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Development of a Multi-Criteria Analysis Decision-Support Tool for the Sustainability of Forest Biomass Heating Projects in Quebec

Raphaël Dias Brandao [1], Evelyne Thiffault [2,*] and Annie Levasseur [1]

[1] Département de Génie de La Construction, École de Technologie Supérieure, 1100 Notre-Dame West, Montréal, QC H3C 1K3, Canada
[2] Département des Sciences du bois et de la Forêt, Faculté de Foresterie, de Géographie et de Géomatique, Université Laval, Québec, QC G1V 0A6, Canada
* Correspondence: evelyne.thiffault@sbf.ulaval.ca

Abstract: Residual forest biomass for heating is an alternative to fossil fuels that is in line with global greenhouse gas emission reduction targets. Even if the opportunities and the benefits of such projects may be important, one should not neglect the barriers and potential impacts of these projects regarding their sustainability. The decision support tool developed and presented in this paper will help guide and support public decision makers in selecting the best project and improving its sustainability. A reliable and relevant weighting method is determined, based on the use of the Analytic Hierarchical Process multi-criteria decision analysis method, allowing the integration of stakeholders and the consideration of their views and opinions. This choice, combined with the privileged use of quantifiable qualitative data, allows the use of the tool in a preliminary phase of the project development and enables the evaluation of the project and its sustainability from a social acceptability perspective. The tool was applied to two fictional scenarios to demonstrate its ability to guide decision making and to highlight the differentiation of weights and scenarios through both weighting and evaluation methods.

Keywords: decision-support tool; multicriteria decision making (MCDM); analytic hierarchy process (AHP); forest bioenergy; sustainability indicators; comparative scenario analysis

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1. Introduction

Bioenergy produced from forest biomass feedstock has a strong potential to reduce greenhouse gas (GHG) emissions and contribute to the transition towards more sustainable heating technologies. Globally, energy production from forest biomass could rise from 132 TWh (10^{12} Wh) in 2001 to 1168 TWh by 2030 [1]. Following the example of other jurisdictions around the world, the province of Quebec, Canada, aims to increase the production of renewable energy by 25% by 2030 and has made plans to convert fossil-based heating systems of institutional and commercial buildings to forest biomass heating [2]. Currently, the Quebec energy system relies mainly on hydro resources that provide cheap electricity to the province, and on cheap North American fossil resources from Western Canada and the United States [3]. However, the boreal forest, that covers a large part of the province, can provide biomass in large quantities which, associated with the well-developed forest industry of the province, becomes an alternative for the conversion of heating systems to bioenergy.

The benefits of these conversions can be multiple: (i) economic, via the creation of new value chains [4,5], (ii) environmental, via the reduction in GHG emissions [6] or (iii) social, with the creation of jobs for local communities [7]. Nevertheless, there are still many risks and obstacles preventing the development of the sector. These include organizational risks associated with the coordination of the forest bioenergy value chain [8], which includes many stakeholders and needs to be harmonized with the supply chains for conventional wood products [9]. Environmental risks also need to be considered, including the impact of residual forest biomass removal on soils [10] and biodiversity. Some stakeholders state awareness of bioenergy development and generally support it when sustainability requirements are met [11], while others, including the general public, are less aware which tends to reduce the social acceptability [12].

To help support the deployment of bioenergy policies and inform stakeholders about benefits and impacts of energy systems conversion, decision support tools for assessing the sustainability of forest bioenergy have been developed in recent years. A literature review by Scott and al. (2012) shows that existing tools focus mainly on the choice of the most suitable technological solution (27% of the tools studied), while only 14% of them address the sustainability of projects. Furthermore, the tools studied were mainly developed for Europe (63%), while only 23% were from North America [13]. For example, the Tool for sustainability impact assessment (ToSIA) is a decision support tool developed by the European Forest Institute [14] that brings together economic, social and environmental indicators. It has been developed mainly for the context of European forests, although it can be adapted to other regions. However, in the case of regions for which the bioenergy sector is still in its infancy, hard data are often difficult to generate in the absence of comparative projects, making quantitative analyses with tools such as ToSIA difficult to perform. Moreover, a literature review by Zahraee, Shiwakoti [15] shows that there is a lack of simultaneous analysis of social, economic and environmental dimensions in multi-objective approaches and that most of the tools are inadequate for strategic level, leading to the need for more qualitative sustainability analysis that can be applied at the first stages of project design. Finally, Timonen, Reinikainen [16] showed that promoting the integration of stakeholders at the outset of energy projects, and facilitating their cooperation and buy-in, are essential steps especially in the context of emerging sectors.

To address the gaps identified in the literature, the paper proposes a tool that:

- Integrates relevant social, economic, environmental, ethical, cultural and governance indicators to assess the sustainability of bioenergy heating conversion projects;
- Increases the social acceptability of these projects by integrating stakeholders in the definition of criteria and their weighting allows for a preliminary qualitative assessment of projects to estimate their potential benefits and impacts in a context of scarce quantitative data.

The article is divided into two main sections. On the one hand, materials and methods explains the approach used for the development of the tool and in particular the determination of the indicators, the choice of the weighting method and finally the methods for evaluating the quantitative and qualitative indicators. On the other hand, the Results and discussion section uses a fictional case study to demonstrate the tool's ability to meet the needs of decision-makers and the research objectives.

2. Materials and Methods

The methodology implemented for the development of this tool was based on four distinct but interconnected stages as shown in Figure 1. These stages are:

(i) The identification of indicators adapted to the Quebec forest bioenergy context and to the expectations of stakeholders, including literature review of existing indicators, sorting and adaptation of the identified indicators to the specific context of the tool and validation of the indicators with experts and stakeholders;
(ii) The determination of an appropriate weighting method, including literature review of existing weighting methods, and determination and adaptation of the chosen method to the tool;
(iii) The development of a dataevaluation method for both qualitative and quantitative data as well as the conversion from data evaluation to indicator performance;
(iv) the verification of the tool with a fictional case study to assess its ability to meet the research objectives and the stakeholders needs.

Each of these methodological steps are detailed in the following sections.

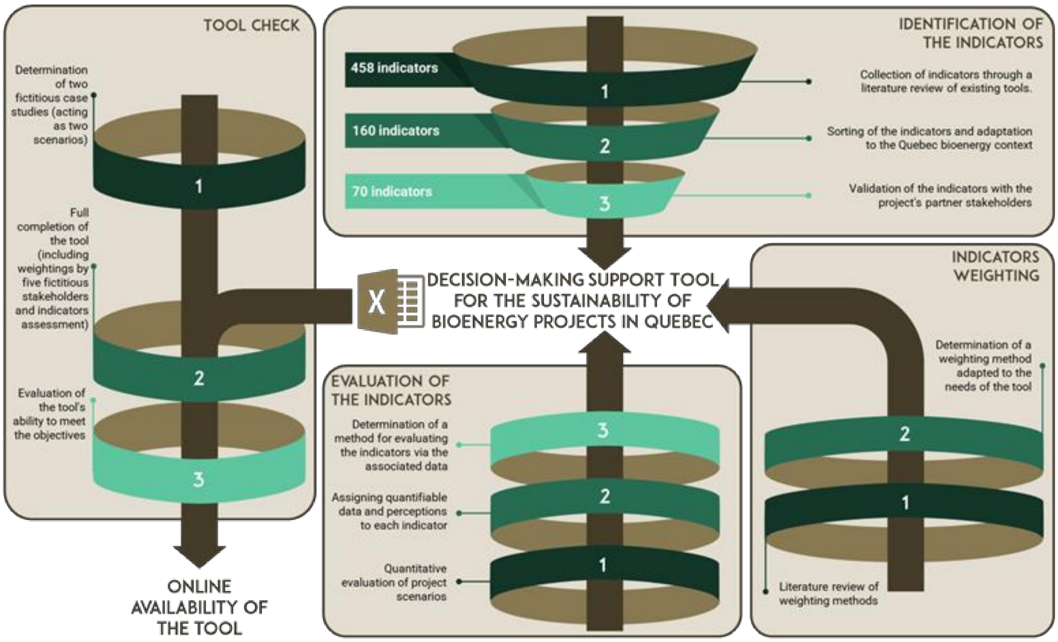


Figure 1. Research methodology implemented to meet the research objectives and enable the development of the tool.

2.1. Selection of Indicators

The selection of indicators was based on the review of existing decision support tools that were relevant for the sustainability assessment of natural resource projects. Since no existing tool analyses the sustainability of bioenergy projects in the Quebec context, the tools selected were chosen for their ability to provide reliable information on specific aspects needed in the tool. They included: (i) a tool to address the sustainability of bioenergy projects in a boreal context in the Tool for Sustainability Impact Assessment (ToSIA) [14], (ii) a tool focusing on bioenergy risks in North America within the Biomass supply chain risks standards (BSCR Standards). This tool is a database of risks associated with forest biomass value chains created by Ecostrat [17]; (iii) a tool addressing social acceptance in the specific context of Quebec, calculating the social risk index for mining projects. This tool, developed by the Chair in Mining Entrepreneurship at the Université du Québec en Abitibi-Témiscamingue notably explores relationships of projects with the needs and aspirations of communities [18]; and (iv) a more complete tool that offers an analysis beyond the 3 classic dimensions of sustainable development (environmental, social and economic), i.e., the sustainable development analysis grid (GADD). This tool created by the chair in eco-counseling at the Université du Québec à Chicoutimi [19] is the most accomplished and detailed one found since it considers six main dimensions to evaluate the sustainability of a project, and thus allows an analysis of sustainability closer to the most recent definitions of sustainable development However, it is a general tool that can be applied to any type of project in any sector.

