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## ► To cite this version:

Manon Enjolras, Maxence Arnould, Mauricio Camargo. Identifying blocking behaviors in small-scale group decision-making and their impact on consensus outcomes: a case study on Forest Management. *Journal of Multi-Criteria Decision Analysis*, 2023, 30 (5-6), pp.219-237. <https://doi.org/10.1002/mcda.1819> . hal-04717628

**HAL Id: hal-04717628**

**<https://hal.science/hal-04717628v1>**

Submitted on 2 Oct 2024

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# **Identifying blocking behaviors in small-scale group decision-making and their impact on consensus outcomes: a case study on Forest Management**

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## **Abstract:**

Group Decision-Making (GDM) problems usually include stakeholders with different views and opinions. In order to find a collective solution, it is necessary to achieve a Consensus Reaching Process (CRP) that may lead to the emergence of non-cooperative behaviors within the group. This paper proposes to study how these non-cooperative behaviors appear in a group of decision-makers and what their level of impact is on the evolution of consensus and on the final decision. To provide some answers to this research problem, we propose a Multi-Criteria Decision-Making (MCDM) methodology implementing AHP (Analytic Hierarchy Process) in order to provide a visualization of the CRP evolution and observe four non-cooperative behaviors within small-scale group decision-making: 1-Collective agreement, 2-Blocking Behavior, 3-Leadership demonstration and 4-Experts' coalition. We implement our methodology within a pedagogical framework, in 29 small-scale groups of Masters and engineering students, through a case study related to the implementation of forest management scenarios in France. Our results

show the evolution of the four non-cooperative behaviors within the groups, as well as their impact on the CRP outcomes.

## **1) Introduction**

Today, the international challenges facing society increasingly require discussion and collective decision-making, involving stakeholders with different views and opinions (Zhang et al., 2020). In the literature, researchers refer to this collective decision-making as Group Decision-Making (GDM), where the objective is to find a collective solution, by consensus, to a decision problem based on the preferences (or opinions) expressed by a set of decision-makers (Hochbaum & Levin, 2006; I. J. Pérez et al., 2018). In general, consensus is achieved when decision-makers modify their preferences (or opinions) to a point of mutual consent (Zhang et al., 2020). It should be noted that the literature has proposed Consensus Reaching Process (CRP) as a crucial tool for building consensus (del Moral et al., 2018; Zhang et al., 2018) and it has become an increasingly important research topic for facilitating consensus in GDM (e.g., Ben-Arieh & Easton, 2007; Dong et al., 2017; Herrera-Viedma et al., 2014). Two processes are required to resolve collective decision problems: a consensus process and a selection process (Choudhury et al., 2006; Herrera-Viedma et al., 2002). Some authors describe the consensus process as a dynamic process with iterative group discussion rounds aiming at reconciling group members' opinions (Herrera-Viedma et al., 2007; Xiao et al., 2020). The selection process is based on individual stakeholder opinions, which are then usually aggregated into a collective opinion in order to reach the final decision (Hochbaum & Levin, 2006)

To support and facilitate this consensus process, various models and tools have been developed in the literature. While they share common features, they also approach the consensus reaching process from different points of view (Labella et al., 2018) and several differentiating factors can be identified: preference expressions (Ding et al., 2020) (preference ordering or relations; numerical values or fuzzy logic); the type of consensus measure applied (Palomares, Estrella, et al., 2014) (e.g. the distance between participants or the distance from the collective

preference), or the use of feedback mechanisms or facilitators to guide discussions (Zhang et al., 2020) (e.g. suggestions or motivational direction rules (Zhang et al., 2019) or minimum adjustment cost (W. Xu et al., 2020))

However, to really address the consensus process, it is necessary to consider an intermediate and potentially iterative phase: the group discussion. The objective of this discussion phase is to improve situation awareness during a decision-making process (Eräranta & Staffans, 2015). Acquiring and maintaining situation awareness becomes increasingly difficult as the complexity and dynamics of the environment increase. Moreover, situation awareness is built over time and is highly temporal in nature. It cannot be addressed using procedures, rules, or optimization processes (Endsley, 1995).

This explains why, despite the support provided by methods and tools, uncooperative behaviors may still appear in the CRP, preventing consensus from being achieved (Palomares, Estrella, et al., 2014; X. H. Xu et al., 2015). It indeed happens when some stakeholders express their opinions dishonestly or refuse to change their minds in order to promote their own interests (Zhang et al., 2018). The literature indicates that it is therefore necessary to study uncooperative behaviors in order to be able to identify and manage them to ensure the quality of GDM results. Non-cooperative behaviors are often addressed in large-scale groups because they provide fertile ground for the emergence of non-cooperation of stakeholders involved in the decision-making process (X. H. Xu et al., 2015). Indeed, according to (Labella et al., 2017), non-cooperative behaviors seem to appear more often in large-scale GDM (LSGDM) when the number of decision-makers is high and therefore includes different points of view. However, less attention is paid to the small group of decision-makers, considered to be less prone to the occurrence of non-cooperative behaviors. Nevertheless, the construction of a common understanding of the problem, as well as the social and power relations complicating the interactions among individuals in small decision-making groups appear potentially as determining and differentiating factors to be considered (Chahine et al., 2017).

The present paper proposes to study how these non-cooperative behaviors appear in a group of decision-makers and determine their level of impact on the evolution of consensus and on the final decision. To answer this research question, we will propose a Multi-criteria decision-making (MCDM) methodology implementing the AHP (Analytic Hierarchy Process) to support the CRP in small-scale group decision-making. Indeed, we are specifically interested in this type of group decision-making because we hypothesize that non-cooperative behaviors can also be present on a small scale. We will implement our method in a pedagogical framework to respond to a case study related to the implementation of forest management scenarios in France. In the first section of the article, we will present the theoretical framework and the literature review. Next, we describe the research design and the consensus reaching process model and the case study chosen for this research work. Following this is a section presenting the results to illustrate the non-cooperative behaviors. Finally, we will present a discussion of the method and the results, our conclusion and the main prospects for future research.

## **2) Theoretical framework: Non-cooperative behaviors in the Consensus Reaching Process (CRP)**

Reaching a consensus usually requires that stakeholders modify their initial opinions, bringing them closer to each other and moving toward a collective opinion which must be satisfactory for all of them. Information sharing and discussions within the group are therefore crucial elements in the consensus process. However, such a process only succeeds if the stakeholder engagement in the consensus process is good (Palomares, Martínez, et al., 2014). Indeed, a noticeable drawback in a Group Decision-Making process is related to behaviors that do not contribute to achieving consensus or agreement. There is therefore a real interest in studying how these blocking behaviors appear as well as their potential impact on the evolution of the consensus.

This section provides a systematic literature review of consensus reaching models enabling the identification and the management of non-cooperative behaviors. A bibliographic search between 2010 and 2021 was made using the search query:

*TI="consensus" AND ("group" OR "GDM" OR "LGDM" OR "SGDM") AND ("non-cooperative" OR "non cooperative" OR "behavior\*" OR "behaviour\*") AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article).*

20 articles were identified, but 2 of them were excluded because of their irrelevance in terms of research topic (medicine). A systematic analysis of the 18 considered publications put forward specific features to be considered as differentiating factors.

### 2.1. Non-cooperative behavior types:

During the discussion phase, a stakeholder could be tempted to strategically adopt non-cooperative behavior if the consensus reaching process does not progress towards his preferred alternative. These non-cooperative behaviors have been described differently according to the literature as strategic or blocking (Table 1):

Strategic behaviors		Blocking behaviors	
Pattern Description	source	Pattern Description	source
Modifying the information given to the group to encourage a specific decision ( <i>overestimating the benefits, balancing the disadvantages, ...</i> )	(L. G. Pérez et al., 2016)	Imposing his opinion on the group/ not changing his mind at all	(Palomares, Estrella, et al., 2014)
having some interest in the decision result	(X. Xu et al., 2020)	expressing his opinion and not considering the group	(X. Xu et al., 2020)
Alternating bad and good cooperation attitude to favor a specific solution	(Palomares, Estrella, et al., 2014)	refusing to follow proposed orientations to reach consensus	(Palomares, Estrella, et al., 2014)
Manipulating the group opinion	(Mata, Francisco ; Martinez, Luiz ; Martinez, 2008)	Insisting that his view is correct	(Palomares, Estrella, et al., 2014)
Appearance of sub-groups or coalitions with similar interest	(Yager, 2002)	senior leaders demonstrating a strong global expertise	(Palomares, Estrella)

			, et al., 2014)
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Table 1: Non-cooperative behaviors description

Two research approaches have been developed to deal with these non-cooperative behaviors in GDM (Zhao et al., 2019): (1) managing non-cooperative behaviors in the aggregation process (Yager, 2002) and analyzing the influence of the non-cooperative behaviors on the aggregation outcome; (2) managing non-cooperative behaviors in the consensus process (Dong et al., 2016; Quesada et al., 2015; Zhang et al., 2019), and focusing on how to achieve a consensus in the presence of non-cooperative behaviors.

