An Objective-Subjective Dynamic Structure to Assist Decision Making: An Environmental Application

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ABSTRACT

Most decision making models deal with selecting an optimal alternative. Researchers have noticed the failure of these models in dealing with real-world problems. This suggests that existing models are not entirely adequate for the needs of decision makers, and there is a need for model structuring that considers behavioral aspects in an in-depth inquiry of the decision situation. Realizing these difficulties, new paradigms have been proposed. Researchers argue that some of the difficulties are due to conflicting objectives. However they still face the inherent difficulty of solving multi objective models. Several decision making methods focus on structuring although selection is still the end result and goal of a decision-making process. It is reiterated here that decision makers need assistance in attaining two further goals*:* ***COMPREHENSION*** of preferences and *GENERATION* of elusive alternatives. In other words, the goal is not to select an alternative but to comprehend and generate. To achieve it an "objective-subjective structure" is presented as the core of a process. Its main components are sets of alternatives, attributes and criteria. The process is about identifying these and establishing two relationships: an objective mapping from alternatives to attributes and a subjective mapping from attributes to criteria. These relationships imply a certain complexity inherent in decision making regarding the acquisition of information. The first mapping relates to information about the external world and the second to the decision maker's inner world. We apply these concepts to a private logging firm dealing with environmental issues. It became clear that the decision variables did not exhaust the full spectrum available; that the firm is not yet in a position to make "environmental decisions"; that there are other players; and that strategic decision variables exist. The firm has recognized that environmental issues impose strategic planning for the long term and that it is necessary to develop appropriate attributes to measure the criteria.

Keywords: Operations research, multi-criteria decision making, structuring, environmental issues.

1. INTRODUCTION

The common approach in Operations Research (OR) is to describe a system by a mathematical model, usually consisting of a number of constraints and an objective function. The goal of such models is rather technical - finding an optimal alternative from a list of usually explicit, many, sometimes infinite, alternatives. Alternatively,Decision theory (DT) deals in representing the preferences of the individual or the firm, by introducing utility functions to capture attitude toward risk and multi-objective trade-offs to accommodate the subjective preferences of decision makers (DMs).

Many researchers, notably [1], noticed the failure of these models, which he termed "hard systems", in dealing with real-world problems. According to Nutt [2], the failure rate for strategic decisions in general lies at about 50%, and the implementation rate for multi-criteria decision-making (MCDM) is even worse [3]. It suggests that existing decision models are not adequate for the needs of DMs, and practitioners and academics are calling for better decision problem structuring methods ([4] and [5] to name just two sources) that consider behavioral aspects of the situation and an in-depth inquiry of the decision situation.

Worse still, at least from a theoretical point of view, the rationality of common procedures for making decisions has been found to be inconsistent with human behavior. This persistent departure of DM's choice behavior from strict economic rationality was observed by [6] who termed it "bounded rationality", and has since been well tested [7, 8] and recognized as a lack or failure of

(standard) rationality. It seems that the gap between the descriptive approaches, which focus on how we actually *make* decisions, and the normative approaches, which consider how we *should make* decisions, is hard to bridge.

Realizing these difficulties, new decision paradigms have been proposed, among them soft systems methodology [1] and prospect theory [8]. MCDM, which evolved from OR, argues that some of these difficulties are due to conflicting objectives. While this is probably true, there remains the inherent difficulty of solving multi-criteria optimization models. Apart from the normative value function approach [9], many other methods, termed prescriptive, have been developed. Many of them do not have any theoretical foundation and only state, implicitly or explicitly, that the method "will" locate the "best" alternative. In fact, many of these methods may only justify and perpetuate what the decision-maker has in mind a-priori. Some of them have been demonstrated to be successful in responding to the desires of the DMs. Notable amoung them are goal programming [10], compromise programming [11] and [12], AHP [13] and decision aid [14]. Furthermore, Keeney [15], realizing the disadvantages of the normative approach, places it in the context of "value focused thinking" where values replace alternatives as the impetus for decision-making.

One can also observe that several decision-making approaches [14] and [15] focus not on the act of selection, but on structuring, though selection is still recognized as the end result and goal of a decision-making process. Finally, [16] raised the question of whether this indeed is the goal of the decision-making process at all.

