NoAW project

Innovative approaches to turn agricultural waste into eco-logical and economic assets

Deliverable n°: D1.3

Deliverable title: Computational Social Choice software programming and data analysis

Planned delivery date (as in DoA): 31/12/2017 (M15)
Actual submission date: 24/11/2017 (M14)

Workpackage: WP1
Workpackage leader: ECOZ
Deliverable leader: INRA
Dissemination level: PU
EC Version: V1

Research and Innovation action: GA no. 688338
Start date of the project: October 1st, 2016

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

1. Document Info

1.1. Author(s)

Organisation name lead contractor	INRA

Author	Organisation	e-mail
Nikolaos Karanikolas	INRA	nkaran@gmail.com
Pierre Bisquert	INRA	pierre.bisquert@inra.fr
Patrice Buche	INRA	patrice.buche@inra.fr
Hélène Coussy	UM	helene.coussy@univ-montp2.fr
Madalina Croitoru	UM	madalina.croitoru@lirmm.fr
Valérie Guillard	UM	guillard@univ-montp2.fr
Rallou Thomopoulos	INRA	rallou.thomopoulos@inra.fr

1.2. Revision history

Version	Date	Modified by	Comments
1	11/08/2017	Nikolaos Karanikolas	Starting version
2	20/10/2017	Nikolaos Karanikolas	Draft version while mission in Patras
3	31/10/2017	Nikolaos Karanikolas	Final version after mission in Patras

1.3. Dissemination level

This deliverable is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 688338	
Dissemination Level	
PU Public	**PU**
CI Classified, as referred to Commission Decision 2001/844/EC	
CO Confidential, only for members of the consortium (including the Commission Services)	

2. Summary

Background	The **NoAW** project's goal is driven by a "near zero-waste" society requirement and focuses in the development of innovative efficient approaches that allow the conversion of growing agricultural waste issues into eco-efficient bio-based products. These approaches aim for direct benefits for the environment, the economy and the EU consumer. Nonetheless, one major challenge is the selection of these new waste valorization routes when the preferences of the stakeholders are taken into account. In order to achieve that, we refer to Computational Social Choice techniques and methods.
Objectives	The objective of this deliverable is to implement software that provides decision making mechanism which relies on the fair aggregation of the individual preferences of the stakeholders, i.e., the preference profile.
Methods	We use voting methods for the aggregation of the individual preferences, which are implemented in the software tool.
Results & implications	The main results of the deliverable 1.3 are the following: ➢ NoAWVote, a software tool which implements a decision-making procedure based on Computational Social Choice. ➢ This report, which explains in detail the role and the functionality of the tool. ➢ Input's data files and the output files containing the results on specific use-cases.

3. Introduction

Nowadays, there is an increasing demand for collective decision-making and aggregation of preferences by the members of our societies. The most well-known example of collective decision-making are the elections but it is not the only one since there are a number of situations where the aggregation of the individual preferences is needed to take a decision. Consider for example situations such as a group of friends choosing for dinner among different restaurants or a committee board choosing what the best strategy is for the company. In all these cases, the individual agents, i.e., the involved stakeholders express their preferences and the objective is to fairly aggregate them into a collective preference and thus obtain a decision which satisfies the group as a total. This setting can directly apply also in the decision-making for agricultural problems, e.g., when the decision to be taken is the right food packaging and the citizens are asked to choose among different alternative packagings. The application of such methods will permit build new valorization routes for decision problems in agro-waste management.

It is common that in most of these collective decision-making problems the preference aggregation is done in a simple and inappropriate way by using simple aggregation methods, such as the plurality voting rule, using tools that are not even intended to serve this purpose. For example doodle is one such unsuitable tool that is used for preference aggregation while its original functionality was for scheduling joint activities. Therefore, we design and implement a procedure for supporting more complex collective decision-making problems, which can be directly applied to agricultural problems. The goal of this deliverable is to build a software tool for decision-making that takes into account theoretical insights from social choice in order to propose social fair decisions that take into account the preferences of the agents.

The problem we are considering refers to decision aiding in relation to valorization options for agricultural materials using Computational Social Choice and argumentation framework. We believe that by combining these two fields we can propose social fair decisions by taking into account the agents preferences and the reasoning behind these preferences. Note that there has been significant research towards decision-making on both of these fields independently but not combined. Social choice theory has been integrated in the analysis of some popular aggregation methods in multi-criteria decision aiding, i.e., the ordinal methods are based on the Condorcet method, e.g., (Roy 1991), and the cardinal ones are based on the Borda method, e.g., (Von Winterfeldt & Edwards 1986). On the other hand, a seminal work towards the usage of AF in decision making is the one by (Amgoud & Prade 2009) which proposes an abstract argumentation-based framework with a 2-step procedure where at first the arguments for beliefs and options, and the attacks between them, are built and at the second step we have pairwise comparisons of the options using decision principles. The problem we are focusing on this deliverable is the classical collective decision-making problem, where we have a set of alternative options *A*, and a set of agents *N.* Usually the set of agents corresponds to the set of the various stakeholders that are involved in the decision problem. Each agent expresses his/her preference over the alternative options by producing a linear order on them. We expand this classical collective decision-making problem by asking the agents to consider the reasoning behind the linear ordering of the alternatives. It is the reasoning behind the agents preferences that is crucial to our analysis since we intend

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

to present a decision making procedure that takes into account both argumentation analysis and social choice.

The purpose of this report is to describe in detail our applied procedure for supporting a decision for problems laying in the context of agricultural applications concerning agro-waste management. The applied procedure includes the design and implementation of a decision-making software tool which is being developed for the needs of NoAW project. The goal of this software is to provide social choice functionalities and methods for the involved agents, in order to support the collective decision-making by taking into account their viewpoints and their justified preferences. Our objective is to provide a generic software for the reasoning and aggregation of the preferences that will be directly applied to the specific use-cases used in the NoAW project. Currently, our team (INRA) in collaboration with IFV and University of Montpellier are designing a survey regarding possible valorization routes for viniculture and viticulture. In this survey the involved stakeholders, i.e., winegrowers, technical centers and consumers are called to express their preferences on different questions regarding current and future valorization routes/products used in viniculture and viticulture. The survey's input will be a really beneficial use-case for the application of our tool and the tool's computed collective preferences will serve as a strong support for the decision makers regarding new possible valorization routes. More details on the survey can be found in section 6 where we explain the collaboration with other partners in the project.

In order to demonstrate the functionality of our tool, we will apply the software procedure on an existing use-case which is extracted from a survey that was conducted for the needs of the Ecobiocap (ECOefficient BIOdegradable Composite Advanced Packaging) project. The use-case objective is to evaluate the interest of consumers in new-generation packagings made of agro-waste materials and hence, the decision problem includes aspects related to the agro-waste valorization questions but is not limited to them. However, note that, this use-case is not restrictive on the applicative usage of the software as we are considering a more general framework for the abovementioned or other future possible applications that will appear inside the NoAW project.

4. Results

4.1. Problem Description.

More formally, the problem is expressed as follows. As input, we have a set of alternative options *A* which will be called *alternatives* and a set of agents *N*, that will elicit justified preferences on the alternative options. We are considering the case where the agents' preferences are expressed by justified rankings, i.e., each agent provides a total order on the alternatives and a justification for this total order. The collection of the linear orders for all the agents is called the *preference profile*. In the classical social choice theory, the aggregation of the preferences is computed by a voting rule, i.e., the preference profile is reported to a voting rule (method), which then singles out the winning alternative and the ranking of the remaining ones. In real life scenarios there are use cases where the goal is to elect a fixed-size committee, i.e., a set of equally winning alternatives. For these problems a multi-winner voting rule is applied to the preference profile and outputs a fixed-size set of winning alternatives. The preference profile of the agents and the justifications are used to build the arguments and the argumentation framework *AF,* whose role is to help us elicit the justified preferences.