The list obtained contained more than 450 indicators. While economic, environmental and social indicators were numerous, only a few indicators were related to cultural, ethical and governance dimensions of sustainability.

Indicators were then sorted and selected, based on the following criteria:

1. The relevance of the indicator for the user, i.e., the extent to which the indicator allows the evaluation of a forest bioenergy project in conditions relevant for Quebec [20–22].
2. The ability to differentiate between scenarios of a bioenergy project to support decision-making [22]. Indeed, the tool must help decision-makers choose the best scenario, so an indicator that cannot differentiate between scenarios is considered superfluous and complexifies the tool while lengthening the time required to complete it.

3. The ability to provide a comprehensive and detailed view of a project sustainability to ensure that all aspects of a forest bioenergy project are assessed within the framework of the tool [21,22].
4. The availability of the information needed to qualify the indicator [16,20,22].

After sorting, indicators were adapted to forest bioenergy in the context of boreal regions such as Quebec. To do this, indicators were modified and renamed to correspond to this specific context, but also to improve the user understanding as it has been identified as a criterion for maintaining the indicator [20,22]. In addition, it was important to adapt indicators to the local or regional level at which the tool will be used. Moreover, it was essential to consider local indicators in addition to the global ones [16]. For example, impacts on biodiversity or soils are assessed at a local scale, while impact on GHG emissions is assessed at a larger scale (depending on the supply chain) [23].

These sorting and adaptation steps resulted in a total list of 160 indicators. This list was then submitted to a focus group of partners. The selected partners were representatives of organisations in Quebec that are involved in the development of forest bioenergy projects including public policy makers and non-governmental organisations. They were specifically selected for their knowledge of the sector and for their awareness of the needs of local and regional decision-makers involved in energy projects. During meetings of the focus group, feedback was collected on the content of the tool and the list of indicators, but also on the operation of the tool and its adequacy with the expectations and needs of the partners. As a result, some indicators were merged or adapted, while others were removed because they did not fit the need.

At the end of this process, 70 indicators grouped into 30 themes and six dimensions were integrated in the tool (as shown in Table 1). The choice of this breakdown into six dimensions corresponds to the need to satisfy the pillars of sustainable development, i.e., classically, the social, economic and environmental dimensions, to which ethical, cultural and governance dimensions are added. The integration of new dimensions in decision-making tools is wide spreading [24] and is in line with the 17 sustainable development goals defined by the UN, following the evolution of the definition of sustainable development.

Table 1. The 70 indicators selected for the decision-support tool are divided into 30 themes and six dimensions.

Cultural	Transmission of cultural heritage	C.1.1	Cultural heritage
		C.1.2	Use and significance of the project site
		C.1.3	Knowledge of the past and history
	Cultural and Artistic Practices	C.2.1	Freedom and pluralism of beliefs and identities
		C.2.2	Development of cultural expression
		C.2.3	Access to culture for all
	Cultural diversity	C.3.1	Interculturality
		C.3.2	Recognition of cultural minorities
		C.3.3	Linguistic diversity
Economic	Production and consumption	Ec.1.1	Responsible production
		Ec.1.2	Responsible consumption
	Economic viability	Ec.2.1	Economic sustainability of the project
		Ec.2.2	Financial risks
	Economic ethics	Ec.3.1	Responsible financing and investment
		Ec.3.2	Social and solidarity economy
	Economic Development	Ec.4.1	Regional development
	Transport	Ec.5.1	Transportation costs

Table 1. *Cont.*

Environmental	Ecosystems and Biodiversity	Env.1.1	Ecosystems
		Env.1.2	Protection of biodiversity
	Soil conservation	Env.2.1	Chemical and biological properties of soils
		Env.2.2	Physical properties of soils
	Resources	Env.3.1	Wise use of resources
		Env.3.2	Management of damaged or dead wood
	Emissions and outputs	Env.4.1	GHG Emissions
		Env.4.2	Toxicity
		Env.4.3	Waste Management
	Water	Env.5.1	Water pollution
		Env.5.2	Water use
	Forest land use planning	Env.6.1	Optimization of the territory and conflicts of use
		Env.6.2	Landscape diversity
	Natural hazards	Env.7.1	Meteorological conditions
		Env.7.2	Forest Fires
		Env.7.3	Insects and diseases
Ethics	Responsibility	Et.1.1	Precautionary Principle
		Et.1.2	Credibility of promoters
	Sharing	Et.2.1	Optimization of benefits
		Et.2.2	Sharing of common goods
	Ethical approach	Et.3.1	Ethical purpose of the project
		Et.3.2	Shared values
	Transparency	Et.4.1	Transparency and integrity
	Benevolence	Et.5.1	Damages and compensations
		Et.5.2	Solidarity
		Et.5.3	Openness and dialogue
Governance	Institutions	G.1.1	Institutional Efficiency and Accountability
	Supplier contracts	G.2.1	Relationship with suppliers
		G.2.2	Legal aspects
		G.2.3	Resource quality requirements
		G.2.4	Resource quantity requirements
		G.2.5	Adaptation to the local market
		G.2.6	Supply Chain Resilience
	Management	G.3.1	Instruments and Processes
		G.3.2	Risk Management
		G.3.3	Monitoring and control
		G.3.4	Information and communication
		G.3.5	Decision Making
	Stakeholders	G.4.1	Participation
		G.4.2	Support and acceptability

Table 1. *Cont.*

Social	Local community	S.1.1	Community Support
		S.1.2	Social acceptability
	Sharing of natural resources	S.2.1	Integrated water management
		S.2.2	Conflicts of land use
	Work	S.3.1	Job creation
		S.3.2	Working conditions
	Quality of life	S.4.1	Health
		S.4.2	Well-being
		S.4.3	Living environment
	Equality	S.5.1	Gender Equality
		S.5.2	Respect for minorities
		S.5.3	Generational discrimination
	Education for sustainable development and citizenship	S.6.1	Education for sustainable development and citizenship

Those indicators are not directly evaluated in the tool and each of them regroups several data. Examples of data are available in Supplementary Materials Table S3. The determination and the attribution of data to each indicator is explained in Section 2.3.

2.2. Weighting Method

The weighting of indicators consists of assigning a numerical coefficient to the indicators to show their importance compared with others [25]. The integration of a weighting method in a decision support tool is not essential, and many tools do not integrate this functionality or at least do not have reliable and efficient weighting methods. Nevertheless, the absence of a weighting method means that the indicators are given an arbitrary weighting and are then considered to be equivalent. The objective of the weighting method is therefore, in addition to the prioritization of indicators, the integration of stakeholders in the decision-making process, in order to integrate their convictions and opinions in the choice of the most appropriate final scenario. Four weightings methods were compared:

(1) The direct rating method, which despite its simplicity and quick use, presents a high risk of bias [26] which led to the abandonment of this method.

(2) The simple multiattribute rating technique (SMART), which is not time-consuming but can be difficult to use when the number of indicators is high [26]. Considering the number of indicators identified in the tool and their categorization, this method was insuitable.

(3) The discrete choice experiment (DCE) method, which is a statistical method that requires a large number of participants to evaluate the weights [26]. In order to offer an easy-to-use tool for a quick evaluation of projects in the preliminary phase of development, this method was unsuitable because it required additional means, resources and time.

(4) The analytic hierarchy process (AHP) method, which relies on the simple technique of pairwise comparisons while limiting their number and therefore, the time required for information. The AHP method also ensures the reliability of the data entered [26]. This method, which is widely used in risk analysis, has been adapted to the context and framework of the tool in order to integrate stakeholders into the decision-making process and to allow for a high degree of differentiation between the different weightings provided. Developed in the 1980s by Thomas Saaty, this method has since been widely used in decision making and weighting problems [27]. The method is based on pair-wise comparisons of indicators organized in different hierarchical levels. The choice of this method is justified by several factors. First, the large number of indica-

tors did not allow for prioritization methods by direct comparison; in fact, comparing the 70 indicators would have resulted in a total of 70 × (70 − 1) / 2 = 2415 comparisons. As the tool, and particularly the weighting part, is intended to be used by a non-initiated public, the aim is to limit the time needed to fill in the weights. By using hierarchical levels, the AHP method allows a total of 144 comparisons, which is more reasonable. Secondly, unlike statistical methods, the AHP method makes it possible to obtain a valid weighting from just one evaluator, which in the context of the project is a crucial element since it limits the necessity of using a large number of stakeholders. Finally, the AHP method provides a standard scale of comparison that facilitates and standardizes evaluations, as well as an assessment of the consistency of the comparisons made.

Indicators were organized into six dimensions (level 1 of the hierarchy), broken down into 30 themes (level 2), which in turn were broken down into 70 indicators (level 3). For each of the levels, all possible pair-wise comparisons within that level are evaluated. A total of n(n − 1)/2 comparisons are required at each hierarchical level to calculate the weights assigned to the n dimensions, themes or indicators. Figure 2 shows an example of hierarchical tree used in the AHP method and the number of pair comparisons needed in each level.