In [16] it is argued that while selection models may be appropriate for solving simple problems, in real cases, DMs may need assistance in attaining two further goals: *comprehension of the preferences* and *generation of alternatives*. In other words, the goal of a decision-making process is not to select or rank alternatives but *to comprehend and generate*. These goals are not easy to attain and in the OR and MCDM literatures they are handled through modeling. Modeling, however, is considered as something a bit removed from the DM where the set of alternatives and objective functions are mathematically formulated in order to be solved.

To achieve these goals of comprehending and generating, this paper presents an "objective-subjective structure" as the core of a decision-making process. The process is outlined in the next section followed, in section 3, by a description of the embedded structure. Application of the process is demonstrated in section 4, followed by conclusions.

2. THE DECISION MAKING PROCESS

Any time one makes a non-instintive decision, he or she endures a decision making process. A formal process is rarely applied in personal life and not always in business decisions, but nevertheless humans apply, perhaps unconsciously, some sort of thinking process. Improving the process should be the desire of all. As expressed in [16]: "While decisionmakers are typically interested in achieving good outcomes, analysts (and academics) should be interested in ensuring that there exists a *good process* of decision making." The quality of the process can be judged vis-à-vis its goals, if they are achieved and how efficient it is done.

Interesting enough, there is no explicit discussion in the literature (at least not in that of OR and DT) of such goals, possibly because the goal is obvious. Technically, it is to solve the decision problem. More sophisticatedly, it is to achieve the DM's goals in resolving the decision problem. However, this is too general and entails nothing of the process. Perhaps this is the reason we do not use any formal method. After all, who else besides us knows what our goals are. Nevertheless, when one examines a method, the goals can be derived from the papers that present the method. Accordingly, one can verify that most of the methods end with ranking or selecting a "preferred" alternative. Even papers in DA, which assess preferences via utility functions, reflect the desires of the DM to select the "best" alternative. However, this should not necessarily be the goal of the analyst and scientist. Although the DM will usually approach his consultant with the question "what is the best decision," the duty of the analyst perhaps should be different.

In [16] the goals of the process are defined as comprehension of preferences and generation of alternatives. The goals are introduced there as postulates with no explanation (this is the meaning of postulates); however, a possible explanation is that by attaining these goals the DM will satisfy his or her preferences. Notice however that these preferences are not necessarily those interpreted by the DM. After all he can ask (taking it ad absurdum) the consultant to assist him in selecting an alternative randomly, or worse, to pinpoint a specific alternative as the best one. Paradoxically, it is the process that assists the DM to understand his preferences that will help him to attain the goal of satisfying his preferences. In this way the process overrules what the DM may think as his

preferences. Only by implying the process, the analyst and the DM can be sure, to some degree, that the preferences are at least understood. Before applying some unknown process he does not know yet what he wants. An alternative will be selected randomly if indeed this method of selection agrees with the preferences learned by the process.

But what about the selection of the best alternative? As should be clear by now selection is not, necessarily, part of the process. Ideally, after the preferences are understood and the set of alternatives is included the desired alternative will stand out from the rest. At most, a technical search algorithm could employed to find it.

3. THE OBJECTIVE-SUBJECTIVE STRUCTURE

The suggested structure is designed to attain the above-mentioned goals. There are possibly several ways to attain these goals, but the structure is obtained after careful analysis of the components of the process. Accordingly, the three main components of the structure are *alternatives*, *attributes* and *criteria*. A *criterion* is defined as the "raison d'etre of the firm" and an *attribute* as an "objective and measurable feature of the alternatives facing a criterion". The process is about identifying them and establishing the relations among them: *objective mapping from alternatives to attributes* and *subjective mapping from attributes to criteria*.

Each decision situation has its unique features but we can generalize and classify the essence of the difficulties in decision making as the absence of full and correct information on the structural components and the mappings. Thus, the decision process is firstly and mostly about acquiring information and using it, which reiterates Roy's [17] insightful description that decision making is about giving a meaning to knowledge. I.e., the process is about (how to get the right) information and to turn it through learning into knowledge.

This is not new. Early on, [18] in his well- known three-phase decision process of intelligence, design and choice, mentioned that intelligence involves some information-gathering activities. More recently, [19] states, "The vast amount of information that must be considered to solve inherently ill-structured and complex strategic problems creates a need for tools to help DMs recognize the complexity of this process and develop a rational model for strategy evaluation".

Information is endless and ill-defined so retrieving what is relevant and meaningful is, in our opinion, the problem of decision making (possibly "great" DMs are those who know how to do that).There are at least three sources of information:

- ? Objective: Knowledge shared by the external world.
- ? Subjective: Inner, concerning preferences;
- ? Mixed: Personal knowledge acquired by learning and experience.