## 2.2. Consensus Reaching Process optimization:

GDM is often associated with operational constraints related to limited time (for example in an emergency context - (Xiang, 2020)), resources (W. Xu et al., 2020), or information availability (X. H. Xu et al., 2015). So, it is necessary to identify some levers to optimize the process for reaching consensus (Zhang et al., 2019), while considering the cost associated with the consensus achievement, which should be minimized (W. Xu et al., 2020).

Consensus efficiency could indeed be improved using punitive or incentivizing mechanisms in order to deal with uncooperative or outlying behaviors (Zhang et al., 2019). These mechanisms act notably on limiting the number of negotiation rounds in order to save time, as well as on the preference adjustment process by placing more or less importance on the contributions of the involved stakeholders according to their cooperativeness. However, punitive mechanisms may demonstrate limitations because they act above all on the preferences aggregation stage for selecting the consensual alternative. Similarly, it is worthwhile to take an interest in the different possible assumptions about how the responses of outliers—those stakeholders whose views differ significantly from the majority—should be handled (Blagojevic et al., 2020). In this perspective the proposed solutions do not act on the consensus stage as such because they focus on the influence of the non-cooperative or outlying behaviors on the aggregation outcome (Zhao et al., 2019).

### 2.3. Decision-makers' involvement during the consensus phase

Where interactions between stakeholders are possible (i.e. the group is not too large, so as to facilitate exchanges) and where the decision is not subject to pressing emergency or to a pronounced optimization objective, management of the CRP can provide the opportunity to analyze whether a consensus solution can be achieved in the presence of non-cooperative behaviors in the CRP (Dong et al., 2018). This approach differs from the punitive mechanism mobilization because it focuses on the consensus/discussion phase, instead of focusing on how to limit the impact of non-cooperative behaviors on the aggregation process. It facilitates the identification of irrational causes underlying deviations in the CRP (Xiang, 2020), so that agreement can be reached among the DMs' opinions before applying the selection process (X. hua Xu et al., 2019).

The consensus phase can be facilitated by a human or automated moderator, by a regular update in order to visualize and interpret consensus evolution (Palomares, Estrella, et al., 2014) or by using a self-management mechanism. Relying on information exchanges, group dynamics and by integrating iterative interaction steps into the GDM process, stakeholders become more certain about the preference evaluation values they indicate during the discussion process (Endsley, 1995), so their confidence increases during the whole decision-making process (Liu et al., 2019), promoting interactions and argumentation (Eräranta & Staffans, 2015). They also become able to provide adjustments and thus manage the non-cooperative behaviors within the group by themselves (Li et al., 2021).

### 2.4. Non-cooperative behaviors within large versus small GDM:

The study of non-cooperative behaviors is often treated in the case of large groups, because the multiplicity of actors reinforces the difficulties and challenges of consensual decision-making (Labella et al., 2018). Due to the large number of stakeholders (defined at around 20 - (Tang & Liao, 2021)) and their different backgrounds, cultures and motivations, the Large-Scale



GDM process is fertile ground for the emergence of non-cooperative stakeholder behaviors (X. H. Xu et al., 2015).

Traditionally, the proposed LGDM approaches have been based on clustering stakeholders and assigning punitive weights to limit their impact on consensus (Li et al., 2021). For example, it is possible to penalize manipulative or blocking behaviors by minimizing the weight assigned to the preferences of a specific stakeholder cluster and by valuing those who are closest to the consensus (Garcia-Lapresta, 2008; Yager, 2013). However, very few studies emphasize the particularity of small groups of decision-makers. In this context, while the steps of the CRP do not seem to differ from the classic GDM approach, the construction of a common understanding of the problem, as well as the social and power relations complicating the interactions among individuals in small decision-making groups appear potentially as determining and differentiating factors to be considered (Chahine et al., 2017).

#### 2.5. Relationships and interactions within the decision-makers' group

The CRP and GDM models are usually based on the premise that decision-making stakeholders are independent, which ignores the trust relationships between experts (Wu et al., 2017). This relationship is built on both stakeholder reliability (reflecting the level of expertise perceived) and stakeholder importance (related to the decision-making power implicitly or factually assigned) and appears as particularly relevant in a small-group dynamic (Fu et al., 2015; Xue et al., 2020).

Some studies also put forward the importance of taking into account the emergence of minority opinion in a GDM process (Xue et al., 2020). Depending on the characteristics or background of the stakeholders (Basak, 2018), minority opinion should be considered as critical when the member who holds this opinion is reliable and/or important. For example, a leader who is able to provide forward-looking and unique views, and has the right to determine the final decision alternative has to be considered even if his opinion is minor. Additionally, a stakeholder who often has a considerable understanding of the decision-making problem and is able to

propose professional and authoritative opinions could be an asset to the CRP. However, some other configurations have to be addressed with care. For example, an aggressive DM who has relatively extreme and usually personally motivated opinions seems to have some predisposition to strategic manipulation behaviors. In the same vein, a noteworthy and independent DM, who provides a view that is often out of the ordinary, could be representative of a non-cooperative behavior.

### 3) Research Design

#### 3.1. Research approach

Non-cooperative behaviors represent an important issue that is widely addressed in the framework of GDM and CRP. Many dimensions of the management of these behaviors are analyzed in the literature and appear as interesting research gaps to be investigated:

- **Group size:** While the issue of non-cooperative behaviors is usually associated with LGDM because of the complexity brought by the large number of stakeholders involved, it is nevertheless also of significant interest to manage the CRP within small groups of decision-makers. As mentioned in section 2, the specific relationships and interactions emerging between stakeholders can appear as particularly important in a small group decision-making process, potentially impacting the decision outcomes provided by the group (Chahine et al., 2017).
- **Operational management of non-Cooperative behaviors:** Approaches are traditionally punitive in order to limit/block the impact of stakeholders identified as uncooperative and they focus on the phase of selecting consensual alternatives (aggregation phase). Few studies consider the management of non-cooperative behaviors during the discussion phase.

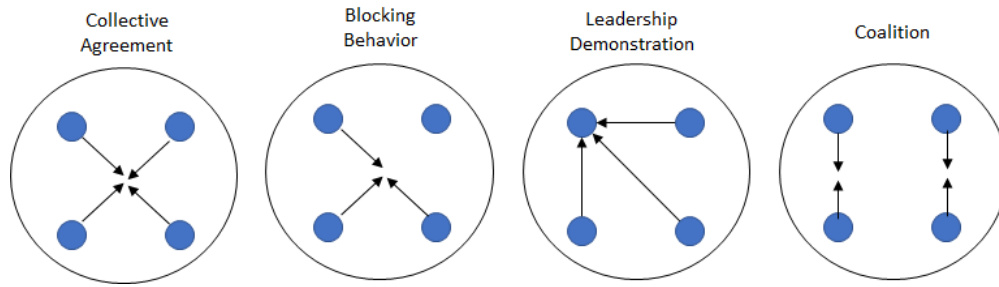
- **Temporality and group dynamic evolution:** Although it is rarely addressed in the GDM academic literature (Quesada et al., 2015; Xue et al., 2020), the dynamic evolution of decision-makers' behavior across time plays an important role in accelerating the convergence of stakeholders' opinions. This evolution may be related to the experience and knowledge acquired by the participants during the information exchanges and discussions within the group and could result in the dynamic variation in stakeholders' reliability and trust.

This research work therefore aims to contribute to these gaps, by proposing a methodology for analyzing non-cooperative behaviors within a small GDM process.

More specifically, a self-management approach to non-cooperative behaviors will be adopted, in order to study how a small group of decision-makers adjust their interactions and behaviors over time in order to reach a consensus, despite the potential contradictory challenges that drive them, as well as specific personal interests.

This study will focus on the evolution of consensus in the discussion phase, through successive iterations in the form of negotiation rounds. The feedback process will also be iterative but will not be carried out by a facilitator (human or artificially-based) to limit its impact within the group dynamics. No suggestions or decision rules will be proposed, in contrast, a dynamic visualization tool of the evolution of the consensus will be proposed to the group, in order to support its self-management during the different rounds of negotiation by transmitting and visualizing the information instantaneously (Endsley, 2012).

During these negotiation rounds, 4 configurations of group dynamics will be investigated (Figure 1). Depending on the observation of the group dynamics and the evolution of the CRP, it will then be possible to visualize how these configurations appear and disappear during negotiation rounds and whether they have an impact on reaching consensus.



