and client-server architecture of the *MyChoice* software

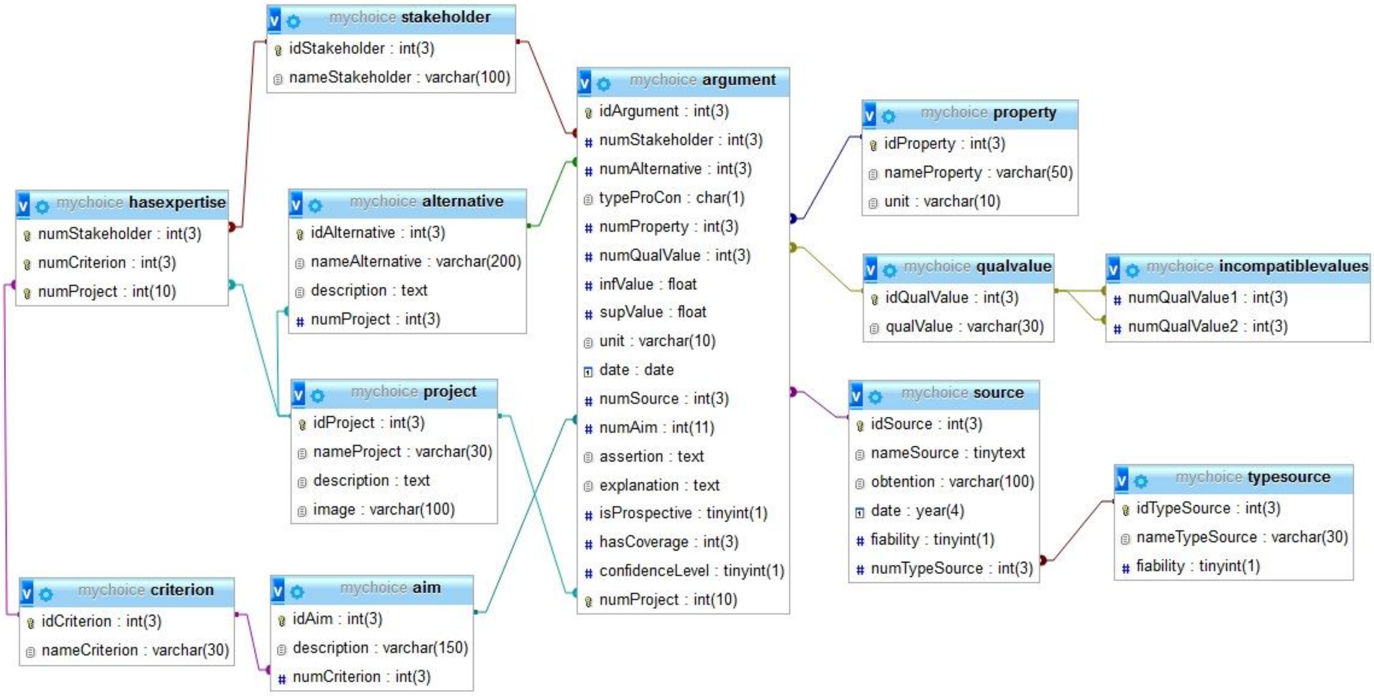
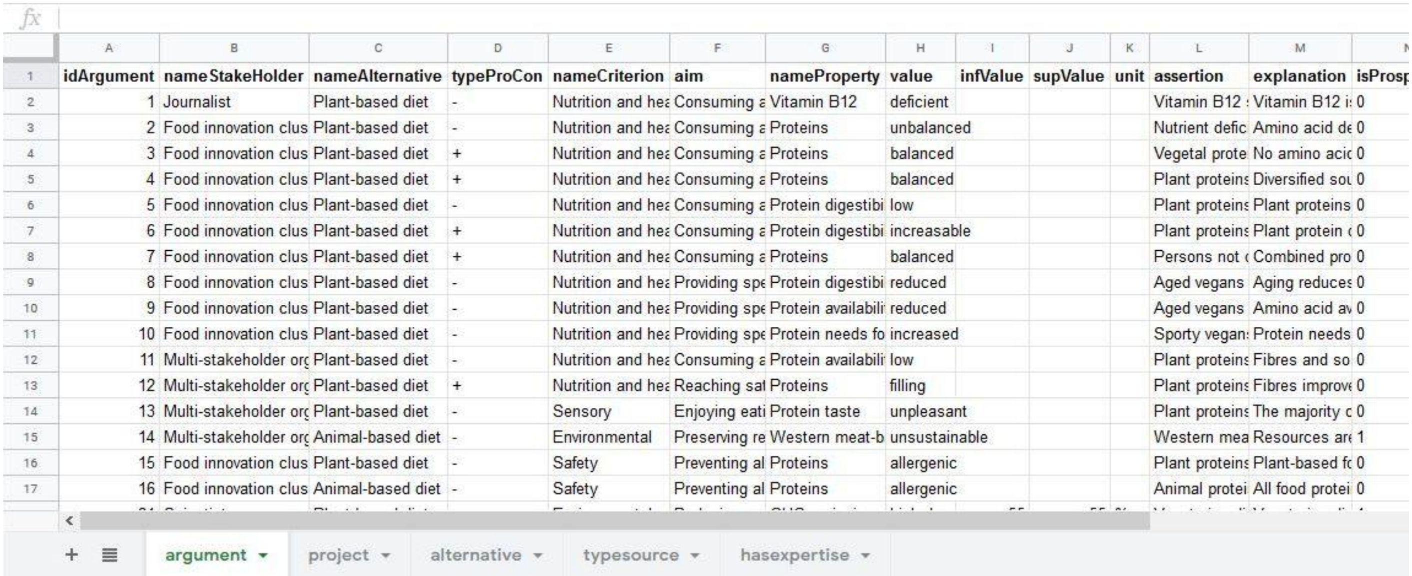