The first relates to information about alternatives and attributes whereas the second relates to the DM's inner world of criteria. Frequently it is not easy to tell them apart as the source of the knowledge is obscured and an effort must be made to try to decode its source to ensure its objectivity, and if not, regard it as subjective.

The process is, therefore, about acquiring the relevant information and combining "soft" subjective beliefs with "hard" objective data in a meaningful way. The leitmotif of the process is the separation between what is objective and what is subjective information and knowledge. We believe that the objective – subjective structure assists in acquiring the right information.

This structure was successfully applied in [20] (winning the Wiley Prize in Applied Multi-Criteria Decision Analysis) and in the following section 4 application is demonstrated on a private forest firm having to deal with environmental issues.

4. AN ENVIRONMENTAL APPLICATION

OR models have been used for many years to plan forest harvesting (e.g. [21] and [22]). A recent publication set in Chile [23] demonstrates where optimization methods were used to plan activities in the firm "Sociedad Forestal Millalemu" who faced environmental constraints. This is in accordance with a recent shift in forest planning to include an explicit recognition of non-timber goals [24]. Accordingly, common MCDM methods were applied, e.g. [25]. In contrast to most of such related publications, our research is carried out for a private firm and not for a public organization, such as a government or regional planner. Another distinct difference is that our purpose was not to select or rank alternatives but to comprehend the preferences and to generate alternatives, which are not the explicit goals of MCDM methods, as mentioned earlier.

In [23] a non-interactive MCDM method was applied, which assessed the Pareto frontier. Environmental decision variables were introduced and the optimal activities for various levels of these variables were considered. More specifically, [23] suggested a linear programming model to calculate the trade-offs between profits and environmental variables. These trade-offs

give the loss in profits for various benefits in the environmental variables. For example, with no environmental constraints annual profit is $US 15,996,000. To have non-harvested strips alongside public roads, profit will decrease by $US64,000. However, it is not explained how, based on these trade-offs, the firm selects its preferred level of activities. Is there a clear and objective selection rule or will the trade-offs reflect the firm's subjective preferences? More fundamentally, do these trade-offs provide the CEO, the board of directors, or the owners with the appropriate information to make such decisions which can affect the firm for many years to come?

In appendix 1, the structure captures the relevant components of the forestry firm as described in [23], where one can identify four criteria and several sub-criteria. Four attributes, of which three measure environmental sub-criteria, were defined. Some sub-criteria, like wildlife protection, were not measured by any attribute. In the sequel, we modify this structure to correspond satisfactorily with the definitions of attributes and criteria.

According to [26], the decision process can start with examining any of the three components of the structure: alternatives, attributes, or criteria. Some of these components, mainly alternatives, were already described in [23] so we continued the process from there, trying to figure out what the criteria of the firm are. According to appendix 1, "environmental values and preservation of biodiversity" is a criterion besides "economic performance". Recalling that a criterion is related to the motive for the firm's existence, this is quite surprising knowing that being a private firm it would have meant that it has only one criterion: profit, "economic performance" or financial value. Usually this criterion is measured by one attribute, NPV – net present value. It means that any other criteria, except profit, should not affect decisions of the firm. Nevertheless, many firms do consider other objectives, notably environmental ones, in their decision making process, as reported by [24]. How can this be justified?

One possibility is that the owners of the firm or their representatives are personally concerned with the environment and use the firm as a tool to take care of that. But then they are not loyal to the "raison d'etre" of the firm, which is to maximize profit. They actually decrease profit as evident from [23]. Actions related to personal values (value is synonym to criterion as defined by [15]) of the environment should be funneled through personal channels. Indeed, our firm's CEO confirmed that, though he personally loves to travel in the forests and he favors preservation of nature, no personal motives should be involved in the firm's actions.

Another possibility is that environmental issues impose a criterion for the firm, similar to what is assumed implicitly in [23]. However, this is implausible unless the firm was established to protect the environment and this is not the case in our firm and, probably, not in any private forestry firm. We asked the CEO bluntly, why he should consider giving up any profit to have non-harvested strips alongside public roads. The response was that he has to consider such actions for the best of the firm, though the firm is not responsible directly to the scenery along the highways. In fact, objectives of the firm are in conflict with the public and the government that represents it.