4.2. Architecture of the decision support software.

In this section we are presenting the general architecture of the decision-making software. Our proposal includes the design and the implementation of a decision-making tool, which is split into two main modules, i.e., the social choice module (*NoAWVote*) and the deliberation module. These modules can act independently or be combined to support a decision. *NoAWVote* is included in this deliverable while the deliberation module is due to month 30 of the NoAW project and will be included in deliverable 2.4 (Argumentation software programming and data analysis). The social choice module is based on Computational Social Choice methods that allow the computation of a "socially fair" global ranking of alternatives thanks to the aggregation of elicited individuals' rankings. The deliberation module will provide the argumentation framework which will allow for the computation of justifications on these individuals' rankings. It aims at allowing the “correction” of misinformed or incomplete information by using justifications coming from the different agents. Therefore, with the implementation of these two modules we adapt social choice and argumentation in order to have better decisions, in the sense of having justified preferences and their fair collective aggregation. Our proposed tool’s modelling is composed of the following four submodules: the data collecting, the voting, the argumentation and the decision submodules. In the following we are presenting the proposed theoretical schema of the tool and in the next sections we give details regarding the implementation of the software.

Data collecting submodule: The role of this submodule is to yield the data needed as input for the voting submodule and the argumentation submodule. Therefore, this submodule takes as input the survey's "raw" data, i.e., the preferences of the agents in an abstract format, as well as the justifications behind these preferences. In general, each survey provides us data which are related to the preferences of the agents in an abstract format and these data are used as the input to the data collecting submodule. Since we are considering different use-cases which have different forms of surveys implies that this submodule is survey-oriented and the method used to compute the output is adapted each time to the

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 688338

survey format. The output of the submodule is a structured json file which contains a total order (ranking) of the alternatives and/or criteria given by each agent with potential justifications supporting each preference. We propose the following two methods to extract the rankings of the alternatives: the first one is to take directly the total order given by each agent; the second method is to derive a ranking of the alternatives from the agents' responses extracted from the surveys. Examples of the second method can be a multi-criteria evaluation based on the utility values given by each agent for each alternative on specific criteria. The multi-criteria evaluation problem can be depicted as a matrix where we can represent in two dimensions the alternatives and the criteria for one agent. There have been deployed many methods in the literature that produce a ranking of the alternatives from a multi-criteria matrix.

Voting submodule: This submodule's function is to provide social choice methods for electing the "best" alternatives and/or criteria. When we refer to the term "best", we mean the alternatives/ criteria that correspond to the socially fairest outcome and, hence, best reflect the preferences of the agents. To achieve that, we consider the problem as a voting setting where we want to fairly aggregate the set of agents' preferences (preference profile) and produce as an output a ranking of the alternatives and criteria or a fixed-sized set of equally winning alternatives. We refer to Computational Social Choice techniques, e.g., voting rules, in order to aggregate the individual preferences of the agents. Recall that a voting rule is a function that takes as input a preference profile and returns a ranking of the alternatives including the winning one (or more in case of a tie). Also, note that a multi-winner voting rule is a function that takes as an input the preference profile and outputs a set of equally winning alternatives. Multi-winners voting rules are used when selecting fixed size committees. Many voting rules have been proposed in the social choice literature which try to satisfy prominent and fundamental fairness criteria. However, due to the impossibility results by Arrow (1950) and Gibbard-Satterthwaite (Gibbard, 1973; Satterthwaite, 1975) there is no hope of finding a voting rule that can be "perfect", because due to these results some vital criteria cannot be satisfied all at the same time. Therefore, we are proposing the usage of various voting rules for the computation so that the user, i.e., the decision maker will be able to choose one among them.

In general, in social choice theory literature there are two main categories of classical voting rules, the scoring methods, e.g., Borda which are based on scoring protocols and the Condorcet consistent rules, e.g., Copeland, which are based on the pairwise comparisons among alternatives. Condorcet, who is considered as the founding father of social choice theory, proposed the following rule for declaring the winner of the elections. An alternative *x* is said to beat alternative *y* in a pairwise election (comparison) if the majority of the agents prefer *x* to *y*, i.e., rank *x* above *y*. An alternative that beats every other alternative in a pairwise election is the winner of the elections and is named as the *Condorcet winner*.

Note that, the social's choice module projected architecture allows the decision maker to choose if she wants the outcome to be a full ranking of the alternatives or a set of "best" alternatives. Using a classic voting method can handle only the case of aggregating the individual preferences to a full ranking but does not cover the case of finding the set of equally winning alternatives, i.e., the "best" alternatives. Hence, we refer to multi-winner voting methods that permit the fair aggregation of the individual preferences when selecting committees. A committee is a fixed-size subset of alternatives who are equally

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

winners. Multi-winner voting rules are becoming really popular in social choice literature because in many real-life problems the objective is to select the “top” alternatives instead of a full ranking. The goal of these rules is that every agent is represented by a committee member and thus these methods are appropriate for electing the best k alternatives, when k is the number of alternatives in the committee.

Remember that many voting rules can be applied but our software proposes to compute the output aggregated ranking using the following voting rules: Borda, Kemeny-Young, k-approval, Extended Tideman’s simplified Dodgson and Multi-winner STV. A detailed explanation of the computation of these rules can be found in the next section as well as their implementation. One should keep in mind that on the same input, i.e., the preference profile of the agents, different voting rules can compute different aggregated rankings as output. In the next section, after defining the voting rules, we will present an example that shows this phenomenon where on the same preference profile different rankings will be produced. We included voting rules covering the whole spectrum of the literature. Therefore, we propose the implementation of Borda rule (Borda, 1781) as an example of a scoring rule and the Copeland’s method (Copeland, 1951) as a representative of Condorcet-consistent rules. We also propose the implementation of *k*-Approval (Brams & Fishburn, 1978) because we want to cover the case where the preferences of the agents include a set of equally “accepted” set of alternatives instead of a total order on them. Observe that for k = 1 the 1-approval rule is equivalent to the plurality rule, which is one of the simplest and most fundamental rules in the history of Social Choice. We also propose the implementation of the Extended Tideman’s simplified Dodgson rule (Caragiannis, Kaklamanis, Karanikolas & Procaccia, 2014) from the new generation of rules that were deployed recently in the Computational Social Choice literature to overcome the computational complexity issues of the other rules. This rule has the advantage of being polynomial time and thus can be computed on any input size. In addition, we propose a multi-winner voting rule, i.e., the multi-winner STV, in order to aggregate the agents’ individual preferences to a set of equally winning alternatives. In contrast to the data collecting submodule which is specific for each survey, the voting submodule is generic tool which can be used for all the use-cases.

Argumentation submodule: The role of this submodule is to provide the set of coherent and complete points of view. In order to achieve that we use the justifications of the rankings on alternatives/criteria of the different agents and eliminate through logical argumentation the inconsistencies between the agents’ preferences. Hence, the deliberation phase interacts with the voting procedure and the ambiguous preferences are eliminated from the preferences of the agents. Following this procedure we build the justified preference profile upon the preferences of the agents. The justified preference profile will interact with the voting submodule. The argumentation submodule will be the core of the deliverable 2.4, i.e., the deliberation module which is due to month 30 of the project.

Decision submodule: The role of this submodule is to provide a recommendation for the decision maker on the given decision problem which is the final output of our software. The decision is combining both notions from social choice and argumentation and hence, it is derived from the justified preferences of the set of agents over the set of the alternatives. Therefore, the recommendation we provide is the outcome of the voting submodule and/or the argumentation submodule. It can have different types (a ranking of the alternatives, a single winning alternative or a subset of winning alternatives) depending

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 688338

on the nature of the decision problem, which the decision maker will have already defined on the problem's formulation.