Figure 2: Database schema



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	idArgument	nameStakeHolder	nameAlternative	typeProCon	nameCriterion	aim	nameProperty	value	infValue	supValue	unit	assertion	explanation	isProsp
2	1	Journalist	Plant-based diet	-	Nutrition and hea	Consuming a	Vitamin B12	deficient				Vitamin B12 :	Vitamin B12 i:	0
3	2	Food innovation clus	Plant-based diet	-	Nutrition and hea	Consuming a	Proteins	unbalanced				Nutrient defic	Amino acid de	0
4	3	Food innovation clus	Plant-based diet	+	Nutrition and hea	Consuming a	Proteins	balanced				Vegetal prote	No amino acic	0
5	4	Food innovation clus	Plant-based diet	+	Nutrition and hea	Consuming a	Proteins	balanced				Plant proteins	Diversified sou	0
6	5	Food innovation clus	Plant-based diet	-	Nutrition and hea	Consuming a	Protein digestibi	low				Plant proteins	Plant proteins	0
7	6	Food innovation clus	Plant-based diet	+	Nutrition and hea	Consuming a	Protein digestibi	increasable				Plant proteins	Plant protein (	0
8	7	Food innovation clus	Plant-based diet	+	Nutrition and hea	Consuming a	Proteins	balanced				Persons not (	Combined pro	0
9	8	Food innovation clus	Plant-based diet	-	Nutrition and hea	Providing spe	Protein digestibi	reduced				Aged vegans	Aging reduces	0
10	9	Food innovation clus	Plant-based diet	-	Nutrition and hea	Providing spe	Protein availabili	reduced				Aged vegans	Amino acid av	0
11	10	Food innovation clus	Plant-based diet	-	Nutrition and hea	Providing spe	Protein needs fo	increased				Sporty vegan:	Protein needs	0
12	11	Multi-stakeholder org	Plant-based diet	-	Nutrition and hea	Consuming a	Protein availabili	low				Plant proteins	Fibres and so	0
13	12	Multi-stakeholder org	Plant-based diet	+	Nutrition and hea	Reaching sat	Proteins	filling				Plant proteins	Fibres improve	0
14	13	Multi-stakeholder org	Plant-based diet	-	Sensory	Enjoying eati	Protein taste	unpleasant				Plant proteins	The majority c	0
15	14	Multi-stakeholder org	Animal-based diet	-	Environmental	Preserving re	Western meat-b	unsustainable				Western mea	Resources are	1
16	15	Food innovation clus	Plant-based diet	-	Safety	Preventing al	Proteins	allergenic				Plant proteins	Plant-based fc	0
17	16	Food innovation clus	Animal-based diet	-	Safety	Preventing al	Proteins	allergenic				Animal protei	All food protei	0

Figure 3: Data template in spreadsheet format used to generate a csv file

Outputs

The outputs of the software are the features described in the "Detailed features" section. Figure 4 displays a screenshot

illustrating part of them. The case study used is the debate concerning animal versus plant-based diets, presented in (Salliou and Thomopoulos 2018).