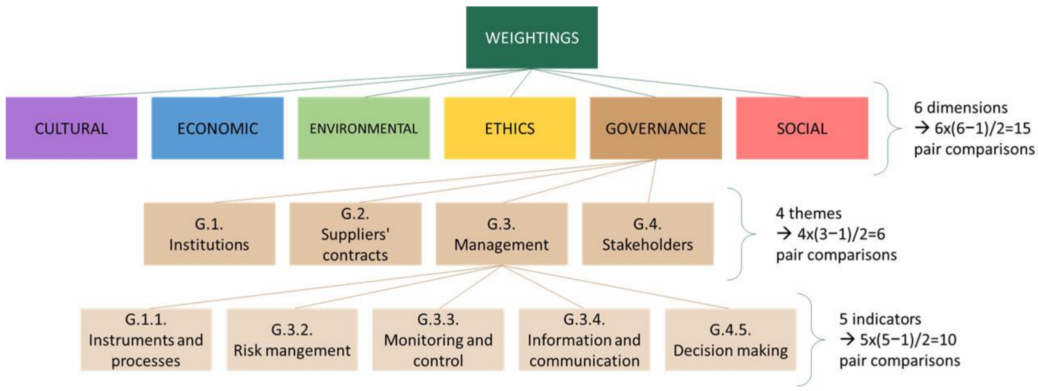


Figure 2. Example of hierarchical tree for indicators in theme *G.3. Management*, of the governance dimension.

A so-called Saaty scale ranging from 1 (both indicators A and B are equivalent) to 9 (indicator A is extremely more important than indicator B) is defined and allows comparison of indicators according to the preponderance of one indicator over the other [28]. Figure 3 shows the weighting tab of the tool.

The set of comparisons for a given theme creates a preference matrix whose eigenvalues allow the calculation of the weights of each indicator in the theme [28]. The formula for calculating the weights obtained from the preference matrix is given by Equation (1).

$$W_x = \frac{1}{N}\sum_{y=1}^{N}\frac{p_{x,y}}{\sum_{1\le z\le N} p_{z,y}} \quad (1)$$

where $[W_x]_{x\in[1,N]}$ is the column vector of weights, $[p_{x,y}]_{x,y\in[1,N]}$ is the preference matrix and N is the number of dimensions, themes or indicators depending on the hierarchical level.

By combining the calculation of the weights of the themes in each dimension and the calculation of the weights of the dimensions, the global weighting of each indicator can be obtained by Equation (2):

$$w_k = \alpha_{ijk} \times w_i \times w_{ij} \times w_{ijk} \quad (2)$$

where w_k is the final weight of indicator k, w_i is the weight of dimension i, w_{ij} is the weight of theme j in dimension i and w_{ijk} is the weight of indicator k in theme j of dimension i. Finally, α_{ijk} is a corrective factor that balances the weights. Indeed, the number of indicators in a theme or the number of themes in a dimension being variable, it is important to correct this error by integrating this α_{ijk} factor defined by Equation (3):

$$\alpha_{ijk} = \frac{N_i \times N_{ij} \times N_{ijk}}{N_{total}} \tag{3}$$

where N_i is the number of dimensions (6), N_{ij} is the number of themes j in dimension i, N_{ijk} is the number of indicators k in the theme j of dimension i and N_{total} is the total number of indicators (70).

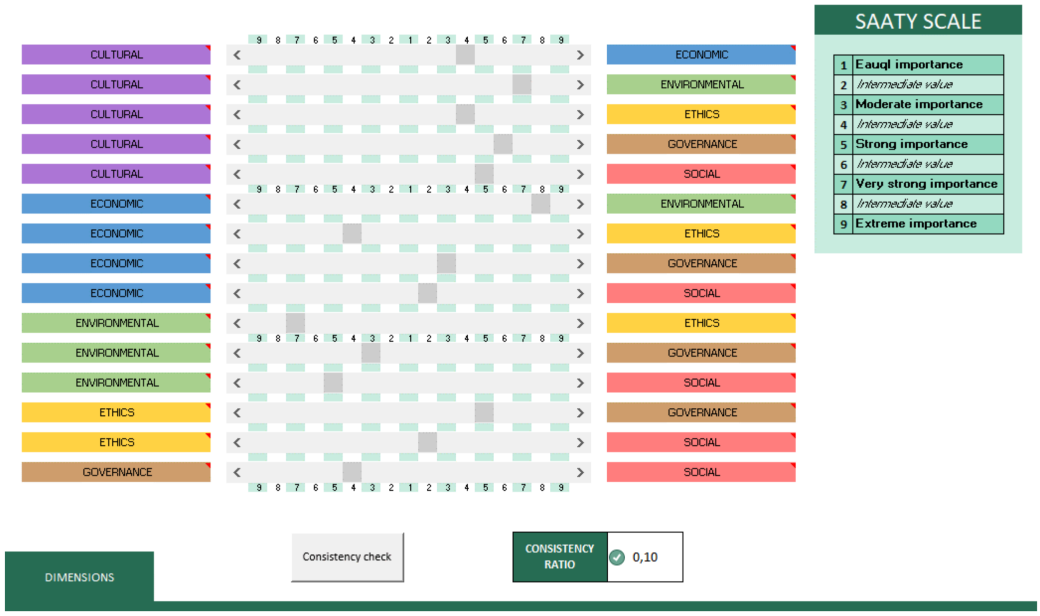


Figure 3. Screenshot of the tool showing the pairwise comparison of the different dimensions considered in the tool to allow the determination of weights for each of them using the AHP method.

The interest of the AHP method lies mainly in the calculation of the consistency ratio, which ensures that comparisons made by stakeholders are consistent. This ratio is calculated by dividing the consistency index CI, which is derived from the calculation of eigenvalues, by a random consistency index RI that depends on the number of indicators compared (between 3 and 11):

$$CR = \frac{1}{RI} \times \frac{1}{N-1} \times \left[\frac{1}{N} \sum_{i=1}^{N} \frac{1}{W_i} \sum_{k=1}^{N} W_k p_{i,k} - N \right] \tag{4}$$

where $[W_i]_{i \in [1,N]}$ is the column vector of weights, $[p_{x,y}]_{x,y \in [1,N]}$ is the preference matrix and N is the number of dimensions, themes or indicators depending on the hierarchical level.

If this ratio is less than 10%, then the comparisons made can be considered consistent. In the case where only two indicators are compared, a consistency ratio cannot be calculated, but the method remains valid since there can be no inconsistency in the comparison of only two indicators [28].

2.3. Development of an Evaluation Method Based on the Indicators

The evaluation of indicators is based on two main and complementary aspects. On the one hand, a quantitative and comparative evaluation of up to three potential scenarios based on a user-defined value chain, and on the other hand, a qualitative analysis based on a series of quantifiable perceptual data. Each indicator is then assigned a combination of data from both analyses that allows the indicator to be rated and a performance to be assigned to each scenario assessed.

2.3.1. Quantitative Analysis

The quantitative analysis is an essential step in supporting the decision-making process for the most suitable scenario. Nevertheless, as the tool is intended to be used in a preliminary phase of project planning, precise quantitative data are rare and usually poorly defined. For this reason, the choice of relevant quantitative data was based on their ability to differentiate between scenarios while requiring only a limited amount of generic input data. One economic criterion and four environmental criteria were chosen:

- Production costs;
- Use of fossil resources;
- GHG emissions;
- Emissions of other gases;
- Emissions of particles.

To perform this technical analysis, the tool relies on the definition of value chains according to the model developed in ToSIA [29], and adapted to the case of forest bioenergy in Quebec.

Six value chains have been identified, depending on the type of felling (whole trees or cut down trees) and the type of bioenergy product obtained (standard pellets, torrefied pellets or forest chips). These value chains are defined by a series of processes decomposed into four modules [30]:

- Forest resources management;
- Forest to industry interactions;
- Processing and manufacturing;
- Industry to consumer interactions.

Nevertheless, given that the objective of the tool is to allow the comparison of scenarios in order to differentiate them as much as possible, the tool ignored the first module because all the proposed scenarios were based on the same processes for this module. The user can then adapt the value chain by choosing the steps of the wood transformation process, to ensure a greater conformity to the reality of the scenario. Figure 4 shows an example of a value chain proposed by the tool.

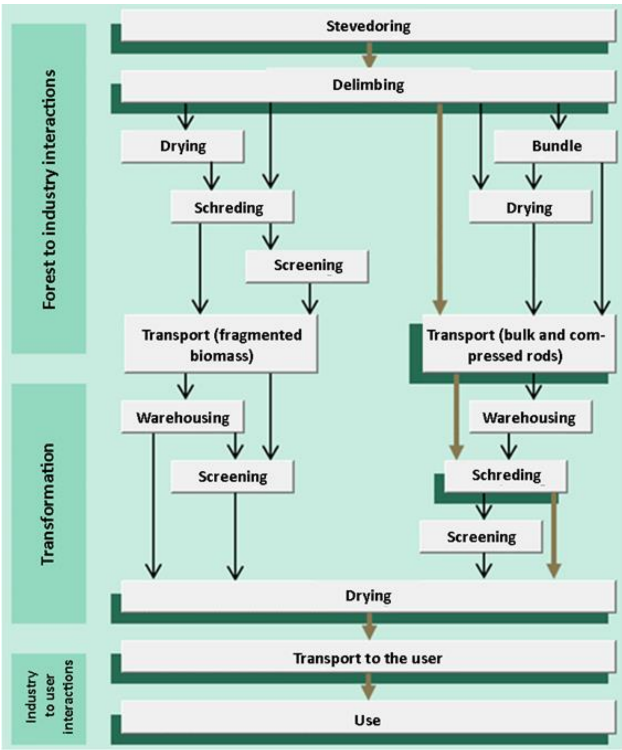


Figure 4. Example of a value chain for the forest chips product type and full-tree felling. The thick brown arrows represent the studied value chain. The thin black arrows represent the possible alternatives.