4.3. Social Choice Module, i.e., NoAWVote.

The social choice module serves as the one of the two modules that compose the decision-making tool and can act independently or in combination with the deliberation module. The social choice module's role is to provide a recommendation for decision-making based on the individual preferences of the agents that reflects the socially fairest solution according to these preferences. Hence, the individual preferences (preference profile) are aggregated and the socially best. i.e., fairest alternatives are computed. We refer to Computational Social Choice techniques, e.g., voting rules, in order to aggregate the individual preferences of the agents. One should note that the social choice module is a quantitative approach and selects the best alternatives with regard to the aggregation of the individual preferences, but if the decision maker demands a more qualitative approach then he/she has to take into account the deliberation phase, hence the need to design the deliberation module which completes the social choice module for the decision support system. The social choice module is composed of an implementation of the following three submodules: the data collecting submodule, the voting submodule and the decision submodule. In this section we present the functionality of the social choice module. The tool is implemented in the Java language and we use the Swing toolkit for creating the graphical interface (GUI).

4.3.1) Implementation of the data collecting submodule.

The role of the data collecting submodule is to transform the raw data which is extracted from different surveys into the suitable input's format for the voting submodule. Remember that raw data can have different formats depending on the format of the surveys. Recall that each survey provides us data which is related to the preferences of the stakeholders in an abstract format. Therefore we implement a java class that can handle several different formats and transform them into a unique format, which is a json structured file. Hence, the output of the module is a json file which is going to be used as the input for the voting submodule and contains the total order (ranking) of the alternatives/criteria. The structure of the json file is analyzed below in the next paragraphs. For the moment we are implementing the transformation of different csv file formats that are exported from LimeSurvey, since it is a popular web server-based software which enables users to develop and publish on-line surveys and collect responses, using a user-friendly web interface. The design and the implementation of the data collecting submodule permits the future addition of functions that can implement transformation of different file format to the json input.

In the Ecobiocap's use-case the survey's data is given from an csv file format extracted from a LimeSurvey where each agent provides a ranking of the alternatives for each one of the questions corresponding to the decision problems. Also, each agent provides additional personal information which helps the classification of the agents to different categories according to the needs of the decision maker. The csv file is composed of a line for each agent and represents the preferences of that agent.

In general, the output json file has the same structure as the voting's submodule input file and contains the following information. For each one of the decision problems we have the following data:

- "Poll's Question": contains the formulation of the decision problem in an interrogative form as it is imposed by the decision maker.
- "Question id": a number for identifying and distinguish between the different decision problems
- "alternatives": the list of the alternatives that correspond to the specific decision problem
- "criteria": the list of the criteria that correspond to the specific decision problem
- "agents categories": contains the categories on which the agents can be classified to. The set of agents can be classified into different categories according to their characteristics. In this field the decision maker defines all the characteristics that she wants to be taken into account for classifying the agents. For example one category can be "age".
- "categories of users": contains the sub-categories of the above categories on which the agents can be classified to, e.g., for category "age", we can have the following sub-categories: "18-25","26-35","36-49","> 50".

While for each agent we store the following data:

- "agent id": a number for identifying and distinguish between the different agents.
- "values for agents categories": contains the personal information for each agent corresponding to the categories defined in the decision problem.
- "alternatives ranking": contains the total order of the alternatives according to the agent.
- "ranking of criteria": contains the total order of the criteria according to the agent.
- "preferences in criteria of alternative <alt> for question id <id>": contains the evaluation of the agent for alternative <alt> on the criteria given for decision problem with question id=<id>.

We are considering the case of future use of this module into the deliverable 2.4 (Argumentation software) so we are taking into account also the justifications behind the agents' preferences. Hence, we contain also fields for explaining the agents' rankings on alternatives and criteria. The json file can support more than one poll's questions if multiple questions on the same set of agents are included in the survey.

Translator's Functionality

As previously noted the role of the data collecting submodule is survey oriented. Therefore, we create a tool, which we call "translator" that can transform the agent's preferences included in a csv file extracted from a LimeSurvey into the json file required as input for the voting submodule. The translator is an implementation of the data collecting submodule and demands the following requirements in order to perform the parsing from the csv to the json file. Hence, the csv file must be extracted with the following guidelines in order for the translator to perform properly. First of all, the csv must have the structure

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

of a table. The first line (row) of the csv file contains the *headings* with the information of the survey, i.e., the *headings line*. The following lines correspond to agents and each line contains the information for one agent, i.e., the *agents' lines*. Each line is split into columns with a comma (,) or with a tab (\t). The information that is included in each column is defined by the headings line. The first columns contain general information about the survey and the next ones the preferences of the agents and the justifications. The translator supports 3 types of format. For all format types, the first column contains the id of the agent and the word "id" must be included in the heading (e.g., id or Response ID, etc...). We can now distinguish between the different formats.

The first one is the simplest. Recall that, the first line file contains the headings with the information of the survey. In the agents lines every cell after the first column contains the alternatives according to the preferences of the agents. For example, in the line than contains agent x, cell (x,2) contains the alternative who is ranked first in the preference of agent x while cell (x,3) contains the alternative ranked second in x and so on.

The second format corresponds to settings with one question (decision problem) and is the following. Recall that, the first line file is the headings line with the information of the survey and that agents lines follow. The columns after the first one contain general information about the poll and the "useful" columns follow. The first one of them contains in the heading the word "stakeholder" and in each agent line below there is a string with the stakeholder type of every agent. Then, the following columns must contain the work "rank" and in every agent line we have a string with the name of the alternative which defines the ranking of this alternative. The next column must contain in the heading the words "justification for the ranking" and each agent line contains the justifications for each agent. The next columns must have as heading the words "evaluation for each" and then a pair of alternative-criterion that is included in brackets []. The agents lines beneath contain the evaluation each agent gives for the corresponding pair included in the heading. The next columns must have as heading the words "justification for your evaluation on each" and then a pair of alternative-criterion that is included in brackets []. Hence, the agents lines beneath contain a string with the justification for the corresponding pair included in the heading. The next columns must contain in the heading the words "rank the criteria" and the agents lines contain the strings with the criteria according to their preferences. The last columns for this format must have as heading the words "justification for the ranking of the criteria" and the agents' lines must contain the strings with the justifications. Note that this is the generic format and some of the columns may not exist.

The third format corresponds to problems with multiple questions (decision problems) and is the following. Recall that the first line is the headings line and below we have the agents' lines. We also have here first some columns with general information and the "useful" columns follow. The columns with general information contain in the heading the symbol ":" or "?" and usually concern the classification of the agents into categories (e.g., sex, salary, education, etc...). Each column is distinguished to the next one using one of the two symbols. The agents' lines correspond to the headings and contain the information about each agent for each one of the categories. Then, the next columns are referring to questions which can be ranking or boolean, i.e., yes or no. The ranking questions include the word "Classement" or "rank" while for boolean there is no specific heading requirement but they must be

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

followed by a justification column. The justification column must include the word “justifier” or “justify” or “justification” in the heading. The agents’ lines include the agents’ rankings and justifications as in the previous format.

4.3.2) Implementation of the voting submodule.

Our design goal for the voting submodule is to aggregate the individual preferences of the agents and compute the socially fairest alternatives. To achieve that we create a java class which implements the voting submodule’s features. The different features that are implemented and supported by the voting submodule are described in the reminder of this section.

Input type.

There are two input types for the voting submodule. The default file input’s format is a structured json file containing information about the different decision problems and the agents’ individual preferences. A single json file can support more than one decision problem. A decision problem is defined by the topic the decision maker designates. Hence, each decision problem corresponds to a question that defines a poll. Therefore, we implement the json file to include several decision problems when multiple questions on the same set of agents are included in the survey. The format of the json file was presented in detail in the previous section.

The second input file format is a csv file derived from LimeSurvey containing the information about the different decision problems and the agents’ preferences. The first line of the csv file is composed of the information about the decision problems and then there is a line for each agent which represents the preferences and the information of this agent. The second input file format method is used to help users by allowing them to directly load the preference profile outputted by LimeSurvey. The csv file that can be directly interpreted by the voting submodule has the same requirements as the ones used as input for the Translator.