*Figure 1: Non-cooperative behavior configurations (our research)*

1 – Collective agreement: indicates a situation where all the stakeholders adopt a cooperative behavior, agreeing to change their opinions to reach a collective consensus (Palomares, Martínez, et al., 2014)

2 – Blocking Behavior: includes situations where one or several stakeholder(s) refuse to change their opinions, blocking the consensus process. The stakeholders could also adopt a defense behavior, by modifying their opinion in an anti-consensus way to indicate a disagreement (Labella et al., 2017). These blocking behaviors can be related to personal interests, or to minority opinions supported by strong expertise or based on extreme and aggressive behavior (Palomares, Martínez, et al., 2014; X. Xu et al., 2020).

3 - Leadership demonstration: refers to a situation where a specific stakeholder encourages a decision that supports his own opinion. This dynamic can be caused by a strategic manipulation of the stakeholder, or supported by a relationship of trust or a strong legitimacy of this stakeholder creating a rallying of other participants to his cause (Mata, Francisco ; Martinez, Luiz ; Martinez, 2008; L. G. Pérez et al., 2016).

4 -Coalition: represents a situation where the emergence of clusters can be identified (Labella et al., 2018). These stakeholders' coalitions are built on shared personal interests or opinions, or result from the creation of a specific trust relationship between a sub-group of participants (Yager, 2002).

### 3.2 Methodological background - MCDM methods and AHP (Analytic Hierarchy Process)

Multi-criteria decision-making (MCDM) is a set of decision support methods to structure and formalize decision-making processes. It aims to capture the decision-maker's choice behavior and the systemic nature associated to the decision process by modelling and structuring a coherent picture about complex decision problems (Korhonen et al., 1992). In the specific context of collaborative decision-making, MCDM methods present several advantages (Mayer et al., 2005; Tran Thi Hoang et al., 2019). First, they can be considered as dynamic, because they show the performance of various alternatives in relation to stakeholder preferences and can be flexible and adaptable to a large range of situations. The results produced are clear and understandable to all stakeholder, and their implementation remains simple, even with non-specialists. Moreover, they are particularly communicative and educational because they bring insights to stakeholder about the problem structure and context, the alternatives or the criteria considered.

Our methodological background relies on the AHP (Analytic Hierarchy Process) methodology. AHP is a calculation technique introduced by Saaty in 1980 to make a multi-criteria decision (T. L. Saaty, 1980). Its main objective is to break down a problem into smaller components, adopting a hierarchical structure, integrating a set of weighted criteria and several alternatives to be ranked.

The main characteristic of AHP is that it allows criteria to be weighted according to their importance from the decision-maker's perspective, based on a principle of pair-wise comparison. It thus makes it possible to numerically model the decision-maker's opinion using the Saaty scale (Ghazinoory et al., 2007), measuring the importance of one criterion in relation to another by assigning a value to each comparison (T. L. Saaty, 1980). In comparison with other MCDM methods, the AHP method has been widely used in MCDM and has been successfully applied to address many practical decision-making problems (T. Saaty & Vargas, 2012). Although it regularly has been the subject of some criticism (Alvarez et al., 2021), this method is particularly interesting in the context of GDM because it allows the preferences of several decision-makers to be modelled simultaneously, based on a common criteria framework (MacHaris et al., 2012; T. L.

Saaty, 1989). Thus, the AHP method is mobilized in this study as a means of representation of the decision-makers' preferences highlighting their similarities and their disparities and showing how they evolve during the CRP process (Figure 2).

### 3.3. Model of the Consensus Reaching Process (CRP)

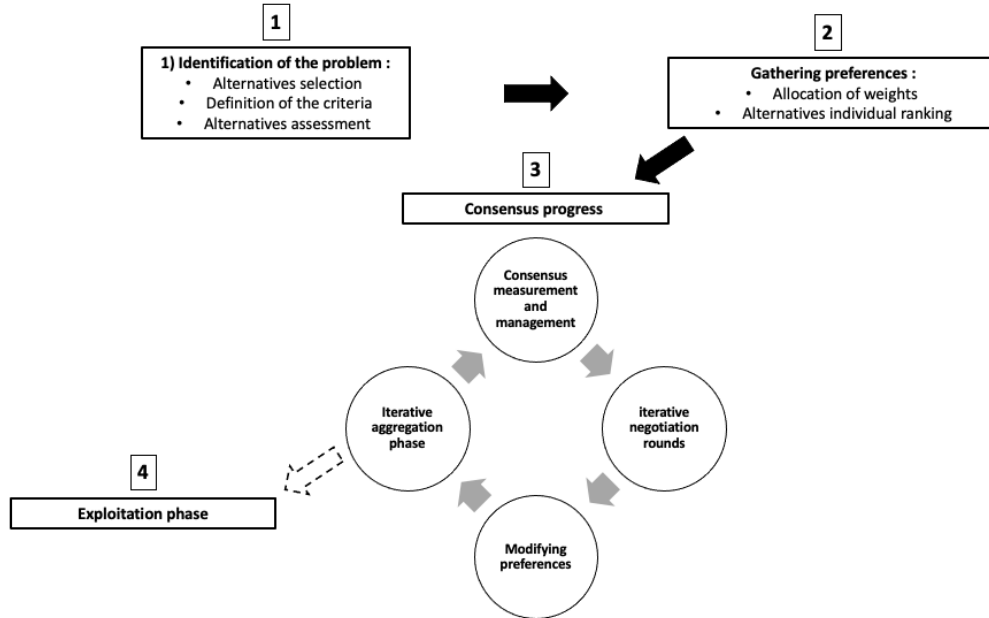


Figure 2: Consensus Reaching Process Model

#### 1- Identification of the problem:

*Alternatives selection* - The stakeholders involved are faced with a problem that requires consensus. When the main issues and challenges have been identified, a set of alternatives is built in order to solve the problem in the best way possible. Alternatives are suitable options that offer a solution to the decision problem under consideration. The objective is to determine the alternative that represents the best compromise among those considered.

*Definition of the criteria* - First, a set of relevant criteria has to be proposed, in order to assess the decision problem alternatives and determine which alternative best matches the decision-makers' preferences. The criteria must therefore assess all the characteristics of the alternatives that are considered in the decision problem. Relying on the "MECE" principle (Lee & Chen, 2018), the set of criteria has to be Mutually Exclusive and Collectively Exhaustive. This means that the criteria included within the set are not redundant (i.e. a situation where two criteria

defined as different seek to evaluate the same characteristic must be avoided) and that they measure all the dimensions that characterize the decision problem.

*Alternatives assessment* - Each criterion will have an associated rating scale to determine whether an alternative is strong or weak on that criterion. Based on this rating scale, it is possible to assess the set of alternatives to identify their advantages and disadvantages regarding the decision-making problem. This phase has to be performed by neutral experts, in order to provide objective judgments about the alternatives.

## 2- Gathering preferences

*Allocation of weights* - This phase is based on the AHP method. It assumes that the criteria considered in a decision problem are not all equally important. Some will potentially play a stronger part in the final decision. This is directly related to the viewpoint of the decision-maker, who will intuitively pay more attention to some criteria than others. By taking this relative importance into account, characterized by the notion of weight, the decision-maker's preferences are modeled slightly more accurately by refining the criterion set. Thus, each participant is asked to perform a pairwise comparison of all the criteria included in the set, using the traditional AHP process. The objective is therefore to achieve all combinations of criteria to build the initial weights of each stakeholder involved in the decision-making process, leading to the building of a comparison matrix A (Table 2):

	$C_1$	$C_2$	$\dots C_j$	$C_N$
$C_1$	1	$x_{1,2}$	$x_{1,i}$	$x_{1,N}$
$C_2$	$1/x_{1,2}$	1	$x_{2,i}$	$x_{2,N}$
$\dots C_i$	$1/x_{1,i}$	$1/x_{2,i}$	1	$x_{j,N}$
$C_N$	$1/x_{1,N}$	$1/x_{2,N}$	$1/x_{j,N}$	1

with  $N$ : number of criteria in the set

$x_{i,j}$ : value of the Saaty scale associated with the comparison  $C_i/C_j$

$x_{j,i}$ :  $1/x_{i,j}$

Table 2: Comparison matrix

Next, this matrix is normalized, by dividing all the terms in each column by the sum of that same column. Finally, the weights of the criteria are defined by calculating the average of each row of the normalized matrix A' (Equation [1]).

*For the Criterion i:*

$$\omega_i = \sum_{j=1}^N \frac{X_{ij}}{N} \quad [1]$$

*With N: number of criteria in the set*

*X<sub>ij</sub>: normalized term of the A' matrix associated with the comparison Ci/Cj*

*Alternatives individual ranking* – As AHP is a “ranking” method, it is then possible to exploit the weight obtained by calculating an aggregated score for each alternative, based on a weighting average method (Equation [2]).

$$\text{Score alternative } A = \sum_{i=1}^N \omega_i \cdot E_{A,i} \quad [2]$$

*With N: number of criteria in the set*

*ω<sub>i</sub>: weight of the criterion i*

*E<sub>A,j</sub>: Assessment value of alternative A for the criterion i*

This score depends on the alternatives' assessment values, as well as the weights associated to each decision criterion. Based on this aggregated score, it is thus possible to rank the alternatives from "best" to "worst" from each decision-maker's point of view.