Input data was associated with each of the processes defined in the value chain and chosen by the user for a given scenario. This allows the calculation of the quantitative criteria defined above. Default values for the different input data were proposed to allow the evaluation of the five criteria in case the specific information is not available at the premature stage of scenario analysis during which the tool is intended to be used. These default values were obtained through a literature review of the costs associated with the various processes and the environmental impacts of these same processes [31].

In addition, other quantitative data can be evaluated in the tool if the necessary information is available. These data do not rely on the use of the value chain to be evaluated.

2.3.2. Qualitative Analysis

The aim of the qualitative analysis is to evaluate and compare the different scenarios of a project at the preliminary stage where the tool is going to be used. The objective of this analysis is to ensure that all aspects of sustainability were considered in the scenarios by questioning the measures put in place or planned in each of them, but also by assessing the user perception of the current state of an indicator.

Qualitative data that assess the current state of an indicator are evaluated using a scale of 1 to 5. For qualitative data that assess actions implemented or planned, the assessment is done using a twostep scale. First, the importance of the action in the context of the project scenario and objectives is rated on a scale of 1 to 3, and then the effect of the actions taken or planned is rated on a scale of 1 to 5.

The assessment of qualitative data, unlike the assessment of weights, can only be done by one person (usually the project manager, commissioned by the decision-maker) since the length of time and level of knowledge required makes it difficult for all stakeholders to evaluate. Nevertheless, it is recommended for perceptions to be filled in following meetings with project stakeholders to consider their point of view on each of the indicators evaluated.

2.3.3. Conversion of Evaluations to Scenario Performance

The different types of data presented are assigned to the different indicators. Each indicator is therefore assessed by a combination of three types of data, including quantitative data, quantifiable perceptions assessing the current state, and evaluation of measures implemented or planned as part of the biomass heating project. The objective is to compile the evaluations of these data to obtain an overall performance for all scenarios to support decision-makers.

The first step in the overall conversion is to convert all the data evaluations to a common scale rating. Each indicator is assigned a rating between −2 and +2. For quantitative data, the scenario with the best result is assigned a +2 rating while the scenario with the worst result is assigned a −2 rating. The intermediate scenario is assigned a 0 rating. For qualitative criteria that assess the current state of the indicators, a linear conversion from a scale of 1 to 5 to a scale of −2 to +2 was used. For qualitative criteria that assess the measures in place or planned, the conversion Table 2 adapted from the work done in the GADD was used [19]. This table allows to convert the double evaluation (level of need for the measure and effect of the measure) into a single rating.

Table 2. Conversion table for qualitative data assessing actions taken or planned.

		Effect of the measure							
							▲	Urgent and effective measures (to be maintained)	+2
		1	2	3	4	5	◆	Effective but not urgent action (not a priority issue)	+1
Level of need of the measure	1	■	■	■	◆	◆	■	Measures not very effective but not very urgent (distant issue)	0
	2	♥	•	•	▲	▲	•	Moderately effective and moderately urgent measures (to act)	−1
	3	♥	♥	•	▲	▲	♥	Measures not very effective but urgent (to react)	−2

A score for each indicator could then be obtained by averaging the data ratings associated with that indicator. To facilitate the understanding of this score, it has been defined on a scale from 1 to 5 after linearly converting the score between −2 and 2 obtained by averaging the data ratings.

Once the scores for each indicator are defined, the performance of the themes and dimensions as well as the overall performance for each of the scenarios could be defined by averaging the scores for each indicator multiplied by the weight assigned in the weighting step. This performance is therefore dependent on the stakeholder who filled in the weightings and there are as many performances as there are stakeholders.

2.4. Case Study

To analyze the tool and evaluate its added value in the decision-making process, a focus has been given on a fictional Quebec municipality that wishes to develop the bioenergy sector from residual forest biomass. The municipality is faced with the difficulty of differentiating between several projects and would therefore like to be assisted by a decision support tool to make the best choice. Although fictional, this situation is representative of the current situation in Quebec, and the scenarios proposed hereafter echo projects implemented in the past or in progress [32]. The objective of this case study is not to make a real comparison of scenarios, which would be meaningless, as the evaluations and weights are filled in by the authors. The purpose of this case study is rather to show the contribution of the tool to decision support, by presenting the results offered by the tool and the analysis and conclusions that can be drawn in the context of the tool's use.

2.4.1. First Scenario: Implementation of a 3 MW Heating Plant

The first scenario consists of the implementation of a 3 MW forest biomass heating plant in a Quebec municipality to heat a network of municipal institutional buildings.

The main objective of this scenario is to make long-term savings on the purchase of the energy resource by establishing a local supply chain that relies on the municipality's own forest resources, supplemented by the forest resources of private landowners under contract. Nevertheless, the reduction in GHG emissions is also part of the project since the municipality must participate in the collective effort to reduce GHG emissions and reach Quebec's objectives. Finally, the city hopes to create new jobs along the supply chain.

However, efforts will have to be made to assess the potential environmental impacts, particularly on soil, water and biodiversity. In addition, given the relative importance of the scenario to the municipality, particular attention will have to be paid to the governance of the project throughout its lifetime, especially in terms of management and stakeholders participation.

2.4.2. Second Scenario: Installation of a 50 kW Boiler

The second scenario focuses on the implementation of a 50 kW boiler in a church in the city.

The main objective of this scenario is to revitalize a heritage building in the city in order to preserve it from being sold, which could have led to a reclassification of the site and its transformation or even destruction. Although smaller in scale, this project must nevertheless ensure a certain economic viability as well as a reliable supply that will rely exclusively on the municipality's forest resources. Particular attention will be paid to community support for the project.

2.4.3. Engaged Stakeholders

It is assumed that the tool is completed by a designated evaluator from the municipality that initiated the project. However, the weights are determined by five different stakeholders from different sectors and backgrounds, representing the diversity within the municipal and regional community.

These fictional stakeholders include:

- A municipal representative who is responsible for carrying the municipality ambitions and promoting its objectives. The municipal representative is also the project evaluator.
- Two community representatives responsible for representing the views of residents.
- A representative of the forest supply chain companies, including harvesting, processing and transportation of biomass.
- A representative of local forest owners.

The tool was completed for these two projects and the results are presented and discussed in the following sections.

3. Results and Discussion

The tool offers the possibility of presenting a wide variety of results in order to allow a fine and detailed analysis of the study carried out.

Thus, it is possible to:

- Compare the prioritization of indicators according to each stakeholder;
- Analyze the greatest differences in indicator weightings;
- Compare the performance of the scenarios for each of the six dimensions;
- Compare the overall evaluations attributed to each scenario.

All of these possibilities are presented in the following sections and then discussed to show the contribution of each of these features to facilitate decision making and to improve the level of knowledge about the sustainability assessment of biomass heating projects.

3.1. Prioritization of Indicators by Stakeholders

The first result proposed by the tool is the display and comparison of the weights assigned to the indicators and the resulting prioritization of indicators (Supplementary Materials Table S1). This comparison allows the differences and points of divergence between the stakeholders to emerge.

For the case study and for comparison purposes, the prioritizations are displayed in Figure 5, in the form of a graph showing the relative importance of the stakeholders' prioritizations of the indicators, according to the dimension considered.

The weights assigned to the indicators might vary greatly depending on the stakeholder who provides the information. For instance, in this example, the economic and governance dimensions are largely overweighted by the industrial and forest owner representatives. Conversely, the cultural dimension is left aside by these representatives, notably to the benefit of community representatives. Furthermore, the municipal representative generally assigned intermediate weightings.

Several factors might lead to marked differences in evaluation between the stakeholders and indicators concerned. On the one hand, the level of understanding of the issues associated with each of the indicators can vary greatly depending on the stakeholder who provides the weightings. Thus, stakeholders will give more importance to the indicators to which they feel closest and for which they understand the sustainability issues best.

Moreover, these strong divergences can also be accentuated by the choice of the AHP method, which tends to strongly differentiate the indicators according to the pairwise comparisons made and thus, to bring out marked divergences between stakeholders.

This type of results could guide policymakers organizing working sessions with project stakeholders involved in the assessment process, and more broadly with all relevant stakeholders. These sessions could have a dual purpose: on the one hand, to provide reliable information on the issues associated with the various indicators, and on the other hand, to open the debate around the main points of divergence between the stakeholders, to identify the causes, and to try to find compromises. The contribution of stakeholders to the process of prioritizing indicators is a major novelty compared to the tools initially studied, which constitutes an important advance in the development of collaborative projects, co-created with communities and stakeholders. To help the decision-maker finding the main differences between stakeholders, the tool developed allows highlighting the main points of divergence in the "Analysis" Table The method is based on the calculation of the relative difference between a stakeholder's prioritization and a chosen reference. The reference prioritization can be chosen from the stakeholder prioritizations, or it can be the average of the participating stakeholder weightings.