Aggregation of individual preferences.

The core functionality of the social choice module is the aggregation of the agents’ individual preferences to a collective preference which best reflects the will of the agents. The scientific field that is related to the fairest aggregation of the individual preferences is called computational social choice, and especially voting theory. Hence, the classical way to deal with this problem are the preference aggregation, or so-called voting rules. As noted, there is no “perfect” voting rule and therefore we are referring to the following rules to compute the collective ranking of the alternatives. A definition of implemented the rules follows.

BORDA'S COUNT: It is a scoring based voting rule. It is one of the simplest and most intuitive scoring rules, where each alternative receives from *0* to m - *1* points from each agent, where *m* is the total number of alternatives. The protocol is that the alternative which is ranked in the *k*th position by agent *i* receives *m-k* points from this agent. The total Borda score of each alternative is the accumulation of all

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 688338

the points received from the agents. The alternative with the highest accumulated score wins and the rest of the alternatives are ranked according to their score.

k-APPROVAL: Each agent "approves" (i.e., selects) *k* out of *m* alternatives and each one of them gets *1* point. The approval score of an alternative then is the cumulative number of the points she receives from all the agents. In all approval rules (including plurality and veto) the alternative with the highest score wins and the rest of the alternatives follow according to their score.

PLURALITY (1-APPROVAL): It is a special case of *k*-Approval. The plurality score of an alternative simply denotes the number of votes in which she is in the first position.

VETO ((M-1)-APPROVAL): Also, a special case of *k*-Approval where each agent approves all but one alternative. The intuition is that each agent poses her disapproval (veto) on one alternative. Therefore, each alternative gets one point if she is not last in the preference of the agent. The veto score of an alternative then is the cumulative number of the points she receives from all the agents.

COPELAND: In Copeland's rule alternatives are compared pairwise. When an alternative is preferred by the majority of the agents she receives one point and the other alternative receives zero points. In case of a tie, in the classical version of Copeland's rule both receive *0.5* points. The sum over the points is called the Copeland score. Winner(s) are the alternatives with maximum Copeland score and the rest follow according to their score. In a generalized version of Copeland the points each alternative receives in case of a tie can be parameterized.

EXTENDED TIDEMAN'S SIMPLIFIED DODGSON RULE: This rule depends also on pairwise comparisons between alternatives and is based on the well-known voting rule of Dodgson (Black, 1958). Since Dodgson's rule is hard to compute we choose this rule because it is a Dodgson's approximation algorithm which can be efficiently computed. This rule is an extension of Tideman's rule and the score of each alternative *x* is defined as follows. If an alternative is a winner under the Condorcet method then her score is *0*, otherwise her score is computed by the following formula:

$sc(x)=m \cdot sc_{td}(x)+m(\log m+1)$,

where *m* is the total number of the alternatives and

$sc_{td}(x)=\sum_{y \in alts.\setminus\{x\}} \max\{0, k-l\}$.

where *k* is the number of agents that prefer *y* over *x* and *l* is the number of agents that prefer *x* over *y*.

The alternative with the minimum score wins and the rest of the alternatives are ranked according to their score.

MULTI-WINNER STV: This rule belongs to multi-winner voting rules which are designed for selecting a fixed k-sized committee of alternatives, i.e., the set of k-winning alternatives. Hence, multi-winner STV is the most appropriate rule to be used when the output selection is set to k-top alternatives. The Single

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

Transferable Vote rule (STV) executes a series of iterations, until it finds k winners. A single iteration operates as follows: If there is at least one candidate with Plurality score at least q =$\lfloor n/(k+1) \rfloor$ +1, then an alternative with the highest Plurality score is added to the committee; then q voters that rank her first are removed from the election (a randomized tie-breaking plays an important role here), and the selected alternative is removed from all voters' preference orders. If there is no such alternative, then an alternative with the lowest Plurality score is removed from the election (again, ties are broken uniformly at random). The Plurality scores are then recomputed.

As noted in the previous section, there is no "best" voting rule and voting rules can produce different collective preferences even if they have as input the same preference profile, leading to the need, for the decision maker, to be able to choose the voting rule used for computation. In the following example we are showing this phenomenon by using the voting rules defined earlier. It's easy to observe that Borda's, Approval and the Condorcet-rules produce different winners.

Example. Let us consider the following individual preferences for the agents. We have 55 agents with the following rankings. We should note here that *x* > *y* indicates that an agent prefers *x* to *y*.

- 18 agents: *A* > *D* > *E* > *C* > *B*
- 12 agents: *B* > *E* > *D* > *C* > *A*
- 10 agents: *C* > *B* > *E* > *D* > *A*
- 9 agents: *D* > *C* > *E* > *B* > *A*
- 4 agents: *E* > *B* > *D* > *C* > *A*
- 2 agents: *E* > *C* > *D* > *B* > *A*

We are now applying the following different voting rules and obtain the corresponding results.

- Borda's count: Alternative *D* wins with (18x3) + (12x2) + (10x1) + (9x4) + (4x2) + (2x2)=136 points. *A* gets 72, *B* 101, *C* 107 and *E* 134.
- *1*-approval (plurality): Here, *A* wins, with 18 votes. Alternatives *B* to *E* have score 12, 10, 9 and 6 respectively.
- For Tideman's and Copeland's rules we observe that a Condorcet winner exists so she is also the winner under these rules. Alternative *E* is the Condorcet winner since she beats each of the other four options in pairwise comparisons, i.e., *E* beats *A* 37-to-18, *B* 33-to-22, *C* 36-to-19, and *D* 28-to-27.
- For Multi-Winner STV suppose that we want the best 3 alternatives, so we fix k=3. A has plurality score of 18 which is at least $\lfloor 55/(3+1) \rfloor + 1 = 14$, so A is included in the winning alternatives and the 18 voters that rank A first are removed from the election, and also A is removed from all voters' preference orders. B has plurality score of 12 which is at least $\lfloor 37/(3+1) \rfloor + 1 = 10$, so B is also included in the winning alternatives and the 12 voters that rank B first are removed from the election, and also B is removed from all voters' preference orders. C has plurality score of 10 which is at least $\lfloor 25/(3+1) \rfloor + 1 = 7$, so C is also included in the winning alternatives. Hence, A, B and C are the winners.

Incomplete (truncated) preferences: We are considering the case where agents do not provide a complete ranking of the alternatives. We call these preferences on the alternatives "truncated". This can happen when each agent is likely to know who her most favorite alternatives are but she is unwilling to put the effort into ranking the remaining ones. Then, it is safe to assume that she likes them less than the ranked ones but among the unranked ones there is no difference in preference. Hence, we consider this assumption when computing the collective preferences under incomplete preferences. Therefore, the typical voting rules, like the abovementioned, have to be adjusted to comply with this case. For example, for Borda, we could assume that each unranked alternative receives *0* points from a given vote (a method used in Slovenia, which we will call the pessimistic scoring model). Or, if there are m alternatives but a vote ranks only k of them, then the ranked alternatives get $m-1, . . . ,m-k$ points (depending on their position in the ranking) and each unranked alternative gets $m-k-1$ points. This method is sometimes called modified Borda and is used, e.g., by the Irish Green Party to choose its leader. We will call this method the optimistic scoring model. We will use the pessimistic model in our computation for Borda because it is more widely used. For k-approval, plurality and veto if the preferences of the agents are incomplete but more than k alternatives are ranked then there is no difference and on the contrary when less than k alternatives are ranked by the agent, then all get one point. For the rules based on the pairwise comparisons we assume that if an alternative is ranked and the other is not, then the winner is the one ranked and when both are unranked we do not take into account this comparison.

4.3.3) Implementation of the decision submodule.