### **3- Consensus progress:**

*Consensus measurement and management* - At the beginning of the CRP, each participant is represented by their own weights profile, as well as their initial ranking of alternatives. Based on these initial data, it is possible to highlight how far apart the decision-makers' preferences are, and thus to extrapolate the degree of consensus initially reached. Therefore, this phase is supported by a visual analysis of the group preferences, representing the weighting profile of each decision-maker about the criteria, as well as the ranking of their associated alternatives. It thus allows each participant to distinguish potential allies among the other members of the group, or the individuals he will have to convince. This visual analysis acts both as a consensus measure and as a feedback mechanism facilitating the CRP among decision-makers by centralizing all the preferences of the group. It represents a self-management tool for the group to prevent and



monitor possible non-cooperative behaviors during the discussion phases, by providing a dynamic representation of the evolution of stakeholders' behaviors (Palomares & Martínez, 2014).

*Iterative negotiation rounds* - Consensus progress relies on different iterative rounds of negotiation among participants. The objective is to allow the stakeholders to interact with each other in order to express their preferences, arguments and knowledge about the decision problem. This discussion phase is an opportunity to bring about changes in the preferences of other stakeholders, thus favoring the reaching of a consensus and is supported by the visualization tool mentioned above.

*Modifying preferences* - At the end of each round of negotiation, a specific time is dedicated to changes in the participants' preferences. Each stakeholder is then allowed, individually and on a voluntary basis, to modify the importance he or she attaches to each decision criterion under consideration, based on the arguments and information exchanged during the discussion phase with the other participants.

*Iterative aggregation* - The visualization tool is then dynamically updated and provides a new weights' profile and ranking of alternatives for each decision-maker. It allows a new round of negotiations to start, until a consensus is reached. We therefore consider that the consensus is reached when all the participants agree on the choice of a scenario. A scenario that is unanimously accepted by all participants constitutes a consensus.

#### ***4- Exploitation phase:***

Finally, the exploitation phase transforms the global information into a final ranking of the collectively agreed alternatives. It is expected that the final decision can be made due to a high level of consensus among participants regarding their preferences (del Moral et al., 2018). However, it sometimes happens that no consensus can be reached, despite the numerous rounds of negotiation that have been followed. In this case, it could be interesting to analyze the evolution of the behaviors of the different decision-makers, to detect any non-cooperative behaviors which could not be prevented by group self-management.

#### **4- Illustrative Case study**

A case study approach is defined as an “empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not evident” (Yin, 2013). A case study approach has been widely used in the different fields of science and has been found to be especially valuable in practice-oriented fields (Crowe et al., 2011; Ebneyamini & Sadeghi Moghadam, 2018). In the context of group decision-making, relying on a case study approach allows for the analysis of a specific consensus reaching process in its proper context, in order to observe how it manifests and develops.

##### **4.1. Case Description**

Our case study aims to address French forest policy priorities for improving wood mobilization. In France, one of the main objectives is to improve sustainable wood mobilization in small private forests because many forest owners are not involved in forest management processes (Arnould et al., 2021) (see details in Appendix 1). While some research experimentations regarding MDCM mobilized for participatory forest planning have been made over the last twenty years, the consensus reaching process and the preferences aggregation is still a challenge to be overcome (Eyvindson et al., 2018). Our case study will implement the methodology proposed in section 3, to involve more private forest owners in forest management approaches aimed at mobilizing wood while balancing other ecosystem services. In a current context linked to the impacts of climate change, society's strong expectations regarding forests, the preservation of natural areas, etc., forest stakeholders are obliged to promote multiple ecosystem services on the same territory or property. We will therefore follow this reconciliation objective in our case study. To implement our methodology, the Vosges department (eastern France) was chosen, which seems to be an appropriate territory for such an experiment (see justification in Appendix 1).

Three main scenarios are proposed to reconcile wood mobilization and other ecosystem services within a territory or a single property. Each wood mobilization scenario could then be coupled with:

- Carbon storage: The aim will be to harvest suitable trees to provide raw material for industries and at the same time conserve the most efficient trees for carbon storage (trees with a lot of foliage, branches and a large trunk, young trees, etc.). This scenario will require very careful harvesting choices, so a high level of forestry expertise is recommended.
- Biodiversity preservation: The aim will be to harvest wood while promoting the preservation of plant and animal biodiversity. To promote the preservation of biodiversity, the owner will be recommended to carry out light cuts of wood to create installations or specific infrastructure (animal species habitat, opening of gaps for plant species, etc.). It will also be possible to leave spaces in the plot with no human activity.
- Public access for educational purposes: The aim will be to harvest wood while promoting training and awareness of the general public (citizens, schools, etc.) in forest management.

In our case study, scenarios will be selected by several stakeholders according to seven criteria identified in the current French forestry context related to wood mobilization : Volume harvested, Impact of harvesting on soils, Impact on forest regeneration, Ease of implementation, Forest management choices and techniques, Monitoring of results and Positive effects on climate change (see description in Appendix 2). Furthermore, to constitute our small-scale GDM, we propose four emblematic players in forest management implementation in France:

- Private forest owners: They are key actors in the implementation of forest management; they own their land and therefore have the final decision-making power over the management of their plots. They may adopt non-cooperative behaviors depending on their objectives and motivations (Arnould et al., 2021; Ficko et al., 2019).

- The forest manager: He is an essential actor in forest management. He assists and accompanies the owners in the implementation of forest management (forest plantations, work, wood exploitation, fiscal and legal advice, etc.). He has a very high level of forestry expertise and a long-term vision, even if his main income currently comes from the sale of wood (commission) in the short term.
- The industrialist: An essential actor in the mobilization of wood. The industrialist buys the raw material from forest owners, exploits it and transforms it into primary products. He makes his short-term income from the material he buys but has nevertheless a long-term vision to ensure the sustainability of his activity.
- Environmental association: Actor whose opinions favor the preservation of the environment. The preservation of biodiversity and soils are its main objectives. It transmits this message to the actors in the forestry-wood industry and to society.

#### 4.2. Implementation

The case study was implemented in a pedagogical context within the curriculum of an engineering school in France. Two workshop sessions were organized in October 2020: the first with 70 engineering students, and the second with 45 Master students. Each session lasted 3 hours and started with an introduction to the case study to highlight the objectives and the scope of the case (phase 1 – Identification of the problem). Some methodological inputs were also provided to the students so that they could implement the steps of the AHP method that are necessary to carry out the consensus process. The students then had 30 minutes to immerse themselves in the role of the actor they were going to play during the session, in order to perform phase 2 of our CRP (preferences gathering). In total, 29 groups of 3 or 4 people were then constituted in such a way that, as far as possible, all the actors considered in the decision-making process were represented in each group (because of the number of participants of each workshop session, some groups were constituted with only 3 actors). Then, the groups were able to start the iterative negotiation rounds in order to reach a consensus (phase 3 – Consensus progress). In each round the students had to

express their own preference (according to the role they played) and they had to put forward arguments to convince the other actors in the group. In order to keep track of the elements put forward during the previous discussions, each participant is asked to indicate, in a written individual report, the specific arguments or motivations explaining the modifications he/she wishes to make to his/her initial preferences at the end of each round of negotiations. At the end of the rounds, the stakeholders either validated the consensus or not and a final decision was made (phase 4 - exploitation).

## **5) Results**

The experiment implemented by the 29 groups of students enabled us to observe non-cooperative behaviors during the CRP. Further to the proceedings of the various rounds of negotiations, the objective was to explore the evolution of the stakeholders' profiles within each group of students as well as consensus progress. The analyses and interpretations carried out following this experiment are based on the data collected during the workshops (evolution of individual preferences during each round of negotiation), as well as on the individual written reports provided by the participants, used as the basis for the interpretation of the changes achieved and the identification of the behaviors appearing within the groups. During the negotiation rounds, the participants first focused their attention on the preference profile of each decision-maker. Which criteria were the most discriminating, and which were the most unifying within the group? The arguments put forward were then directed towards the criteria themselves, and their importance from each person's point of view. Progressing through the negotiation rounds, participants then observed the ranking of the scenarios, and gave their opinion as to the reason for a particular judgment. However, the judgments were not questioned during the negotiation rounds, as they were considered to be the result of a reliable external expertise. In this way, the main negotiations were directed towards a way of changing the preference profile of the group members, on the basis of the criteria considered.