Visualizing the arguments is achieved in a table displaying the criteria and aims. The arguments pro or con each alternative are summarized by a short information providing the property considered and its value (e.g. "Vitamin B12: deficient"). Their complete descriptions can be consulted in a detailed view (bottom left slide of the screen).

Analysis by color code is provided both in the general view by associating a color with each criterion and each aim; and in a property view (not displayed here), by associating a color with each property.

The global acceptability of each alternative is computed at the bottom of the argument table. It can be specified per stakeholder, as shown at the top of the screen.

Different modes to filter the arguments can be chosen (top left of the screen) according to the analysis purposes.

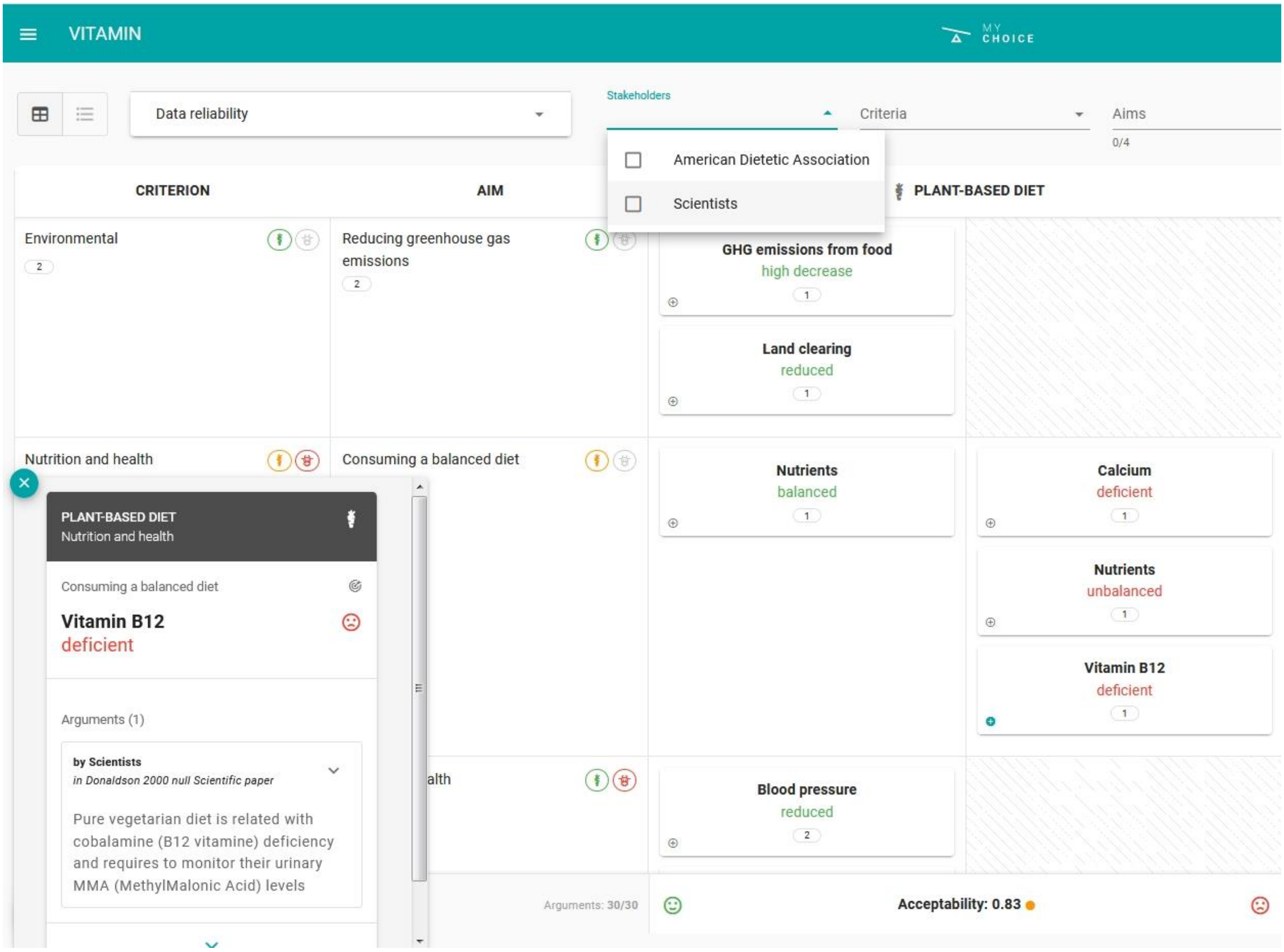


Figure 4: *MyChoice* web user interface

DISCUSSION

Related Work

Multi-actor approaches.

Several qualitative participation approaches, based on dialogue to guide the actors to a final decision in public decision-making, have been proposed (O'Faircheallaigh 2010). Among them, the Delphi method (Geist 2010) for instance is a multi-actor approach in management, mainly designed for qualitative prediction within a group of experts, where the experts make predictions and a facilitator controls these predictions until the experts end up with a level of consensus.

These participatory approaches are interesting since they involve a wide range of actors in the decision process, engage them all along the process and allow reaching a decision closer to the values and concerns of each actor. They also favor the acceptance of the final decision by the actors, due to the transparency of the process. However, one of the main limitations reported on these approaches concerns their **low level of formalization and reproducibility** (Hutchel and Molet 1986), which limits the traceability of the decision, and their lack of information regarding hypotheses made, values considered, estimated impacts, etc.

Multi-criteria approaches.