The role of the decision submodule is to provide a recommendation for the decision maker. The output (decision) will be based on the aggregation of the individual preferences but may contain different results according to the parameters that are imposed by the decision maker. To achieve that we create a Java class which implements different features, which we call decision-aiding features. The decision-aiding features are interacting with features from the voting submodule so there is a strong connection in the implementation with the voting submodule. The decision maker can choose amongst decision-aiding features that can be classified into 3 categories according to the computation phase where they belong to. We have the following phases during on which the decision maker can select her appropriate decision-aiding feature.

Voting phase.

The first parameter on which the decision maker can parameterize her decision is the choice of the appropriate voting rule. The decision maker can therefore choose one or more of the abovementioned voting rule(s) according to her needs and obtain different decisions, since different rules on the same preference profile can lead to different collective rankings.

Aggregation phase.

During the decision-making procedure choosing the right voting rule is not the only crucial matter in order to support a decision. The decision maker is provided with different aggregation procedures that

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

can help her take a better decision according to the needs of the problem by either taking a subset of the agents preferences or/and increasing the weight of the opinion of some agents. The preference profile can be partitioned in different subsets when agents share common characteristics. When agents belong to the same subset we say that they belong to a specific category. For example, the decision maker may be interested in obtaining results according to the sex of the agents, i.e., we have two groups, one for male agents and one for female. In this way the partition of the preference profile which is taken as the input is the one that differentiates the aggregation procedures. The decision maker can also combine categories in order to get the preference profile for the input (combination of categories). For example, the decision maker can choose her input to be men aged 18-35. For this reason, the software allows the option to combine categories “Sex: male” and “Age: 18-35” in order to get the desired preference profile as the input. Therefore, we propose the following decision-aiding aggregation procedures.

TOTAL AGGREGATION: The decision that is provided is computed by the application of a voting rule on the totality of the votes in the preference profile.

AGGREGATION PER CATEGORY: In this procedure the agents are forming groups (subsets) according to their classification on different categories. Therefore, in order to provide a decision, we apply a voting rule having as input the preference profile that corresponds to agents belonging only on the specified, by the decision maker, category (or combination of categories).

2-PHASE AGGREGATION: Also, in this procedure the agents are forming groups according to their category (or combination of categories). In the first phase a ranking for each one of the agents’ categories (subsets) is computed by applying a voting rule. In the second phase the supported decision is the collective preference which is computed by the aggregation of the rankings produced during the first phase. For both steps we are using the same voting rule. We consider that each one of the agents’ types has equal say (i.e., weight) to the final collective preference.

2-PHASE AGGREGATION WITH WEIGHTS: It is similar to the above procedure but in this case we do not consider that each one of the agents’ types has equal say to the final collective preference. Instead we provide the ability to the decision-maker to define the weights for the different categories according to the needs of the decision problem. The final ranking (decision) is computed by the proportional, according to the weights, aggregation of the votes of each category.

Output phase.

During this phase the decision maker can base her decision on different types of output. The output produced by the tool can have the following forms.

SINGLE WINNER: The recommendation that is provided to the decision maker is the winning alternative according to the specified rule. In case of a tie we can have multiple winners.

K-TOP ALTERNATIVES (COMMITTEE SIZE): The recommendation that is provided to the decision maker is a committee of size k, which corresponds to the set of the best k alternatives. For better results, you

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 688338

are advised to use a multi-winner voting rule, for example, Multi-winner STV or Borda (in this case k-Borda is used for computation).

RANK: The recommendation to the decision maker is provided in the form of a complete ranking over all alternatives, i.e., the collective preference, and is computed by the used voting rule.

The results which are the output of the decision submodule can be depicted directly on the screen or be saved in a text file. The decision maker can choose which of the parameters she will include in the visualization on the screen or in the text file.

4.3.4) Graphical User Interface.

The goal of our decision support software is to be used by decision-makers which are non-voting experts. Taking this goal into account, we implement a graphical user interface (GUI) which corresponds to the functionalities described in the submodules. We believe that our GUI is user-friendly and permits the decision maker to explore all the functionalities in terms of preference aggregation and achieve a decision based on her needs. A screenshot of the GUI is shown in Figure 1.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

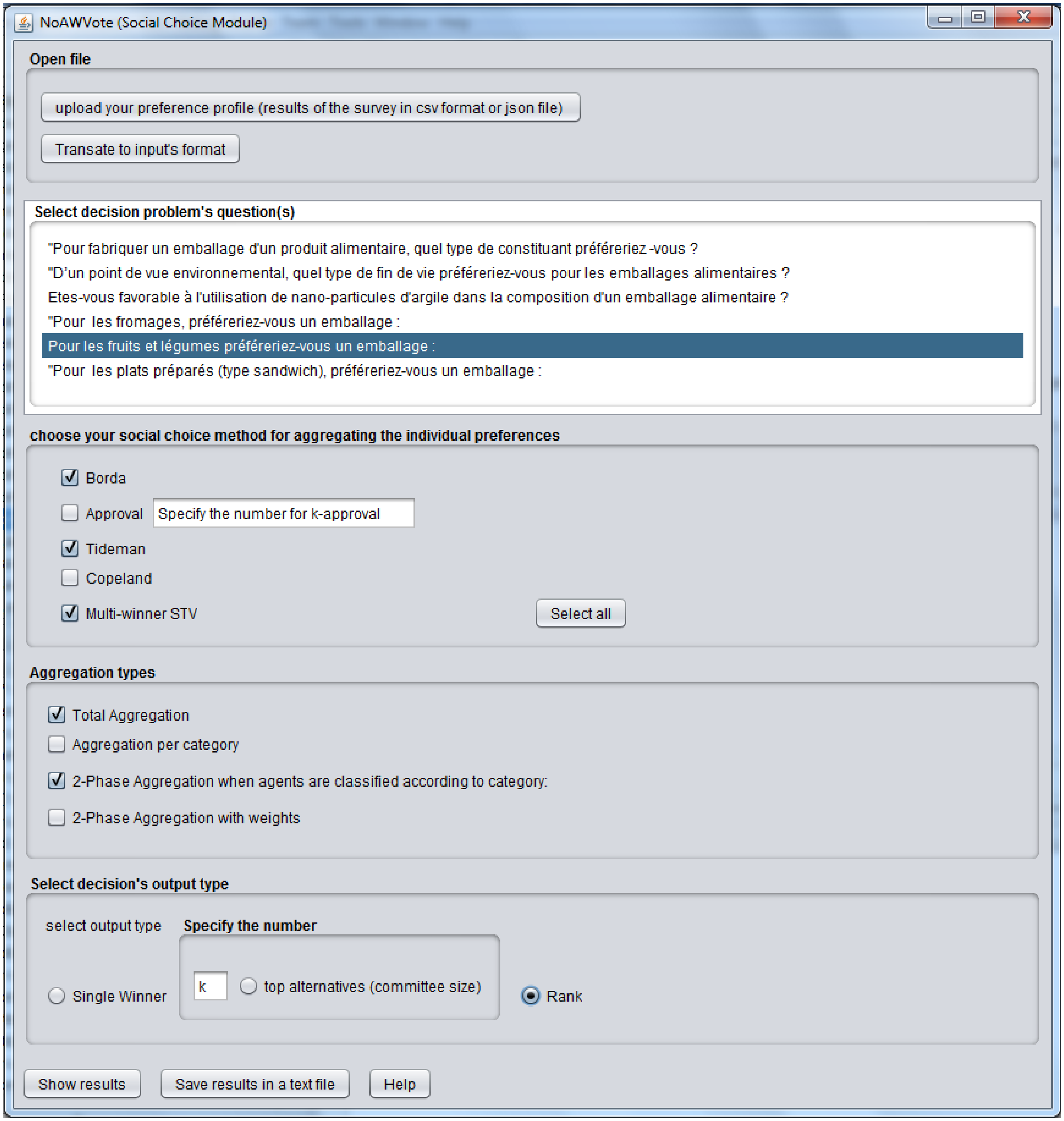


Figure 1: A screenshot of the GUI

The layout of the interface is the following. On the upper part of the application we depict the *data collecting submodule* where the user can load the survey's file (json or csv). Right beneath is the *translator* where one can transform the survey csv file into the json file format which is appropriate for input to the voting submodule. In the middle part of the GUI the *voting submodule* is being visualized where

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

the decision maker can choose the voting rule that is going to be used for the aggregation of the preference profile. Then in the lower two panels the *decision submodule* is being shown the decision maker can select the aggregation and output types she prefers. In order to select the aggregation types a new window appears (Figure 2) and for example here for the decision problem of selecting the best food packaging for fruits and vegetables the decision maker wants to take into account only the preferences of age group 26-35.