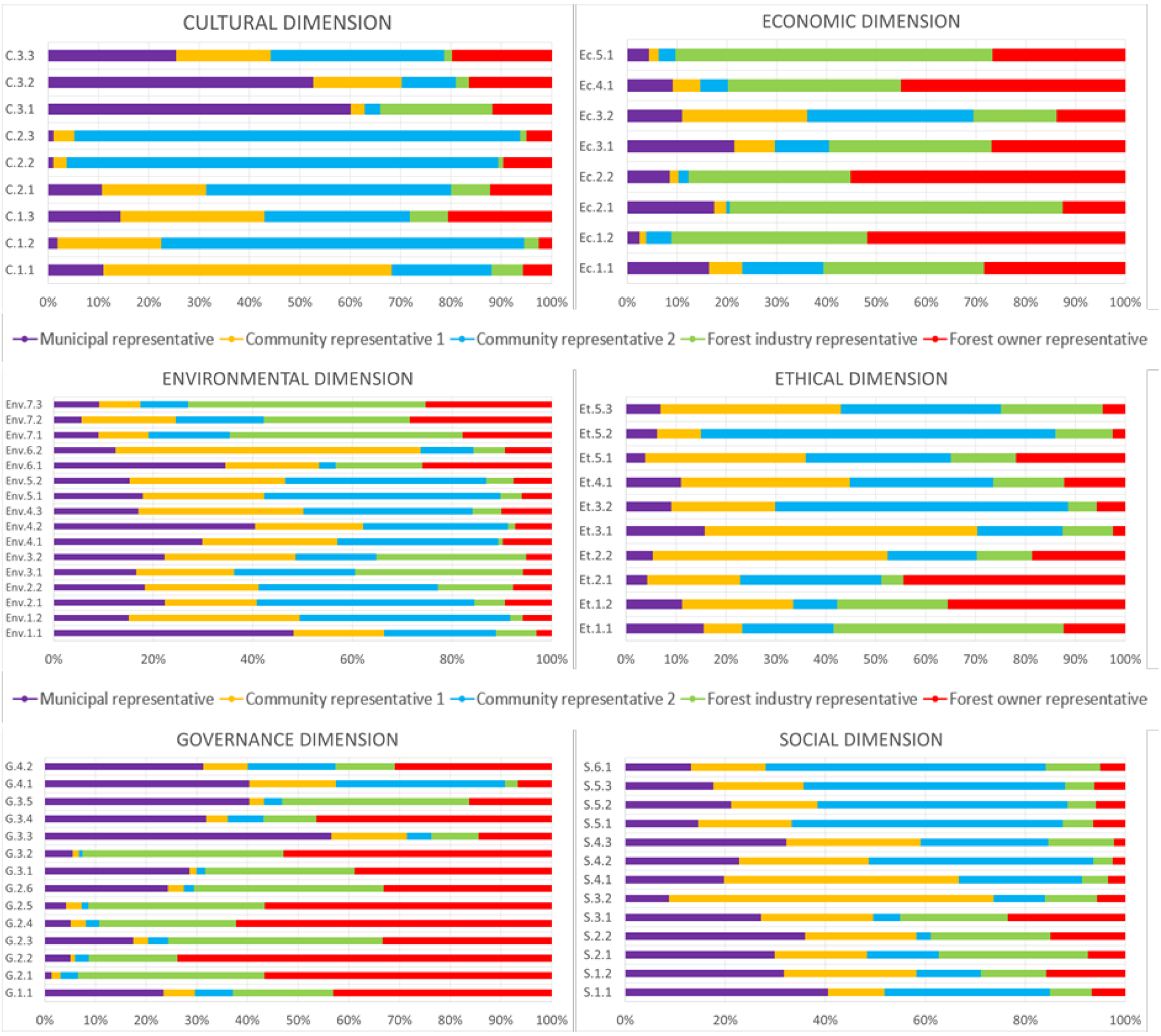


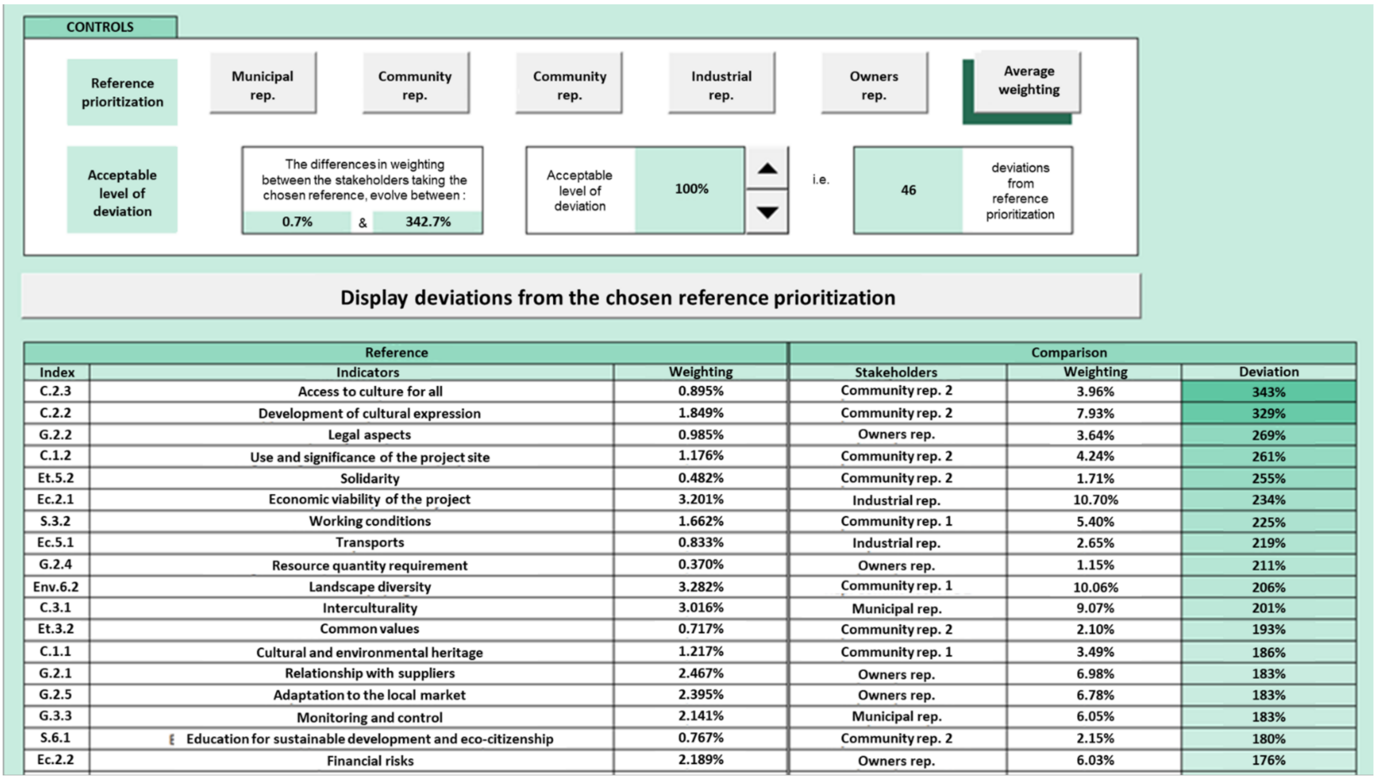
Figure 5. Relative importance of stakeholder prioritization by indicator.

For our case study and choosing the average weighting as the reference, the differences range from 0,7% to 343%. It is possible to display all relative differences above a maximum value relative difference in order to identify the main points of divergence between stakeholders regarding the weightings and prioritization of the indicators, and therefore regarding the desired lines of work and orientations for the project.

For the case study, 46 indicators had a relative difference greater than 100% (Figure 6 and Supplementary Materials Table S2). Table 3 summarizes them according to the stakeholder responsible for the difference and the dimension of the indicator concerned.

Table 3. Number of relative differences above 100% by dimension and stakeholder.