Thus, if indeed the only criterion of the firm is profit then the only possibility for why environmental decisions are considered is that they actually affect the firm's profits, but are not criteria per se. The effect manifests in two forms: directly, when protecting the environment, the economical value of the firm in terms of quantity and quality of timber, not necessarily for the worst, and indirectly, by influencing legislation and the demand for the firm's products. Thus, what remains is to understand and relate the environmental variables to various attributes that measure these direct and indirect changes and to understand how they affect profits. In [23] only direct costs of preservation were considered, whereas the long-term benefits to the firm were not addressed. It can be justified by the difficulty of assessing these benefits. However, can a rational decision be taken without understanding the impact of these variables?

The CEO took part in this discussion concerning the criteria of the firm and acknowledged that his preferences, especially regarding protection of the environment, were then put in the right perspective and he was pleased not to be forced to determine trade-offs which were difficult for him. On the other hand, he argued that he was not completely happy with profit being the sole criterion of the firm and more sessions were needed to get the preferences established.

During the first session, we felt that the main source of the CEO's anxiety was the possible intervention of the government and other authorities in regulating forest management for the sake of environment preservation. Analysis of the government motives reveals that they are influenced by several organizations: foreign governments (specially the US) and organizations for protection of the environment ("Greens"). Actually, the Greens are organizations whose list of criteria includes

"integrity of ecosystems and preserve biodiversity" (Charter of the Global Greens, Canberra, 2001). Other motives are the wish of the government to protect communities near the forests from contaminating their resources and the preservation of the environment for the benefit of Chilean citizens and visitors. On the other hand, the government is well aware of the importance of the forest industry to the economic and social life of Chile and so, contrary to the Greens, their support in protection is not automatic, as was evident in the last global recession when the government relaxed the pressure on the timber industry.

In analyzing the power of foreign governments and the Greens it became clear that they not only can advocate legislation but may alter the demand for the firm‘s products, and, in the extreme case, even initiating consumer boycotts. The driver behind these organizations is public opinion, both foreign and local, which is increasingly concerned with the effects of industrialization on nature. It led us to recognize the importance of the image, both domestic and abroad, of the firm and the timber industry.

What emerged here was a major shift in the process: the firm is only one of the "players" in this "game" of preservation and there is a mutual influence between the organizations. Actually, the main reason for the process to take place is that there are other players in the forest. The firm has to understand first the strategies of these organizations before taking any action. Furthermore, as these organizations are sensitive to public opinion, it is clear that the firm’s image as a preserver of the environment is important.

Formally, we identified two sub-criteria that are related to profit: reactions of organizations and firm image. In trying to understand how these factors affect the firm's economical performance we realized that we were head on with an obstacle that other approaches tried to circumvent. It is clear that firm image and organizations' reactions are feeding each other but it is hard to understand their dynamic. They both may cause fluctuations and decrease of demand, decreasing value of the forest areas and increasing costs due to regulations, but, again, it is not easy to map the relations.

It became clear that a new dimension of decision variables was needed after revealing these sub criteria. Although this was postponed for a later stage of the process, it became clear when identifying decision variables relating to the influence of public image, both in Chile and abroad, learning and understanding the intentions of the organizations are only part of these new decision variables.

Above all, the process introduced a new factor, surprisingly not considered so far - uncertainty. That is, uncertainty in the behavior of the public and the organizations in respect to the actions of the firm. The CEO acknowledged that, indeed, this unconsciously bothered him all the time, and some of the actions he considered were in response to an unknown future. It became clear that an effort must be made to come to terms with uncertainty.

The potential intervention into the organizations became the turning point of the decision process. The CEO expressed his opinion that such intervention is not only related to economic performance, but also to the existence of the firm. Trying to understand the possible impact of an intervention and regulation, he realized that in the long-run the firm could be closed, either by law, as a polluter, or due to bankruptcy, as demand is halted and costs rise.

It seems now that environmental variables may affect the firm in a much broader sense than thought before. Indeed, it depends on how broad the criterion of profit is. In fact, different executives and stakeholders may understand "profit" in different ways. There are two major elements that are responsible for such differences: uncertainty and the timing of profits. Terms like "stability" and "survival" are among those used by firms to explain decisions that are not in accord with maximizing NPV. Those terms are intuitive and not well defined, which, as criteria, is not unusual. Generally speaking, stability is related to a steady stream of profits over time, which eases running the firm, and survival refers to the possibility that events like high losses or environmental catastrophes may lead to the fading of the firm. NPV does not capture these criteria and other attributes to assess them need to be found. It is worth mentioning that a firm can be compared to a human being who not only wishes a high level of income but also dislikes severe fluctuations that may risk his existence. The similarity is apparent because, after all, preferences of the firm reflect those of its owners and managers. This resembles a risk-averse attitude that is common in human beings.