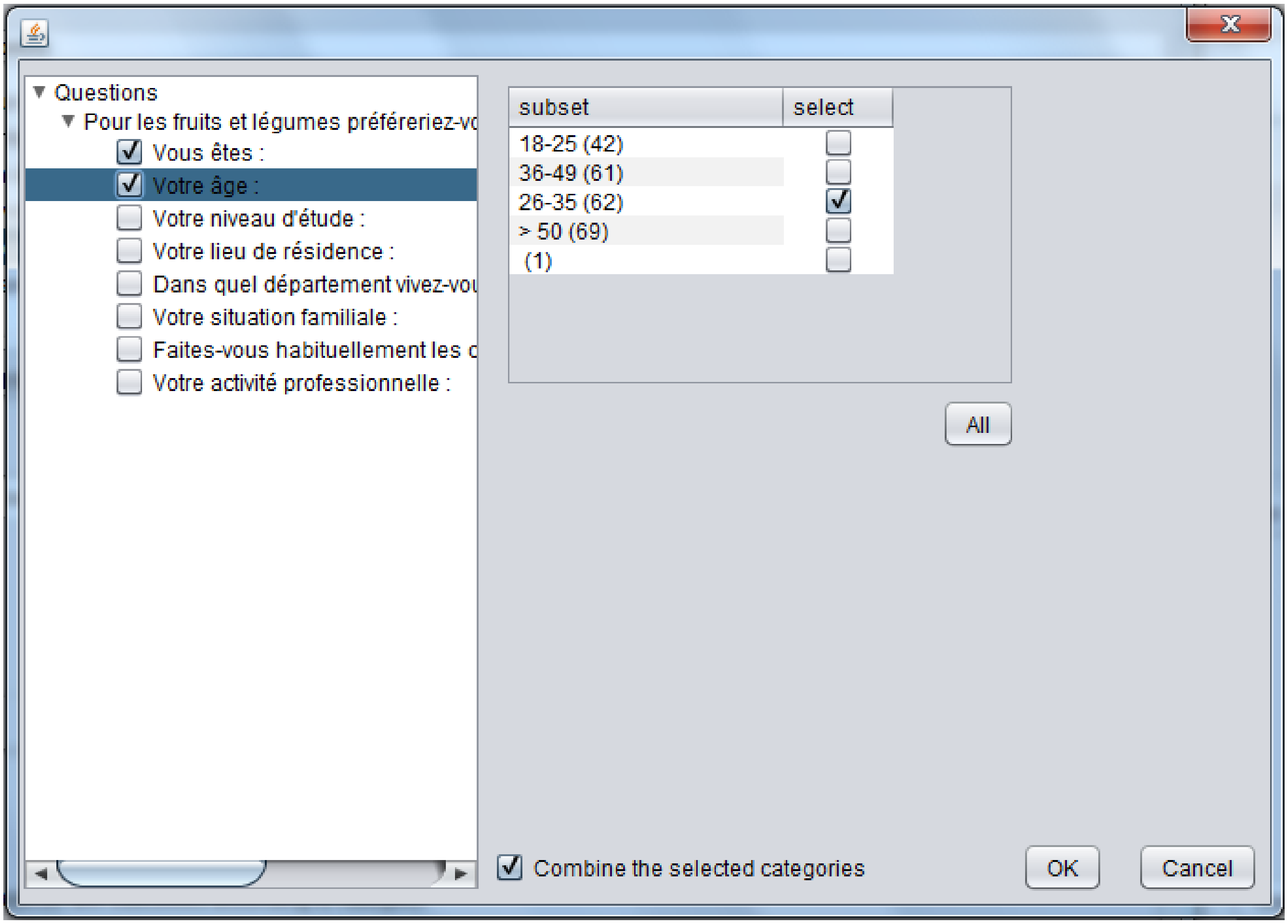
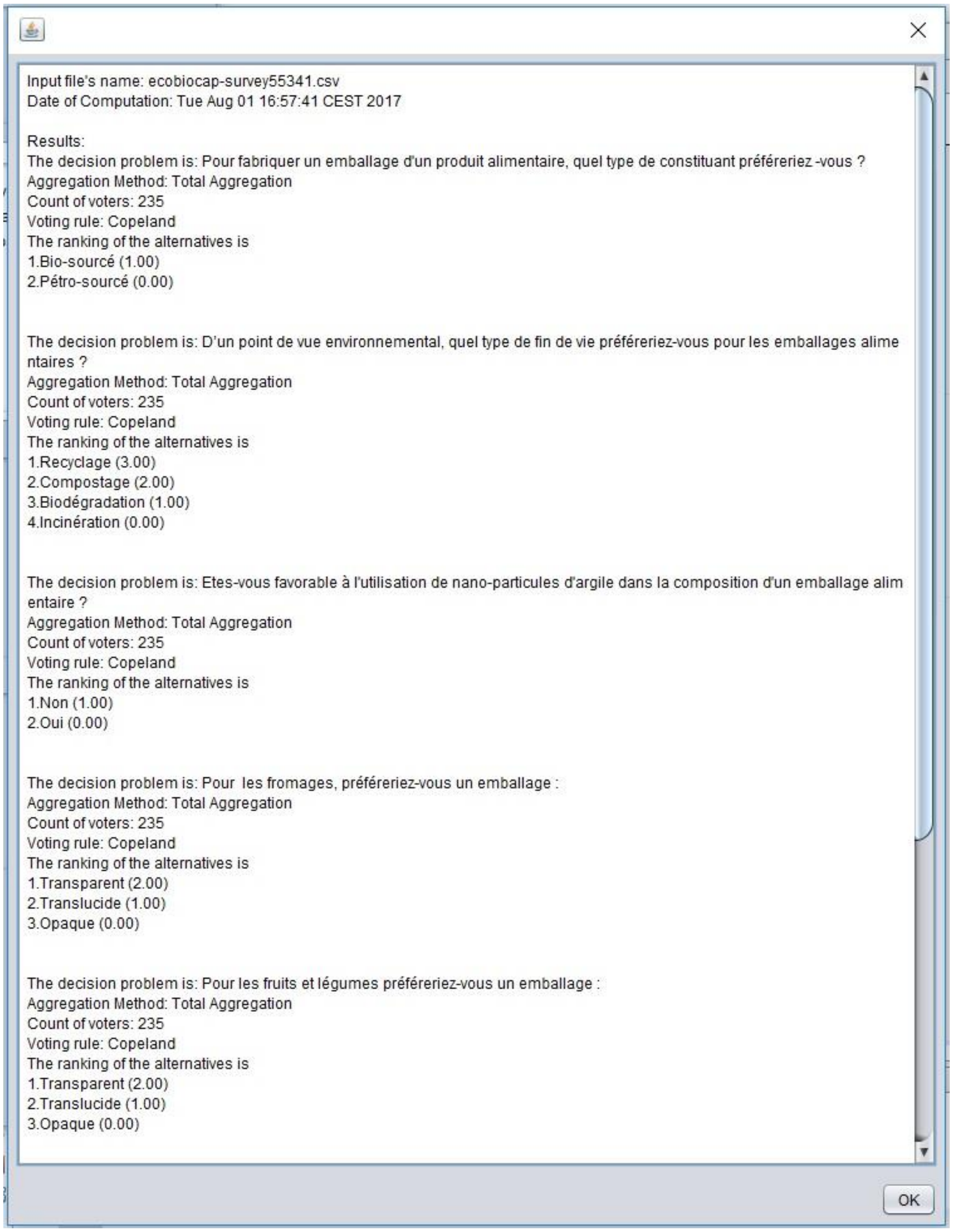


Figure 2: Interface for aggregation types. In this example the decision maker wants to take into account only the preferences of the female agents aged 26-35.