Dimension	**Cultural**	**Economic**	**Environmental**	**Ethics**	**Governance**	**Social**	
	7	**5**	**9**	**6**	**11**	**8**	**46**
Stakeholders	Community Rep. 1	Community Rep. 2	Industry Rep.	Municipal Rep.	Forest owners Rep.		
	6	15	6	8	11		46



Reference			Comparison		
Index	Indicators	Weighting	Stakeholders	Weighting	Deviation
C.2.3	Access to culture for all	0.895%	Community rep. 2	3.96%	343%
C.2.2	Development of cultural expression	1.849%	Community rep. 2	7.93%	329%
G.2.2	Legal aspects	0.985%	Owners rep.	3.64%	269%
C.1.2	Use and significance of the project site	1.176%	Community rep. 2	4.24%	261%
Et.5.2	Solidarity	0.482%	Community rep. 2	1.71%	255%
Ec.2.1	Economic viability of the project	3.201%	Industrial rep.	10.70%	234%
S.3.2	Working conditions	1.662%	Community rep. 1	5.40%	225%
Ec.5.1	Transports	0.833%	Industrial rep.	2.65%	219%
G.2.4	Resource quantity requirement	0.370%	Owners rep.	1.15%	211%
Env.6.2	Landscape diversity	3.282%	Community rep. 1	10.06%	206%
C.3.1	Interculturality	3.016%	Municipal rep.	9.07%	201%
Et.3.2	Common values	0.717%	Community rep. 2	2.10%	193%
C.1.1	Cultural and environmental heritage	1.217%	Community rep. 1	3.49%	186%
G.2.1	Relationship with suppliers	2.467%	Owners rep.	6.98%	183%
G.2.5	Adaptation to the local market	2.395%	Owners rep.	6.78%	183%
G.3.3	Monitoring and control	2.141%	Municipal rep.	6.05%	183%
S.6.1	Education for sustainable development and eco-citizenship	0.767%	Community rep. 2	2.15%	180%
Ec.2.2	Financial risks	2.189%	Owners rep.	6.03%	176%

Figure 6. Screenshot of the tab of the tool that displays the main points of divergence between the weightings given by the stakeholders.

First, all dimensions and all stakeholders are affected by the divergence of views. Moreover, there is generally only one stakeholder per indicator that is far from the average weighting.

This example justifies the choice of the AHP method for calculating stakeholder weights. Indeed, a strong differentiation between stakeholders can be observed as well as a characteristic weighting profile for each stakeholder. The method thus makes it possible to actively involve the project's stakeholders in the decision-making process, then to identify the sensitive indicators and to open the discussion around these particular points to allow a continuous improvement of the projects and to guarantee a better global acceptability.

3.2. Displaying the Performance of Themes and Dimensions

The second part of the "Results" tab focuses on displaying the results and performances of themes and dimensions (see Figure 7). The tool uses radar charts for this purpose, which allows an easy and quick comparison of the three scenarios. The user can choose to display a particular dimension and thus compare the performance of the three potential scenarios for the different themes of this dimension, or to display the overall performance and thus compare the performance of the different dimensions for the three potential scenarios. The user can also choose the weighting used for the performance assessment. The display of scenario performance is inspired by the tool developed by UQAC for sustainable development projects. The main improvement brought by the tool developed here, lies in the possibility to evaluate three scenarios simultaneously in order to compare them more easily and according to the weightings of the different stakeholders.

Figure 8 shows that, regardless of the weighting chosen, scenarios can be highly differentiated. Scenario 1, which consists of the implementation of a heating plant for several municipal institutional buildings, is evaluated more favourably on economic, governance and ethical aspects. On the other hand, scenario 2 for the implementation of a bioenergy boiler in a church better satisfies the cultural and environmental dimensions. The social dimension can, depending on the weighting chosen, be evaluated more favorably in one or the other scenario.

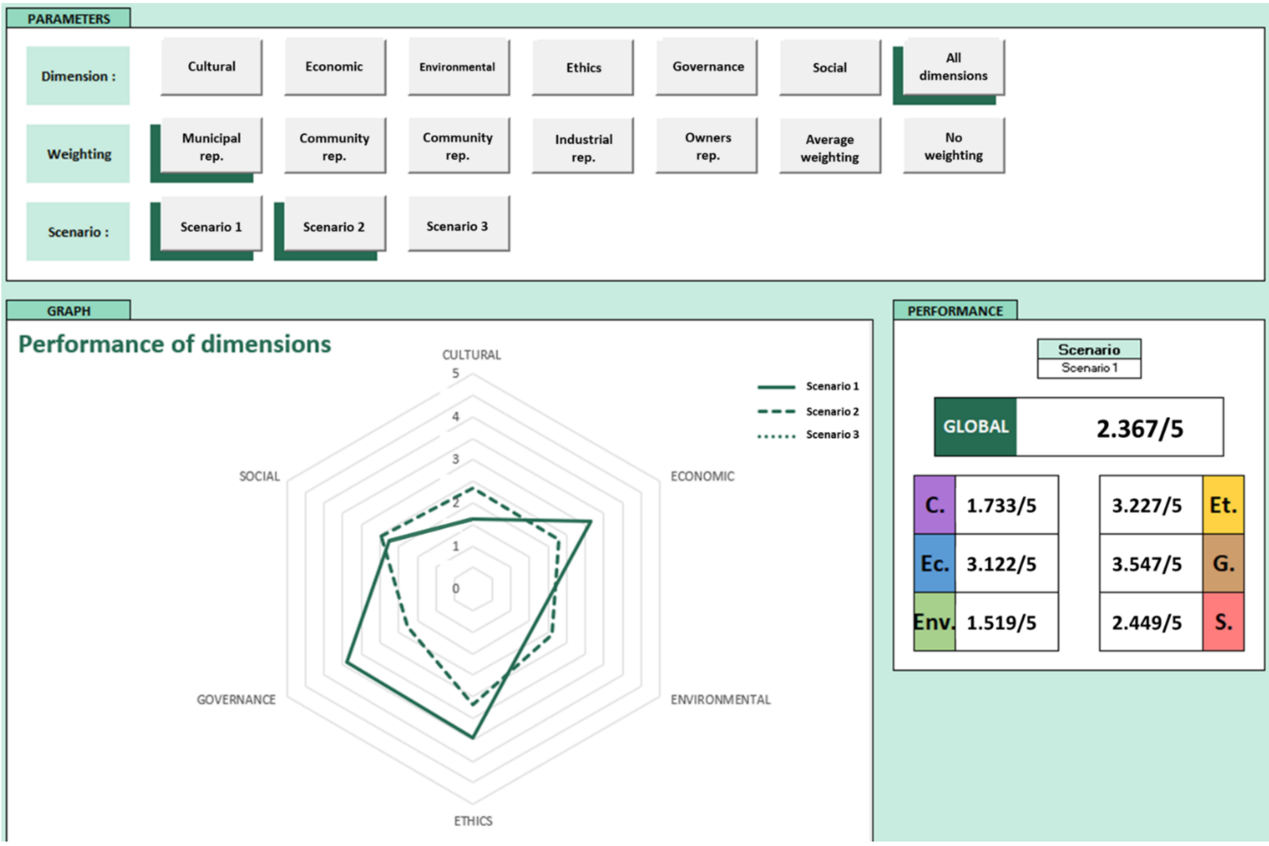


Figure 7. Screenshot of the tab of the tool that displays the performances of the dimensions for each scenario according to the prioritization chosen.

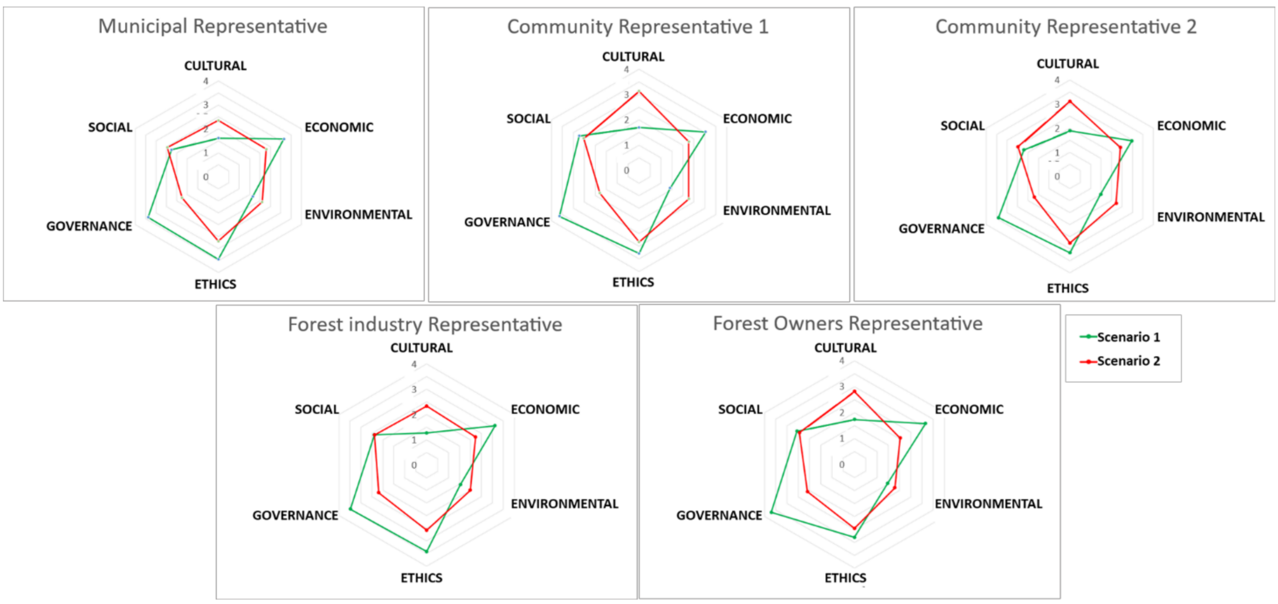


Figure 8. Comparison of the performance of scenarios 1 and 2 for the different dimensions according to the chosen weighting.

The method of evaluation of the indicators as well as the method of calculation of the performances, make it possible to ensure the differentiation of the scenarios and thus to accompany the decision makers in the decision-making.