Thus, the evolution of the several rounds of negotiation in each group was analyzed in order to identify whether the group dynamics from our methodological framework could be observed: collective agreement, blocking behavior, leadership demonstration or coalition (these behaviors were defined in section 3.1). During this phase, some groups were identified as illustrative:

- either as an emblematic case of a specific behavior: meaning that the group represents an illustration perfectly in line with the definition proposed in section 3.1
- or as a variant case: meaning that the group illustrates the considered behavior but in a slightly different configuration than that proposed by its definition.

The outcomes of each illustrative group were then consulted in order to check whether the consensus was reached or not. The groups' outcomes are presented in two ways. Firstly, the evolution of decision-makers' opinions is represented by the successive weight profiles of the stakeholders regarding the decision criteria (calculated from equation [1]), and updated at each negotiation round. Secondly, the final situation obtained at the end of the negotiation rounds is represented by the aggregated score obtained by each scenario (Carbon storage, Biodiversity preservation and Public access) and calculated from equation [2]. Consensus is considered to have been reached if the scenario with the highest score is the same for all stakeholders. Among the 29 groups representing our experimental panel, 13 were considered as relevant to highlighting specific group dynamics and are presented in Table 3.

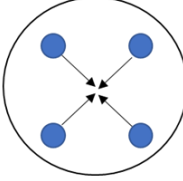
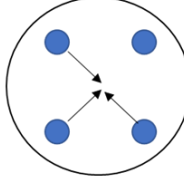
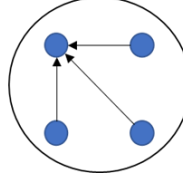
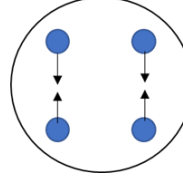
Illustrative Groups	Collective Agreement	Blocking Behavior	Leadership Demonstration	Coalition	Consensus Reached?
					
G4				Variation	No
G5		Emblematic			No
G6			Variation		No
G8	Emblematic				No
G9	Emblematic				No
G11			Variation		No
G14		Variation	Variation		Yes
G16			Variation		No
G17	Emblematic				No
G19	Variation			Variation	Yes
G21				Variation	No
G22	Variation				No
G23	Emblematic				Yes

Table 3: Illustrative cases

### **Illustration of Collective agreement**

The experiment enabled us to put forward several cases of collective agreement among the groups. As an emblematic example, the consensus evolution of Group G23 highlights the effort made by each stakeholder to reach a collective agreement. This group is composed of 3 stakeholders: industrialist, forest owner and ecological association. Starting from 3 divergent profiles in round 1, the industrialist finally placed less importance on the volume of wood in round 3, a criterion that is nevertheless essential for the sustainability of his activity (see Fig. 3 – Round 3). We also note that the association reduced its emphasis on ease of implementation (see Fig. 3 – Round 2) and that the owner placed less emphasis on monitoring results (see Fig. 3 – Round 3). As a result of the efforts of each stakeholder, scenario 2 of biodiversity conservation was selected and consensus was achieved (see Fig. 3 – Scenario choice). As a result of the discussion rounds, the stakeholders' preferences led to a higher consensual score for the biodiversity preservation scenario.

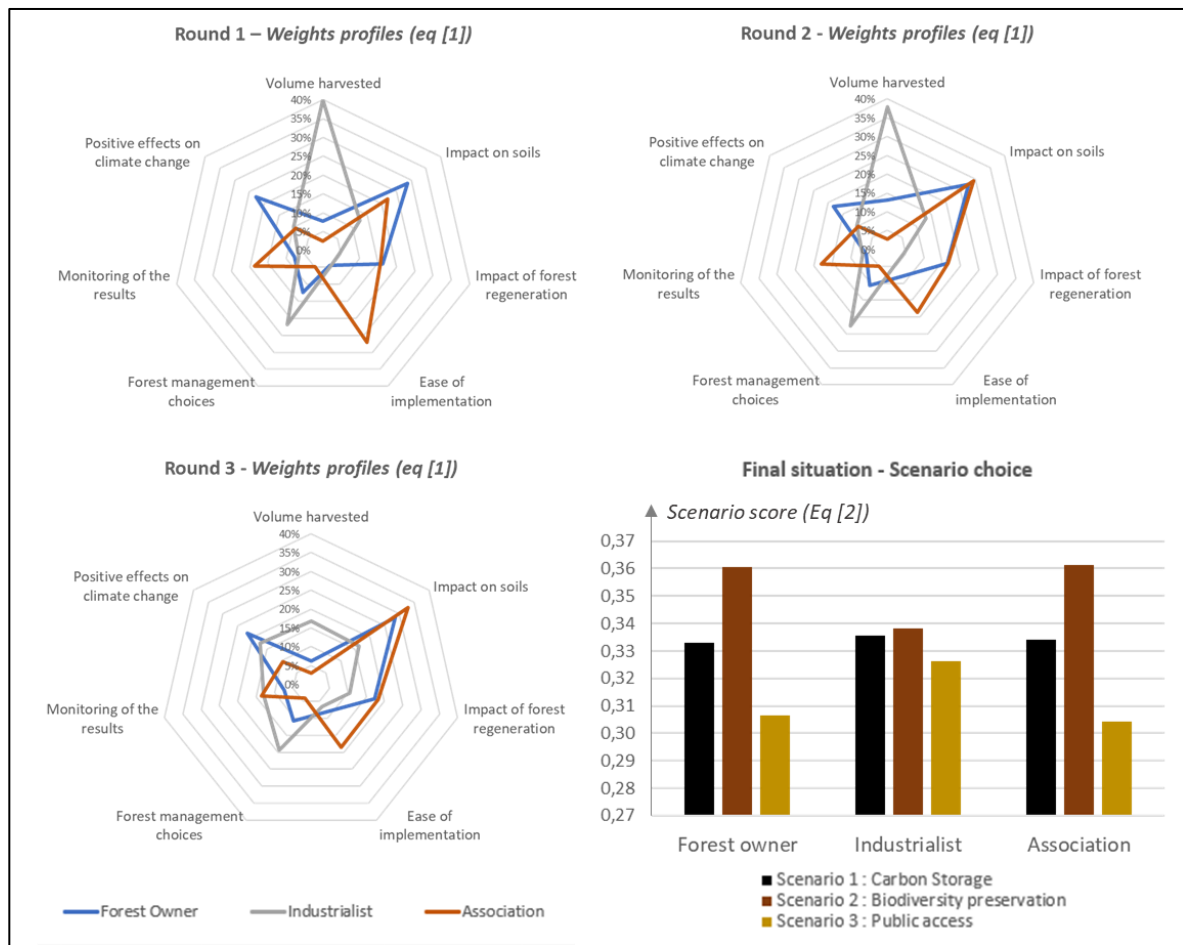


Figure 3: Group 23 outcomes

### Illustration of blocking behaviors

In group G5, the owner, the manager and the industrialist started the consensus reaching process with similar profiles, showing a common agreement given to the importance of the criterion "forest management choices" (Figure 4 – round 1). Nevertheless, the association adopted a blocking behavior because during the two rounds of discussions it maintained its position of giving very low importance to the management choices criterion (Figure 4). Moreover, the association stayed focused on the impacts on soils and the effect of climate changes, which blocked the collective agreement process, despite making a small effort in round 2 on the Effect on climate change criterion (see Figure 4 – round 2). Figure 4 (scenario choice) indeed shows that a consensus is reached within all stakeholders except the association. This example shows that despite a form of coalition between the Forest owner, the manager and the industrialist, the blocking behavior of the association meant that a collective agreement could not be reached.