The *output of the computation (results)* is depicted in a text form when the show results button is clicked. The decision maker can choose through the interface the parameters she wants to impose and hence obtain the corresponding results. The interface for the results is depicted in Figure 3. We provide the option to the decision maker to *save* the results in a text file. We have also added a *help file* that allows the user to get useful information for interacting and using the social choice module.



Input file's name: ecobiocap-survey55341.csv
Date of Computation: Tue Aug 01 16:57:41 CEST 2017

Results:
The decision problem is: Pour fabriquer un emballage d'un produit alimentaire, quel type de constituant préféreriez -vous ?
Aggregation Method: Total Aggregation
Count of voters: 235
Voting rule: Copeland
The ranking of the alternatives is
1.Bio-sourcé (1.00)
2.Pétro-sourcé (0.00)

The decision problem is: D'un point de vue environnemental, quel type de fin de vie préféreriez-vous pour les emballages alime
ntaires ?
Aggregation Method: Total Aggregation
Count of voters: 235
Voting rule: Copeland
The ranking of the alternatives is
1.Recyclage (3.00)
2.Compostage (2.00)
3.Biodégradation (1.00)
4.Incinération (0.00)

The decision problem is: Etes-vous favorable à l'utilisation de nano-particules d'argile dans la composition d'un emballage alim
entaire ?
Aggregation Method: Total Aggregation
Count of voters: 235
Voting rule: Copeland
The ranking of the alternatives is
1.Non (1.00)
2.Oui (0.00)

The decision problem is: Pour les fromages, préféreriez-vous un emballage :
Aggregation Method: Total Aggregation
Count of voters: 235
Voting rule: Copeland
The ranking of the alternatives is
1.Transparent (2.00)
2.Translucide (1.00)
3.Opaque (0.00)

The decision problem is: Pour les fruits et légumes préféreriez-vous un emballage :
Aggregation Method: Total Aggregation
Count of voters: 235
Voting rule: Copeland
The ranking of the alternatives is
1.Transparent (2.00)
2.Translucide (1.00)
3.Opaque (0.00)

OK

Figure 3: Results interface.

4.4. An Example on real Data: Agro-Waste Valorization and Packaging Choice Decisions for Ecobiocap.

In order to demonstrate the usability of our tool we adapt real-data decision problems on agro-waste valorization. Hence, the functionality of our tool can be shown through the following case study extracted from a survey that was conducted in a national level for France for the needs of the Ecobiocap

(ECOefficient BIOdegradable Composite Advanced Packaging) project. This survey is related to different problems regarding food packaging where 235 citizens helped by answering the questions and providing their rankings. Therefore, we use this survey for collecting the data, i.e., the citizens (agents) preferences and the justifications, and answering in the next step the decision problem. One should observe that using our applied procedure on these examples is not restrictive on the applicative usage of our software since it is designed as a more general framework which can support future possible applications and problems that will appear in the NoAW project. Our team in a joint effort with UM have already designed a draft of a survey regarding the agro-waste management in viniculture and viticulture and the objective is to finalize the survey in collaboration with other NoAW partners, such as the IFV, CBHU, VA and IAUS as well as other partners involved in WP1 and WP2 who will show interest in decision-making problems.

The application we consider aims at evaluating the interest and potential of proposing and marketing new-generation packagings made of agro-waste materials, such as cereals by-products. To study this decision problem, we adopt a more general approach, by analyzing on which criteria and according to which preferences consumers make their packaging choices. The criteria correspond to the different sub-decision problems included in the survey and are forming together the major decision problem of which features should be taken into account when designing a food packaging. The first objective of the decision problem is to select the best alternative options among different food packagings regarding the material (among which, the use of agro-waste) and the visibility, while the second objective is to select the best end-of-life for food packaging. It is easy to see that each one of the problems can correspond to a criterion (or feature) when designing a food packaging.

The first category of problems included in this survey consists in finding the best alternatives in terms of food packaging for various kinds of foods. Hence, the citizens were asked to give their preferences on different questions regarding cheese, fruits & vegetables and sandwich packagings. These questions correspond to different decision problems (for each type of food) as the agents evaluated and ranked the alternatives for each question separately. The set of alternative options given to be ranked by each agent were transparent, translucent and opaque.

The second decision problem on which the agents were asked to give their opinion concerns the type of material for food packaging. Therefore, each agent gave her preference on the type of the material she prefers for producing the food packaging. The agents had to choose between two alternatives for this problem, i.e., bio-source (in particular, using agricultural by-products to produce the packaging) and petro-source.

For the next decision problem each agent had to answer if she approves the usage of clay nanoparticles for the composition of the food packaging. The agents had to choose between yes and no.

The last decision problem is related to the end-of-life management of the food packaging. The agents gave their preferences on the type of the end-of-life they prefer for the packagings. For this problem the set of alternatives were: recycling, composting, biodegradation and incineration.

The individual preferences of the agents are included in the ecobiocap.csv file and can be found in the accompanying files of this deliverable. The csv file was directly extracted from LimeSurvey.

Results and decision support.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

Running the decision tool on this survey provided recommendations to the decision maker for designing food packagings taking into account the citizens collective preferences. Also, based on the decision maker parameters some interesting facts were revealed when partitions of the preference profile are taken into account.

The results revealed that for the type of packaging the citizens prefer for cheese, fruits & vegetables and sandwich the transparent is ranked higher than translucent while opaque is the last one in all but the plurality rule. In the case of 2 or more alternatives plurality is not considered an appropriate method by social choice theorists. Hence, the recommendation provided to the decision maker is than citizens prefer transparent to translucent to opaque.

Regarding the second decision problem, the results revealed that in the collective preference of the citizens for the type of the material they prefer for producing the food packaging the bio-source is ranked higher than petro-source. The same result appeared when all the voting rules were used for the aggregation of their individual preferences. Hence, the recommendation provided to the decision maker is than citizens prefer bio-source to petro-source.

For the decision problem concerning the usage of clay nanoparticles for the composition of food packaging, we used plurality and the recommendation provided to the decision maker is than citizens do not prefer the usage of clay nanoparticles.

The results for the last decision problem, which corresponds to the end-of-life for packagings, revealed the following same ranking for the rules of Borda, Tideman's and Copeland: recycling, composting, biodegradation and incineration. Using plurality we obtained a slight different ranking: recycling, biodegradation, composting, and incineration but observe that the winner is still the same under all voting rules. In this case we have 4 alternatives so we will not use the ranking provided by plurality and hence, the recommendation provided to the decision maker is than citizens prefer recycling to composting to biodegradation to incineration for the end-of-life for food packagings.

We split and include in the text files the results for each question separately. The name of the files are q*?*-all-total-rank.txt, where *?* stands for the number of the question. For each question we compute the collective rankings using all voting rules and the whole preference profile.

Summing up the results of all the above decision problems the decision provided by the collective preferences of the citizens is that they prefer a food packaging that satisfies the following features. It should be transparent, made of bio-source materials without the use of clay nanoparticles and should also be recyclable.