Into the details of each dimension (Supplementary Materials Table S1), the performance of the themes for the different scenarios can be compared., In this case, the differentiation is clear for the cultural, economic, ethical and governance dimensions, with scenario 1 performing better on the last three, and scenario 2 performing better on the cultural dimension only. On the other hand, for the social dimension, the two scenarios are very close, and the best performing scenario depends on the theme considered. Similarly, for the environmental dimension, the performances of the two scenarios are intertwined and depend on the themes considered; nevertheless, it can be considered that scenario 2 performs better overall (as shown by the performance of the global dimension presented earlier in Figure 8).

Figure 9 results show that the choice of weighting has very little influence on the choice of the most suitable scenario. This aspect makes it easier for the decision maker to choose one scenario over another. However, stakeholders are involved in the decision-making process and it is up to the decision-maker to take into account the fears and ambitions that will have resulted from the information provided by the stakeholders.

The tool therefore allows assessing the performance of the scenarios by considering the six dimensions and the five stakeholders. This report can help stakeholders in their decision-making process, since it allows them evaluating a given scenario from the angle they wish, but it cannot justify the choice of one scenario over another, since each scenario has its advantages and disadvantages.

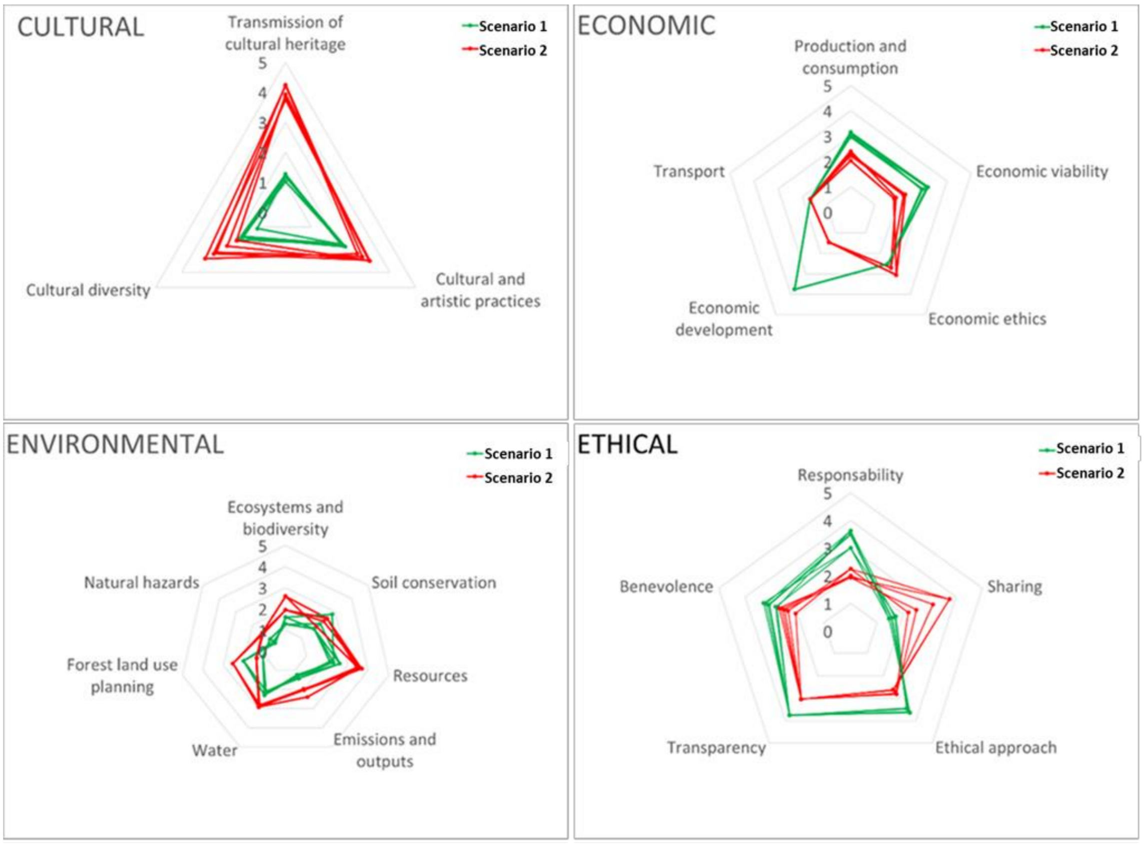


Figure 9. *Cont*.

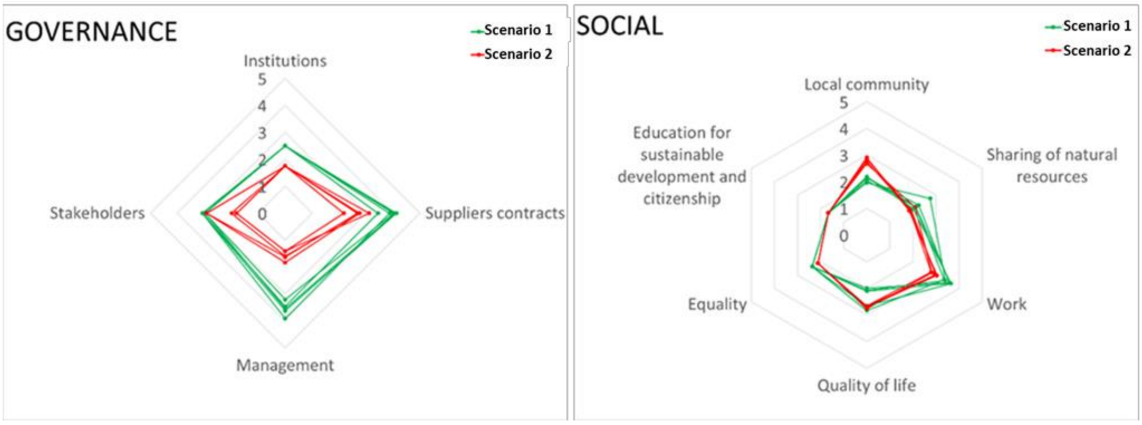


Figure 9. Comparison of the performance of scenarios 1 and 2 for the different themes according to the dimension considered. These results show that the tool allows a global, quick and efficient evaluation of the scenarios.

3.3. Strengths, Weaknesses and Mitigation Measures

The tool also proposes to list the strengths and weaknesses of each scenario. To this end, the user has to define a minimum performance from which the indicators can be considered as strong points, as well as a maximum performance below which the indicators will be considered as weak points.

This way, the number of strengths and weaknesses in each of the three scenarios can be displayed. In addition, the tool proposes to display these strengths and weaknesses for each of the scenarios so that the decision-maker can take note and use these indicators to improve the performance of the project scenarios. This analysis is independent of the choice of a weighting since the average of the scores given by stakeholders is considered to determine whether an indicator is a strong or weak point.

The choice of thresholds is arbitrary and left to the discretion of the user. Nevertheless, a display of the number of weak and strong points associated with the choice of thresholds is given in order to guide the decision maker to avoid considering too many indicators (Supplementary Materials Table S2).

The display of weaknesses is accompanied by the proposal of some mitigation measures to improve the performance of these indicators as part of a continuous improvement process for the project and its scenarios. Thus, the tool accompanies decision-makers beyond the assessment stage by helping them improving the projects to best meet the objectives and to increase social acceptability.

Moreover, this database of mitigation measures is an important source of additional knowledge. Indeed, it is possible for the user to add new mitigation measures to the tool as part of a participatory approach to improve forest bioenergy heating projects. Some mitigation measures from the literature are initially included in the tool, but the database is being developed and enriched with proposals from successive users.

The display of strengths and weaknesses is an important contribution of this tool, which is a notable difference from the other tools studied. Indeed, in addition to evaluating project performance, this display allows for continuous improvement of projects.

The tool also proposes the creation of an automatic report that can be loaded on a platform to offer a database that can be used for research projects interested in residual forest biomass heating projects in Quebec. This report contains all the data entered in the tool, including the technical characteristics of projects, pairwise comparisons of indicators by all stakeholders and the resulting weightings, the evaluation of indicators as well as the display of performance, strengths and weaknesses of the scenarios considered. This report can also be used by the user to present the results of the analysis.

3.4. Framework for the Use of the Tool and Method

The tool developed focuses specifically on the context of heating institutional and commercial buildings in the Canadian province of Quebec. The indicators that are analyzed are therefore adapted to this context. Nevertheless, although specific, this context is not unique in all its aspects, and it is possible to envision a wider use of the tool and the method used.

First, this tool can be used in all regions of the world where the boreal forest dominates, including, but not limited to, northern Europe and North America. This extension is possible with the adaptation of some specific indicators. However, the limited number of quantitative data required to complete the tool limits the number of modifications and adaptations to the local context. Moreover, it is possible to omit the evaluation of some irrelevant data without distorting the result of the analysis.

The tool is primarily intended for municipalities, regardless of their geographic locations, since the indicators used consider the municipalities' fields of action and levers. Although not all municipalities have the same competencies, the possible adaptations of the tool allow for widespread municipal use.

Furthermore, the method used in this tool is adaptable to many other contexts. It is characterized by the participation of stakeholders in the weighting and classification of indicators via the AHP, but also by the ability to propose a comparative analysis of forest biomass heating scenarios in the early planning stages of the project.