In order to include these terms in the list of the firm criteria we term "welfare" as the overall criterion of the firm. Therefore, profit, stability and survival are possible criteria encapsulated within the overall criterion of welfare. Different stakeholders may aggregate them differently to attain maximum welfare

of the firm in accordance with their subjective preferences.

The sessions with the CEO became a kind of "strategic therapy" as he started to expose his fears relating the dangers the firm faces in the long run if it confronts the other organizations. Elaborating on stability and survival, he remarked that they are also related to the operational capabilities of managing the firm. Introducing new regulations can affect the morale of the workers and managers. Worse than that, they can feel detested by the public and in the worst case even attacked physically. In his words, "I can visualize the tomatoes thrown toward me entering our offices". People may not be willing to work for such a firm with such consequences for the firm's production. This discussion resulted in another sub criterion related to "worker's welfare".

At this point, we decided to end the sessions regarding comprehension of the preferences and to turn to the other more objective component of the structure: attributes and alternatives. The results of the above sessions are described in Appendix 2 as the subjective part of the structure.

5. CONCLUSION

Is our decision process, with the dynamic structure at its core, a good process? Is this process an easy task for the firm? The answer to the first question is straightforward. By building the structure, a real decision making activity took place. The firm understood the real effects of dealing with the environment. Understanding led the firm to making the right steps in order to advance its welfare. It is our opinion, and it was strengthened while working on the current situation, that comprehension of preferences includes not only assessing trade-offs, but mainly understanding and bringing into daylight the criteria of the firm. Indeed, in a relative short time the full subjective structure of the criteria was revealed to put the decision situation on the right track. It led, as was seen in the previous section, to the emergence of the right decision variables and to the beginning of formation of the right attributes.

The process is also educational. It exposed the owners and the managers to environmental issues. Until now, these issues were frightening and the firm was reacting blindly and perhaps in panic. The process put the issues in the right perspective.

The process also gave the CEO the ability to express himself. The process has not forced him to make unnecessary decisions but to express himself in a free way, using his words concerning preferences. It can be asked whether survival and stability are genuine criteria. Criterion is an elusive term and it reflects the elusiveness of preferences. Note that many researchers agree with [14] that preferences and values are not pre-existing. This led him to a new paradigm termed multicriterion decision aid (MCDA). Our paradigm shares this view and as such, these criteria merely reflect thoughts of the CEO. More importantly, it led to new decision variables.

The transparency of the process is important to convince government of the seriousness of the firm that environmental considerations are taken into account. Let everybody know that the firm is aware of the environment.

The answer to the second question is not simple. The process involves much more effort than just posing trade-offs to the firm. However, as the CEO feels that this process may advance the firm to the right decision, he was willingly cooperating. Making long-term decisions about the environment necessitates understanding well the issues and that is what the process suggests.

It is possible that the main shift of the analysis will be not to MCDM or MCDA procedures but rather to uncertainty analysis, as the effects on the firm's welfare are uncertain due to developments in technology, trends in public opinion and political influence, in Chile and abroad. Instead of being asked about trade-offs, the firm will be asked about forecasts concerning future developments. The motivation will be then to collect data and to consult experts about these developments. An important outcome of this is the expansion of the set of alternatives. New alternatives concerning technology, public opinion, and politics will be considered in addition to the standard decision variables of timing and quantities of harvesting. These include: alternatives for developing technology which do not harm the environment, facilities for water cleaning, constructing positive image, contribution to the Greens, and participating in preservation in other parts of the country.

Based on this application it seems that the goals of comprehension and generation were obtained although no measures were yet developed which can inform us to the extent these were attained. It is also clear that the process fits decision opportunities that are strategic in nature. The decision process then accompanies the application process through time. In this sense, the objective- subjective dynamic structure is updated

continually. It seems that in the first phase of the process comprehension of the preferences sums up to identifying criteria and sub-criteria. This led to the discovery of new decision variables.