The following interesting insights appeared when the decision maker parameterized the decision problem by using different voting rules and aggregation types for the aggregation of the individual preferences. The first category of the observed insights in real data examples concerns the discrepancies appeared for the same preference profile when a different voting method was used. For example, as already mentioned above, the collective ranking obtained using the plurality rule is different compared to the other voting rules for the same input. The second category of insights observed are the ones related to the aggregation when different subsets of citizens were taken into account. We make the following interesting observations. Note that all the remarks that we make below refer to computation under the same voting rule.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

Example 1. For the problem of the end-of-life, the collective ranking according to different sex is different when men are compared to women. The collective preference of the 91 men included in the survey is: recycling, biodegradation, composting and incineration. On the other hand 143 women voted for the survey and their collective ranking is: composting, recycling, biodegradation and incineration.

Example 2. For the same problem different results are also obtained if we change the category of aggregation to age. All the age groups except the ones over 50, i.e., "18-25", "26-35", "36-49", have the same ranking: recycling, composting, biodegradation and incineration while people over 50 have composting, biodegradation, recycling and incineration.

Example 3. The end-of-life problem is not the only one with interesting insights. For the problem of cheese packaging we also obtain different rankings when different subsets of the preference profile are used. For example, citizens living in the Herault department have the following preference: transparent, translucent, opaque while people living in Paris have: translucent, transparent, opaque.

Therefore, we can see in practice that collective preferences change according to a partition of the preference profile used as the input. Apart from the above examples more insights were observed by different partitions of the citizens according to their classification.

We provide the partitioning of the preference profile as an important tool to the decision maker in order to support her decision when the nature of the decision problem is driven by different constraints. For example, if the decision maker is only interested for producing a cheese packaging that will only be sold in Paris then she should rely her decision only on the preferences of the agents that live in Paris (example 3). Also the 2-phase aggregation is a really important tool for the decision maker. In **example 4**, for the end-of-life problem you can see that people living in Herault have different preferences from people living in Paris. People from Herault prefer recycling > composting > biodegradation > incineration while people from Paris equally prefer composting and biodegradation to recycling and incineration. The total of aggregation of the all the agents produces the collective ranking: recycling > composting > biodegradation > incineration which is the same as the Herault's collective ranking. This is due to the ratio of the statistical sample which is not proportional to the real population ratio because in the survey we had 137 agents voting from Herault and 14 from Paris. However, if the decision maker wants a fairest solution according to population ratio she can adjust the weights of the voters living in different regions. Hence, if we assume weight of 12 to Paris compared to 1 for Herault (12 million inhabitants versus 1 million) then the following collective ranking is computed: composting > biodegradation > recycling > incineration. Note that, we also assume the weight of the other departments 0 since the statistical sample is small for them. You can find the detailed results of the examples in the attached text files.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

5. Conclusions

Summing up, in this deliverable we have proposed a software tool for decision-making for issues coming from agricultural engineering with the aid of Computational Social Choice and Argumentation Framework. In the report above we described thoroughly the social choice module of the decision support software and demonstrated its application on a real-data example in the context of a survey taken from Ecobiocap project where the objective is to find the best food packaging in terms of material, visibility and end-of-life. Taking into account the individual preferences of the citizens, we computed the collective preference for food packaging problems. Different collective preferences were computed according to the parameters imposed by the decision makers. The decision makers could choose to parameterize the results according to the voting rule and the citizens' categories of their choice. A preliminary version of the decision support system has been presented in EFITA WCCA congress (Bisquert, Buche, Croitoru, Karanikolas & Thomopoulos 2017).

The designed software will serve as decision-making tool for problems appearing in the NoAW project. In collaboration with UM we designed a survey that fits our specifications for NoAWVote and aims at identifying the preferences of the stakeholders regarding new valorization routes and products that will appear in viniculture and viticulture. It's our intention to closely collaborate with other partners inside the NoAW project and identify common decision problems that will allow us to design exclusive surveys corresponding to the potential problems. There have been some preliminary discussions with the partners involved in WP1 and WP2 in order to achieve this goal.

Regarding the future, we want to further extend our research towards the integration of Argumentation and Social Choice for "better" decisions. We have already planned the design and the implementation of the deliberation module which will complete the decision support software and is the subject of deliverable 2.4 which is due to month 30 of the project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

6. Partners involved in the work

In order to improve the quality of the data collection our team (INRA) has collaborated with the following partners for the deployment of this deliverable. The partners involved in the work are the Institut Français de la vigne et du vin (IFV – France) and Université de Montpellier (UM – France).

UM has helped in the design of the survey and in the identification of the decision problems regarding viniculture and viticulture. The designed survey aims at identifying the preferences of the stakeholders regarding possible valorization routes for viniculture and viticulture. Hence, the involved stakeholders, i.e., winegrowers, technical centers and consumers are called to express their preferences on different questions regarding current and future valorization routes/products used in viniculture and viticulture. Our survey has the form of questions corresponding to different decision problems where the agents rank the alternatives according to their preferences. For example, one question extracted from the survey is "Could you rank your preferences regarding these CURRENT possible valorization routes?", where the agents rank the following ten alternatives according to their opinion: "manuring/fertilizing (for green waste), burning in the field (for green waste), incineration (collecting …), composting, landfilling, feeding, biomass for heating (industry and private individuals), sell/give to another valorization route, milling + mulching, other. The survey results are directly applied to our tool as these data contain preferences of agents. Recall that the input format of the data collecting submodule contains the agents and their preferences on multiple different questions/decision problems.

We have planned for the near future collaboration with the following partners in order to collect data for our input and improve the surveys in order to fit the needs of decision problems inside the NoAW project:

- Campden BRI Magyarorszag Nonprofit Korlatolt Felelossegu Tarsasag (CBHU – Hungary)
- Institut za Arhitekturu i Urbanizam Srbije (IAUS – Serbia)
- Preduzece za Proizvodnju Promet i Usluge Vinarija Aleksandrovic Doo, Vinca (VA – Serbia)

More specifically, we are collaborating with CBHU to adapt the general designed survey to our needs for collecting data that will match our tool's input, i.e., agents and their preferences. IAUS and VA will be involved in order to collect data and the preferences of the involved stakeholders in viniculture and viticulture for the region of Serbia. It is also planned to expand our collaboration by making a call and propose other partners (especially the ones involved in WP1 and WP2) to join our efforts for collecting data using the designed surveys.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

7. Bibliographic References

Amgoud, L, & Prade, H, (2009). 'Using arguments for making and explaining decisions'. *Artificial Intelligence,* vol. 173, no. 3-4, pp. 413-436

Arrow, K. J. (1950). A difficulty in the concept of social welfare. *Journal of Political Economy*, 58(4):328–346.

Bisquert, P., Buche, P., Croitoru, M., Karanikolas, N. & Thomopoulos, R. (2017). Selection of agro-waste valorisation routes based on a computational social choice and argumentation decision support tool. In *Proceedings of the 2017EFITA WCCA Congress.*

Black, D. (1958). *Theory of Committees and Elections*. Cambridge University Press.

Borda, J.-C. d. (1781). Mémoire sur les élections au scrutin. *Histoire de l'Academie Royale des Sciences*, pages 657–665.

Brams, S. J., & Fishburn, P. C. (1978). Approval voting. *American Political Science Review*, 72(3):831–847, 009.

Caragiannis, I., Kaklamanis, C., Karanikolas, N., & Procaccia, A. D. (2014). Socially desirable approximations for Dodgson's voting rule. *ACM Transactions on Algorithms*, Volume 10(Issue 2).

Copeland, A. (1951). A "reasonable" social welfare function. *Seminar on applications of mathematics to social sciences*.

Gibbard, A. (1973). Manipulation of voting schemes: A general result. *Econometrica*, 41(4):587–601.

Roy, B, 1991 'The outranking approach and the foundations of electre methods'. *Theory and Decision*, vol. 31, no. 1, pp. 49–73

Satterthwaite, M. A. (1975). Strategy-proofness and arrow's conditions: Existence and correspondence theorems for voting procedures and social welfare functions. *Journal of EconomicTheory*, 10(2):187 – 217.

Von Winterfeldt, D, & Edwards, W, 1986, Decision analysis and behavorial research, Cambridge University Press, Cambridge

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338