The scientific literature contains numerous formal decision support methods, whether they are mono-criterion based such as benefit/cost analysis, or multi-criteria based as MCDA (Multi-Criteria Decision Analysis) which resulted in a large number of methods and applications (Belton and Stewart 2010). However, these methods generally assume that stakeholders have homogeneous preferences and are considered as a **single decision-maker**, which is unrealistic in a multi-stakeholder situation. Moreover, the main challenge in using MCDA is undoubtedly the structuring phase since decision problems are often quite difficult to deal with, and alternatives and criteria are rarely readily available (Marttunen et al. 2017). Therefore, structuring and formalizing a decision problem to fit into a MCDA framework is known to still be an issue, notably in a multi-stakeholder context.

A Contribution to Ethical Decision Making

In (Picavet 2009), the author considers "ethics involves research on the adequate way to take into account a plurality of individual values in the definition of common objectives and partly chosen constraints". In (Wenstop and Koppang 2009), the authors recommend, when dealing with decision problems that involve value conflicts, to encourage: the view that stakeholders have intrinsic value; focus on consequences rather than virtues and rules; fair processes to identify stakeholder values. Based on these elements of definition, the *MyChoice* tool can be considered as part of ethics-oriented initiatives in artificial intelligence and more specifically in decision support, by bringing in the perspectives and views of all concerned stakeholders on challenges and opportunities on the route toward most promising alternatives.

CONCLUSION AND PERSPECTIVES

The *MyChoice* software presented in this paper is an innovative user-friendly web application computing stakeholders' attitudes regarding alternatives and supporting collective decision, based on a formal transdisciplinary approach borrowing concepts from social psychology, argumentation, multicriteria decision, and databases. It can be used interactively, in real time, for instance during debates. It is intended to be available to the community:

- Accessible for consultation online, as of now: go to page https://ico.iate.inra.fr/MyChoice/project?name=VITAMIN to access the tool and to consult an example already populated with data from the case study of (Salliou and Thomopoulos 2018).
- Usable online, in the forthcoming weeks.
- Downloadable under open-source licence, in the forthcoming months.

Future research will focus on additional multi-stakeholder analysis indicators, as well as on the automated generation of summaries providing the main conclusions.

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