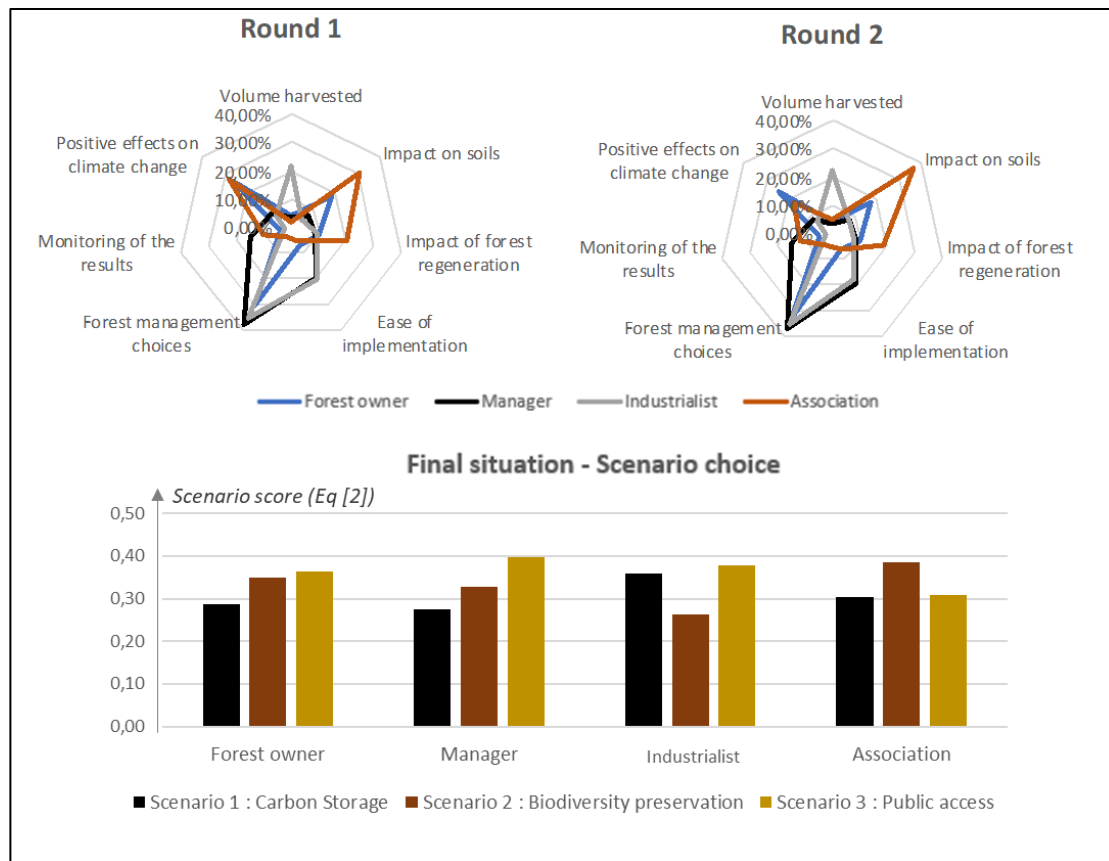


Figure 4: Group 5 outcomes

### Illustration of Leadership demonstration

The experiments allowed us to highlight different instances of leadership demonstration. Although no emblematic case was observed in the sense that it was theoretically defined (an actor who manages to convince the whole group and bring it to change its point of view with his arguments), several manifestations can be analyzed as variations of the leadership demonstration configuration.

In the case of group G14, the manager, who was initially closer to the profile of the association, was finally convinced by the owner and came closer to his point of view, particularly concerning the "monitoring of results" criterion. The industrialist was also convinced about the volume harvested criterion. The association, on the other hand, changed its point of view very little; it was not sensitive to the owner's arguments and maintained a different profile (see Figure 5 – Round 2). But nevertheless, the owner's demonstration of leadership in relation to the other stakeholders

allowed a consensus to be reached on scenario 2, related to biodiversity preservation (see Figure 5 – scenario choice).

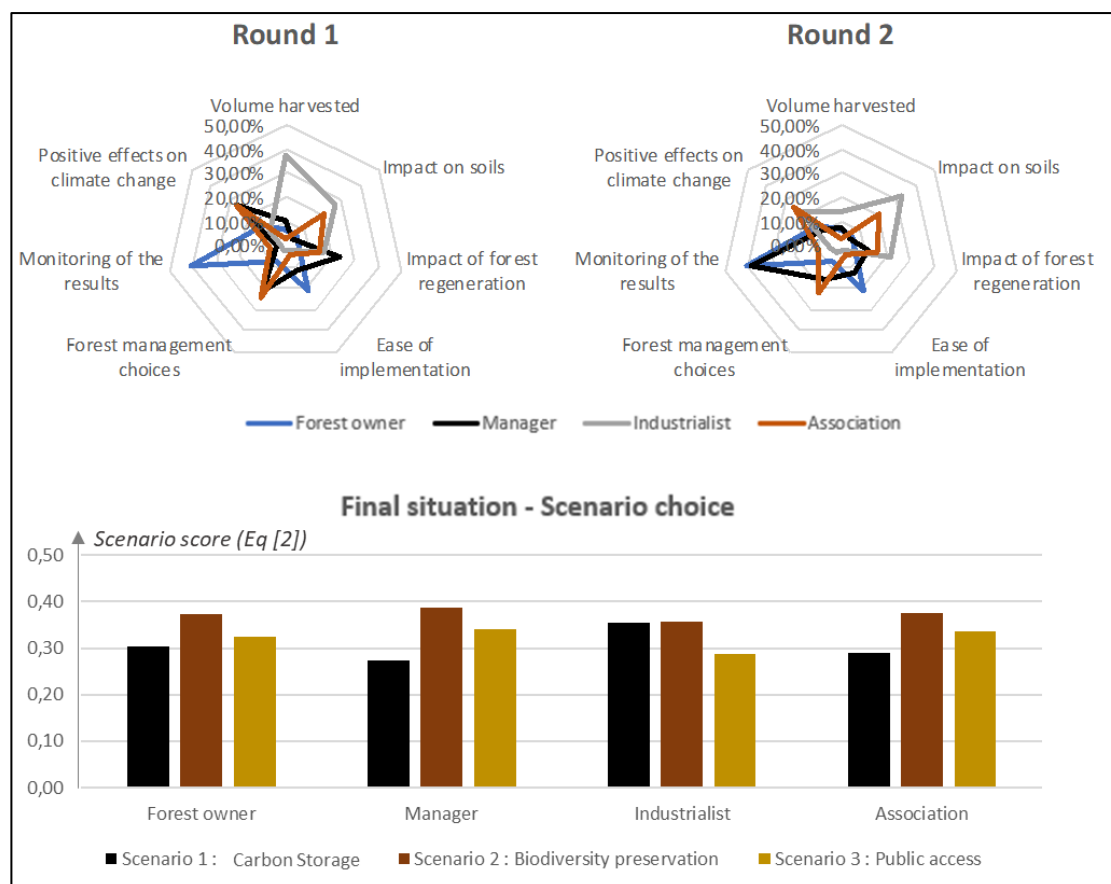


Figure 5: Group 14 outcomes

In the case of group G6, the 4 profiles obtained at the beginning of the first round of negotiations are relatively divergent (Figure 6 – round 1). The owner favors the ease of implementation criterion, the manager focuses on forest management practices, the industrialist emphasizes the volume of wood harvested and the association focuses on criteria related to climate change, as well as impact on the soil and on forest renewal. At the end of the first discussion phase, we observe that the main change comes from the manager, who seems to have been convinced by the industrialist's arguments. He seems to have embraced the industrialist's cause, particularly on the criterion of volume harvested, to the detriment of the forest management practices. A coalition was formed between the industrialist and the manager, while the other actors made little or no change in their initial point of view (Figure 6 – round 2). However, consensus was not reached at the end of the session (Figure 6 – scenario choice).