We argue that conventional MCDM or DT methods may fail in our situation. These approaches would focus on tactical planning. However, such planning cannot be executed without first considering strategy. Furthermore, the decision making process cannot be separated from the implementation process as is evident from the short-term recommendations. The decision process must continue from within the firm with external consultation in decision-making, the environment, and public relations. It is a long process, perhaps endless, which must be flexible, informative, connected to the realities of the changing world, and attentive to the DMs' preferences.

There is a considerable difference between the process outlined here and the traditional MCDM approach. The last approach concentrates on trade-offs between profits and environmental variables, whereas our process is an inquiry into the relations between these issues and profit in its broadest meaning: welfare. Assessment of the trade-offs between profit and other criteria like stability and survival is postponed for later stages, if needed. Our process tries to push the boundary between objective knowledge and subjective preferences to where it belongs. Deciding on actions confronting trade-offs between profits and the various environmental attributes uses subjective preferences in the wrong place.

In commenting on the process that he endured, the CEO said that after all, the process followed what he termed "common sense." We believe that this is exactly what is needed in a high quality decision making process.

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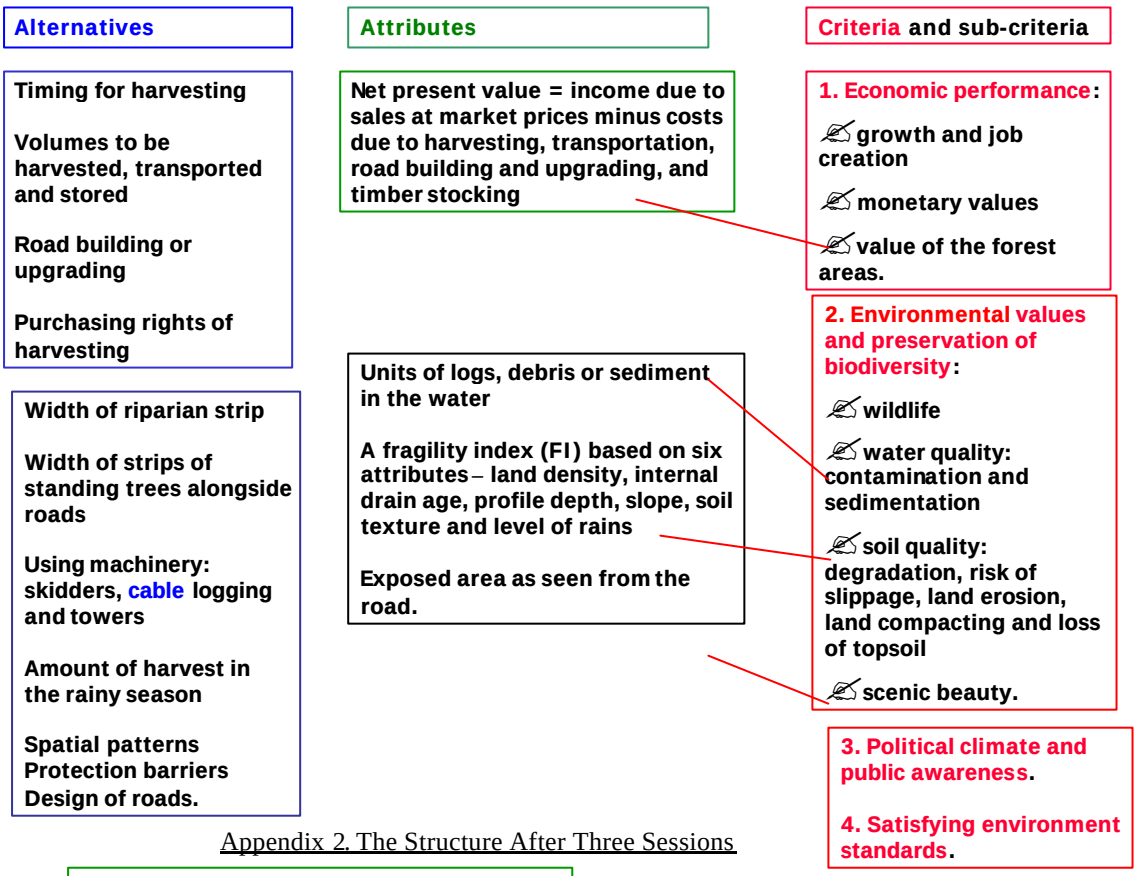
Appendix 1. The Objective-Subjective Structure according to [23]



Appendix 2. The Structure After Three Sessions