Further research should explore the importance of taking into consideration other biomass sources such as tertiary residues from construction, renovation and demolition activities. The potential of these residues is largely under-exploited and could become an opportunity in the bioenergy supply chain. Adaptations are also possible to extend the scale of use of the tool to other regions of the world with sufficient biomass potential for the creation of a new bioenergy value chain. These adaptations are consequential and require significant research work to ensure the relevance of the results obtained.

4. Conclusions

The work carried out has made it possible to develop a decision support tool that is innovative in its approach since it offers the possibility of integrating stakeholders into the decision-making process, ensuring a better social acceptability of the projects. The tool guarantees a comprehensive assessment of forest biomass heating projects, as early as the preliminary stages of project development, thanks to a relevant qualitative approach. The use of this tool by public and private decision makers will allow the development of more socially, economically and environmentally sustainable projects, as well as more organizationally and ethically viable projects.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su142013200/s1, Table S1: Stakeholders' indicators prioritization as displayed in the «Results» tab of the tool, Table S2: Relative differences greater than 100% in the case study with average weighting for reference, Table S3: Example of data associated with each indicator.

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References

1. International Energy Agency. *Renewables 2019-Analysis and Forecast to 2024*; International Energy Agency: Paris, France, 2019.
2. Gouvernement du Québec, Ministère de l'Energie et des Ressources naturelles. *Plan action de la politique énergétique 2030*; Bibliothèque et Archives nationales du Québec: Québec, QC, Canada, 2017.
3. Whitmore, J.; Pineau, P.-O. *Etat De L'Énergie Au Québec*; Chaire de gestion du secteur de l'énergie, HEC Montréal: Montréal, QC, Canada, 2020.
4. Asikainen, A.; Ikonen, T.; Routa, J. Challenges and opportunities of logistics and economics of forest biomass. In *Mobilisation of Forest Bioenergy in the Boreal and Temperate Biomes: Challenges, Opportunities and Case Studies*; Thiffault, E., Berndes, G., Junginger, M., Saddler, J., Smith, T., Eds.; Academic Press: Cambridge, MA, USA; Elsevier: Amsterdam, The Netherlands, 2016; pp. 68–83.
5. Bhuiyan, M.A.; Dincer, H.; Yuksel, S.; Mikhaylov, A.; Danish, M.S.S.; Pinter, G.; Uyeh, D.D.; Stepanova, D. Economic indicators and bioenergy supply in developed economies: QROF-DEMATEL and random forest models. *Energy Rep.* **2022**, *8*, 561–570. [CrossRef]
6. Arodudu, O.; Helming, K.; Wiggering, H.; Voinov, A. Towards a more holistic sustainability assessment framework for agro-bioenergy systems-A review. *Environ. Impact Assess. Rev.* **2017**, *62*, 61–75. [CrossRef]
7. Alidoosti, Z.; Ahmad, S.; Govindan, K.; Pishvaee, M.S.; Mostafaeipour, A.; Hossain, A.K. Social sustainability of treatment technologies for bioenergy generation from the municipal solid waste using best worst method. *J. Clean. Prod.* **2021**, *288*, 125592. [CrossRef]
8. Famoso, F.; Prestipino, M.; Brusca, S.; Galvagno, A. Designing sustainable bioenergy from residual biomass: Site allocation criteria and energy/exergy performance indicators. *Appl. Energy* **2020**, *274*, 115315. [CrossRef]
9. Abdel-Basset, M.; Gamal, A.; Chakrabortty, R.K.; Ryan, M. Development of a hybrid multi-criteria decision-making approach for sustainability evaluation of bioenergy production technologies: A case study. *J. Clean. Prod.* **2021**, *290*, 125805. [CrossRef]
10. Löfgren, S.; Stendahl, J.; Karltun, E. Critical biomass harvesting indicator for whole-tree extraction does not reflect the sensitivity of Swedish forest soils. *Ecol. Indic.* **2021**, *132*, 108310. [CrossRef]
11. Titus, B.D.; Brown, K.; Helmisaari, H.S.; Vanguelova, E.; Stupak, I.; Evans, A.; Clarke, N.; Guidi, C.; Bruckman, V.J.; Varnagiryte-Kabasinskiene, I.; et al. Sustainable forest biomass: A review of current residue harvesting guidelines. *Energy Sustain. Soc.* **2021**, *11*, 10. [CrossRef]
12. Mai-Moulin, T.; Fritsche, U.R.; Junginger, M. Charting global position and vision of stakeholders towards sustainable bioenergy. *Energy Sustain. Soc.* **2019**, *9*, 48. [CrossRef]
13. Scott, J.A.; Ho, W.; Dey, P.K. A review of multi-criteria decision-making methods for bioenergy systems. *Energy* **2012**, *42*, 146–156. [CrossRef]
14. European Forest Institute. ToSIA-Leading the Way to Sustainability. Available online: http://tosia.efi.int/ (accessed on 13 June 2022).
15. Zahraee, S.M.; Shiwakoti, N.; Stasinopoulos, P. Biomass supply chain environmental and socio-economic analysis: 40-Years comprehensive review of methods, decision issues, sustainability challenges, and the way forward. *Biomass Bioenergy* **2020**, *142*, 105777. [CrossRef]
16. Timonen, K.; Reinikainen, A.; Kurppa, S.; Riipi, I. Key Indicators and Social Acceptance for Bioenergy Production Potential as Part of the Green Economy Transition Process in Local Areas of Lapland. *Int. J. Environ. Res. Public Health* **2021**, *18*, 527. [CrossRef] [PubMed]
17. Ecostrat Natural Resources Canada. *Canadian Standards for Biomass Supply Chain Risk*; Ecostrat Inc.: Toronto, ON, Canada, 2019.
18. Bergeron, K.M.; Jébrak, M.; Yates, S.; Séguin, C.; Lehmann, V.; Le Meur, P.-Y.; Angers, P.; Durand, S.; Gendron, C. Mesurer l'acceptabilité sociale d'un projet minier: Essai de modélisation du risque social en contexte québécois. *VertigO* **2015**, *15*, 16737. [CrossRef]
19. Villeneuve, C.; Riffon, O.; Tremblay, D. *Comment Réaliser Une Analyse De Développement Durable? Guide D'utilisation De La GRILLE D'Analyse De Développement Durable*; Département des Sciences Fondamentales, Université du Québec à Chicoutimi: Saguenay, QC, Canada, 2016.
20. Thivierge, M.-N. *Développement D'Un Ensemble D'Indicateurs Pour L'Évaluation De La Durabilité Environnementale Des Fermes Québécoises En Grandes Cultures*; Université Laval: Quebec City, QC, Canada, 2011.
21. Dale, V.H.; Efroymson, R.A.; Kline, K.L.; Davitt, M.S. A framework for selecting indicators of bienergy sustainability. *Biofuels Bioprod. Biorefin.* **2015**, *9*, 435–446. [CrossRef]
22. Niemeijer, D.; de Groot, R.S. A conceptual framework for selecting environmental indicator sets. *Ecol. Indic.* **2008**, *8*, 14–25. [CrossRef]
23. Meyer, M.A.; Priess, J.A. Indicators of bioenergy-related certification schemes-An analysis of the quality and comprehensiveness for assessing local/regional environmental impacts. *Biomass Bioenergy* **2014**, *65*, 151–169. [CrossRef]
24. Singh, A.; Raj, P. Sustainable recycling model for municipal solid waste in Patna. *Energy Environ.* **2019**, *30*, 212–234. [CrossRef]
25. Cambridge dictionnary. Weighting. Available online: https://dictionary.cambridge.org/ (accessed on 13 June 2022).

26. Németh, B.; Molnar, A.; Bozoki, S.; Wijaya, K.; Inotai, A.; Jonathan, C.; Kalo, Z. Comparison of weighting methods used in multicriteria decision analysis frameworks in healthcare with focus on low- and middle-income countries. *J. Comp. Eff. Res.* **2019**, *8*, 195–204. [CrossRef] [PubMed]
27. Saaty, T. *The Analytic Hierarchy Process: Planning, Priority Setting, Resources Allocation*; Mcgraw-Hill: New York, NY, USA, 1980.
28. Saaty, T. How to make a decision: The Analytic Hierarchical Process (AHP). *Eur. J. Oper. Res.* **1990**, *48*, 9–26. [CrossRef]
29. Lindner, M.; Suominen, T.; Palosuo, T.; Garcia-Gonzalo, J.; Verweij, P.; Zudin, S.; Päivinen, R. ToSIA—A tool for sustainability impact assessment of forest-wood-chains. *Ecol. Model.* **2010**, *221*, 2197–2205. [CrossRef]
30. Werhahn-Mees, W.; Palosuo, T.; Garcia-Gonzalo, J.; Röser, D.; Lindner, M. Sustainability impact assessment of increasing resource use intensity in forest bioenergy production chains. *GCB Bioenergy* **2011**, *3*, 91–106. [CrossRef]
31. Locoh, A. *Calculs des éléments économiques d'un projet de chauffage à la biomasse. 2021: Working Paper*; Faculté des sciences du bois et de la forêt, Université Laval: Québec, QC, Canada, 2021.
32. Transition énergétique Québec. *Outil de suivi des projets financés dans le cadre du Programme biomasse forestière résiduelle (volet TEQ)*; Ministère de l'Énergie et des Ressources naturelles: Québec, QC, Canada, 2021.