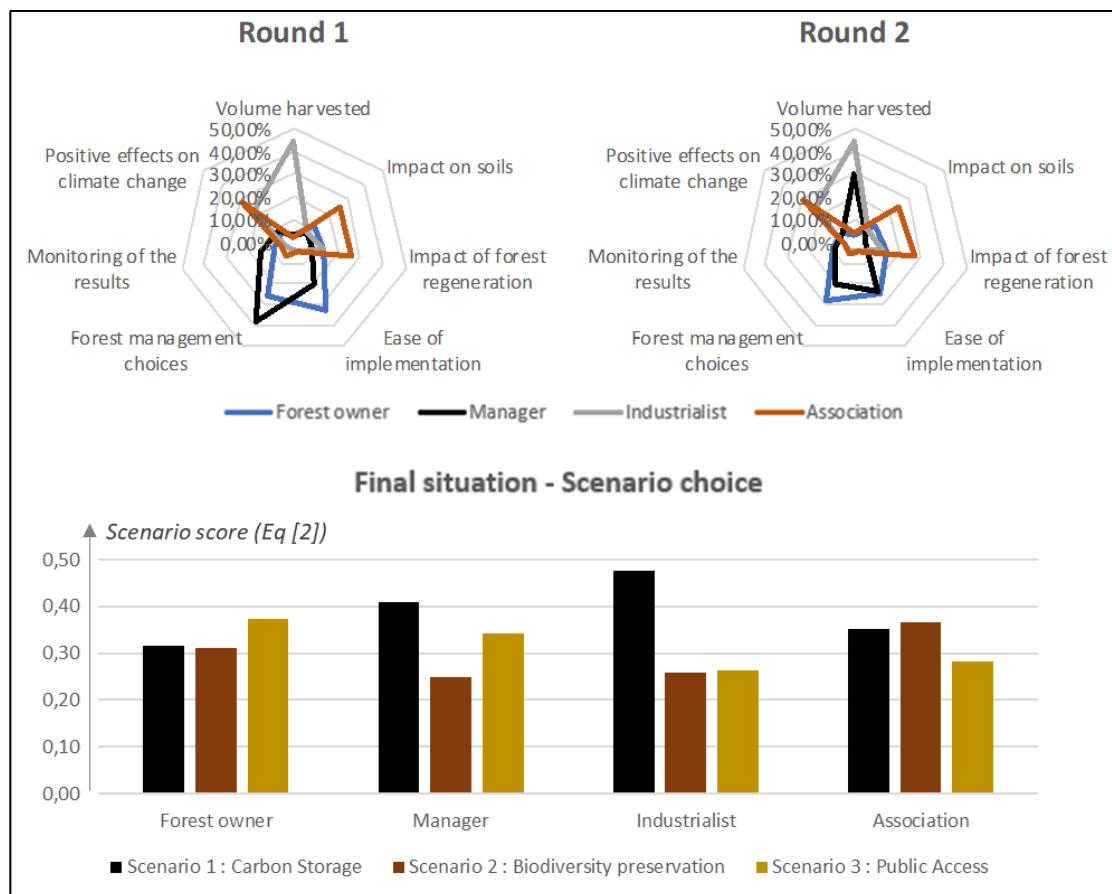


Figure 6: Group 6 outcomes

These observations highlight potential causal links between the configurations identified within the groups. Indeed, a demonstration of leadership seems to be able to lead in a rather immediate way to a coalition situation, in the case where the leader stakeholder does not manage to convince all the stakeholders to support his cause.

### Illustration of Coalition

As mentioned above, the observed cases of coalition are often the result of a demonstration of leadership that has convinced only some of the actors. However, in some cases, coalitions are present from the beginning of the discussion phases. Although from the observations made we were not able to observe an initial coalition by pairs of actors, as theoretically defined, other variations can be considered. An interesting case is that of Group G19, where we observe from the beginning a strong proximity between the profiles of the owner, the industrialist and the manager, particularly on the volume harvested and forest regeneration criteria

(Figure 7 – round 1). They form a coalition. The association adopts a different profile, favoring the positive impacts on climate change as well as the impact on the soils. Nevertheless, during the negotiation phase, the association tries to reach a collective agreement by gradually changing its opinion and coming slightly closer to the point of view of the other 3 stakeholders. It succeeds by giving more importance to the volume harvested and by lowering its focus on the impact on the soil (Figure 7 - Rounds 2 and 3). A consensus was reached on the wood mobilization and carbon storage scenario (Figure 7 – scenario choice). In this case, the coalition configuration reached a collective agreement.

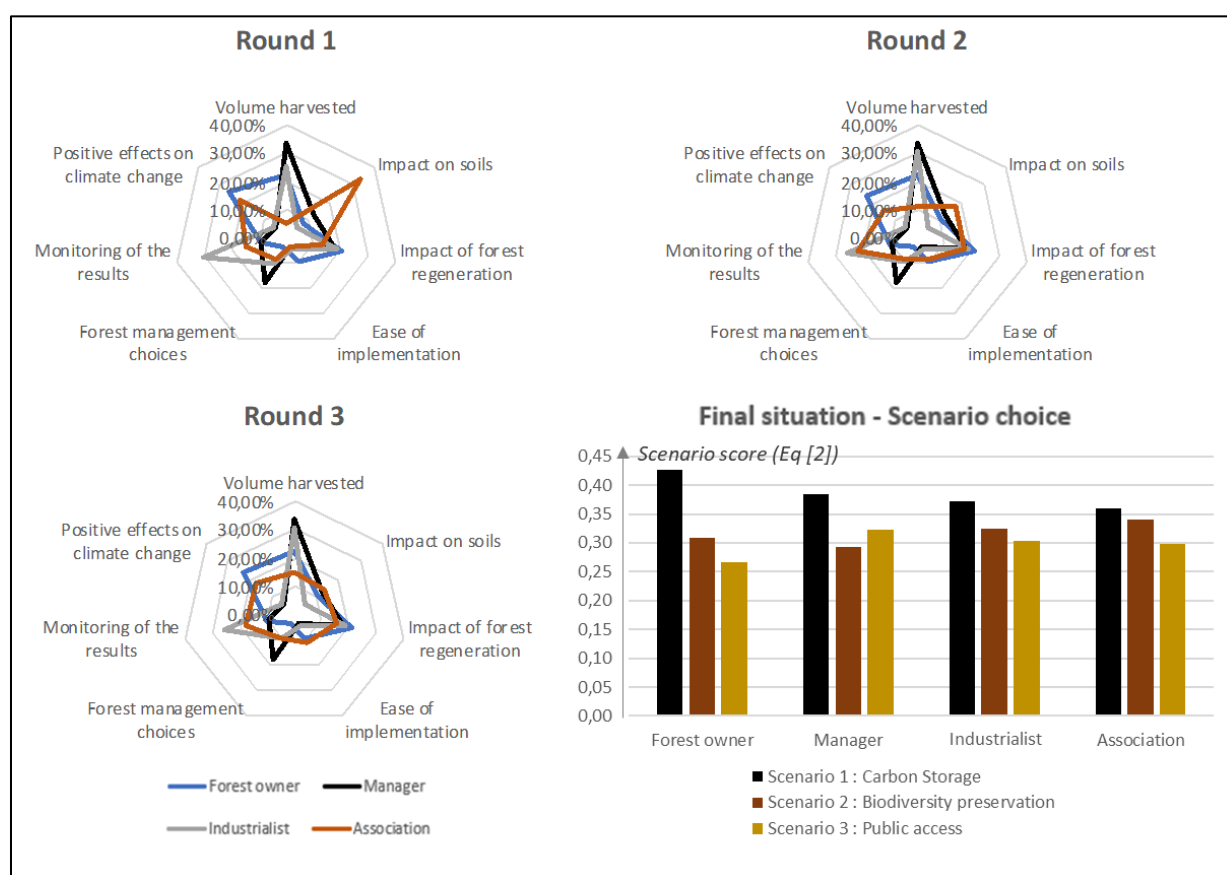


Figure 7: Group 19 outcomes

## 6) Discussions

In this paper, the objective was to identify non-cooperative behaviors in small-scale group decision-making and study their impact on the consensus outcomes, by implementing a case study in a pedagogical context.

Concerning the results, we have achieved this objective by observing the four theoretical behavior configurations (Figure 1) either as emblematic or as variants. Sometimes these non-cooperative behaviors are present from the beginning, sometimes they result from the discussions and sometimes they can emerge in the ongoing CRP.

- Collective agreement was identified as emblematic. In our illustration, we can see that each stakeholder makes an effort towards the others to reach a consensus. For example, we can see that the industrialist considerably reduces the volume harvested even though this is the most important criterion for him. In a case study such as ours, collective agreement may seem rare because the stakeholders have different objectives and interests. We suggest that our methodology may have fostered this behavior by visualizing the evolution of consensus. These results are aligned with those of previous research which concluded that pointing out the potential mismatches between the groups' members favors discussions and argumentation so that group preferences shift because group members are exposed to new arguments not previously considered during group discussion (King et al., 2010).

- Blocking behavior was identified as emblematic with the association that defends strong environmental values. In this illustration, we see that the association is blocking consensus and that the other three stakeholders agree with each other. The association may be the only stakeholder with very strong beliefs about environmental preservation. This decision-making process reflects an ethical problem-solving approach (Robbins & Wallace, 2007) for this stakeholder, which would explain its non-cooperative behavior. Negotiation is a special type of group decision-making in which interested parties have conflicting goals but also have a common cooperative interest in reaching agreement; in such mixed-motive circumstances, concession plays a key role in reaching agreement (Johnson & Cooper, 2009). The stronger the stakeholders' opinions, the less inclined they may be to make concessions, because it implies a reduction in their own benefit. This may lead to blocking behaviors

- The demonstration of leadership has been identified as a form of variation: there is no case where one single actor succeeds in convincing all the other stakeholders, but in one of our illustrations, we can see that the owner manages to convince the manager and the industrialist to share his own beliefs. Only the association does not modify its preferences, adopting a form of blocking behavior. We believe that the owner demonstrates so much leadership because of the specific context of our case study. This phenomenon is related to the decision-making power implicitly or actually assigned to this stakeholder (Fu et al., 2015; Xue et al., 2020). Indeed, a forest owner has the final decision in making choices on his own property.

However, our second illustration of leadership shows that the industrialist succeeds in convincing the manager to join him in a coalition. This displays another configuration, specific to our case study context, where the three actors, industrialist, manager and association, must convince the owner to adhere to their preferences, beliefs, interests, etc. They form a coalition to reach their goals, while knowing that the owner will have the final say.

- Coalitions were also observed, but mainly in a configuration involving 3 stakeholders against one. The association usually shows divergent profiles compared to those of the industrialist, the manager and the owner. These coalitions mainly appear at the beginning of the negotiation rounds. Sometimes, a coalition also appears between the industrialist and the manager, who have an operational vision of the forest management issues. The owner indeed adopts different profiles within the groups, depending on his own beliefs and sensitivity. On this basis, the owner can rally the industrialist/manager to his cause (as illustrated in our results) or get closer to the association, according to its environmental awareness.

It is also interesting to note that the 4 behavior configurations are usually combined during the CRP. For example, a leadership demonstration reaches a coalition, which can potentially result in a collective agreement, or lead to a blocking behavior. These cases are characterized by stakeholders who hold a majority using their influence to change the opinion of minority stakeholders during the negotiation process (King et al., 2010; Lim & Guo, 2008).

We also observed that the behavior configurations do not appear systematically within the groups. Among the 29 groups involved in our experiment, 13 were considered as relevant in illustrating non-cooperative behaviors. These results reveal a potential limitation of our study. Indeed, some groups' outcomes were removed from our database, because they were not properly exploitable (some data were missing). This can be explained by the pedagogical aspects of our experiment, which limits the involvement of some participants, and by the usability of the CRP methodology supporting tool that may be difficult to handle.

Concerning our methodological approach, we propose to discuss several aspects. First, our CRP methodology mobilizes the Multicriteria aggregation technique AHP (Analytic Hierarchy Process) because it allows the preferences of several decision-makers to be modelled simultaneously, based on a common criteria framework. We built our methodological background on this technique as a continuation of research on group decision support (Choudhury et al., 2006; Dyer & Forman, 1992; Srdjevic, 2007). However, further consideration could be given to this issue. We have chosen to use the AHP method (Saaty, 1980), in particular because it enables a systematic and transparent construction of the criteria weights. This is not necessarily the case with all multicriteria analysis methods. This aspect is of particular interest for representing the preference profile of each decision-maker, and identifying points of divergence/convergence during negotiation rounds. However, for the ranking of scenarios, it would be entirely conceivable to use a different multicriteria analysis method, such as PROMETHEE (Brans et Mareschal, 1994; Brans et Vincke, 1985) or MAUT (Neumann and Morgenstern, 1953) for example, and combine it with the weights constructed by applying AHP. Indeed, a method such as PROMETHEE has the advantage of being non-compensatory, unlike AHP, which can be interesting in a sustainability context, where one would not expect to compensate an environmental or social criterion with an economic one, for example.

In addition, through its four iterative steps (Consensus measurement and management, Iterative negotiation rounds, Modifying preferences and Iterative aggregation), our CRP model

enables the observation of different behaviors and dynamics within the groups. However, it does not allow us to manage these blocking behaviors so that a consensus is reached systematically. According to (Eräranta & Staffans, 2015), favoring exchanges and discussion improves the stakeholders' situation awareness and increases the probability of reaching a consensus, but it does not guarantee it. So we can conclude that our methodology does not promote consensus optimization but rather exchanges between stakeholders. Note that consensus usually means obtaining consent, not necessarily the agreement of all group participants (Herrera-Viedma et al., 2014). Our CRP does not rely on an adjustment coefficient as proposed by (Dong et al., 2016) nor on penalties given by a moderator, as proposed by (Palomares, Estrella, et al., 2014). Our research rather contributes to providing a visualization of the consensus evolution in the different rounds. It is a discussion support methodology for stakeholders, its objective is to enrich and support the exchanges through a continuous visualization process transmitting information to the group (Endsley, 2012). It also allows all the stakeholders to express their point of view, since they have to make their own weight modifications in each round. From our case study, we believe that this methodology encourages stakeholders who might be more introverted to express themselves. By revealing the extent to which a group is balanced in its different behavior patterns, awareness of their interaction increases, particularly within the context of an on-going group interaction. Groups could be expected to alter their behavior and information sharing patterns (Dimicco, 2005). Therefore, our research also brings a self-management approach, like (Palomares, Estrella, et al., 2014), to a small group decision process, based on data visualization to identify non-cooperative behaviors. However, in a real context, a decision should generally be made within a specific period of time and even if this research work does not aim to optimize the consensus process efficiency, the presence of a human or automated moderator could be envisaged to increase collective agreement success at the end of the negotiation rounds. It should be noted that the absence of a moderator avoids bias in decision-making (Zhang et al., 2019), but on the other hand, it can generate problems in reaching consensus (Herrera-Viedma et al., 2002). Including a



moderator could be a way to facilitate consensus within the groups, because it is widely assumed that participants are willing to accept the suggestions provided by a moderator during the GDM process, to modify their preference information in order to reach a group consensus (Tang & Liao, 2021). However, in practical decision-making problems, decision-makers may be reluctant to accept the modification advice (Zhang et al., 2018). Moreover, this facilitating process is heavily dependent on the moderator and can occasionally be excessively demanding for him (Dong et al., 2016; W. Xu et al., 2020).

Secondly, as (Tang & Liao, 2021) point out, trust relationships play a critical role in decision-making. In small groups in particular, notions of stakeholder reliability and importance impact the group dynamic and the trust relationships. For example, the importance of the “forest owner” is high in our case study, because the forest is his own property. His decision power is indeed very high. Additionally, the manager, characterized as the expert in forest management, has a high reliability that can also impact the discussion and the trust relationships (Fu et al., 2015; Xue et al., 2020). In this configuration, we can wonder whether our methodology supports trust relationships among stakeholders through the visualization of consensus evolution.

This observation raises limitations related to the implementation of this case study in a pedagogical context. Indeed, the participants in the discussions were not experts in the field and had to assume a role in order to best represent a specific stakeholder with an interest in reaching consensus. Even though workshop facilitators were present to ensure the veracity of the information/arguments put forward, and that the participants had preliminary work with the persona method to appropriate their role, their ability to mobilize the relevant knowledge to put forth meaningful arguments related to their roles could be called into question and affect the group dynamic and the trust relationships.

In the same line, we can question the motivation of the participants to reach a consensus, which can be slowed down or moderated by the artificial convictions adopted by the participants who must play the role of a stakeholder, without having the real capacity to capture all the motivations

and convictions that can drive him/her. The hypothesis of an assumed motivation was realized, considering that the challenge brought by the role playing proposed by the workshop allowed to encourage the immersion and the convictions of the participants, but without real stakes, there would sometimes be little reason for them to change their initial evaluations.

The objective of this workshop was to simulate a group decision making situation and to illustrate the behaviors of the different stakeholders involved. This study focusing on group consensus reaching process independently of decision quality evaluation, these limitations related to the pedagogical context in which the workshop took place do not necessarily challenge the observations made. Instead, they open up interesting perspectives for making the case more robust. Indeed, an experimentation in a real context could be envisaged, in order to mobilize participants from the field who can assert argued and embodied convictions, as well as a real motivation to reach a consensus. The changes in preferences achieved at each round of negotiations will then have to be interpreted with respect to the personal stakes and motivations of each stakeholder. The recording of the discussions during the negotiation rounds could appear to be an interesting methodological support, complementing the written reports requested from the participants, to reinforce and facilitate the interpretation of the successive changes in individual preferences during the CRP. This future experimentation will also be an opportunity to strengthen our research approach by exploring whether the 4 considered non-cooperative behaviors appear systematically within the groups, or if they appear in another configuration.

#### Conclusion:

The objective of this paper was to study how non-cooperative behaviors appear in a small group of decision-makers and what is their level of impact on the evolution of the consensus reaching process. Our study responds to our research question by identifying within a pedagogical experimentation four theoretical behaviors (collective agreement, blocking behavior, leadership and coalition) targeted either in an emblematic way or in the form of a combination. Our

pedagogical case study was particularly original through the presence of the specific role of forest owner in the GDM who brings an individual final decision-making oriented by the other stakeholders' arguments. Our main research prospects are first, to improve the interface of the supporting tool to make it more visual and intuitive for the participants. For this purpose, a design process for a web-based collaborative tool to support group decision-making is being deployed, mobilizing a living-lab approach (Arnould et al., 2022). Secondly, this methodology will be applied to a real-world case in order to obtain results as close to reality as possible. In the short-term, it is planned to organize a workshop bringing together several small groups of practitioners who can relate to this case study because of their own expertise or experience. Participants such as forestry stakeholders (forests experts, industrials, owners...) and representatives of local environmental associations should be mobilized in order to compare negotiation dynamics during the successive rounds of negotiations.

We believe that this kind of methodology can facilitate consensus building in a GDM. Nevertheless, we still have to determine the place of the moderator when using this methodology, as it seems to us to be an essential role in facilitating multi-stakeholder processes.

### **Acknowledgement**

The authors would like to recognize L. Dupont and G. Tran Thi Hoang (2019), for their participation in the genesis of this research work.

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