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Management of a rural estate using a multi-criteria tool to support decision making

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The global population increase associated with an increase in purchasing power has caused an increase in food demand greater than productivity. This global context has generated demand for scientific development in agriculture and the collection of practical results from experimental farms and research institutes. The objective of this study was to build a process, illustrated by a model, to support the management of an experimental farm by highlighting, organizing and measuring what, in the view of the manager, are the most relevant factors in management and performance; in this way, the aim was to expand its current performance and re-examine its goals and practices to move from the current state to the new design. This is a case study: the source of data collection was unstructured interviews with the experimental farm manager through which primary traits were identified. The methodological approach is classified as both qualitative and quantitative and the logic of the research is thus both inductive and deductive. The intervention instrument used was the multi-criteria decision aid - constructivist tool, which allowed us to identify, organize and measure operationally, tactically and strategically the aspects judged as necessary and sufficient by the key decision maker to monitor and improve the performance of the experimental farm in a transparent way that is scientifically substantiated. Although this work has contributed to the development of a model that takes into account variables such as infrastructure, results and restrictions in the workplace, the model presented only qualitative data. In this sense, for future work it is recommended the use of cardinal scales for the measurement, which allows quantifying the degree of compliance of the objectives outlined by the decision-maker in a localized and holistic way.

Key words: Management, experimental farm, means of production.

INTRODUCTION

Business organizations are generally continuously asked for results, both in the form of sustainability in the long term and economically in the short term. In addition to these demands, there are demands for experimental farms and agricultural research institutes to yield scientific results in the form of creative innovations, such as increases in productivity, but also in the form of disruptive innovations, such as the development of new

varieties and products. Thus, the management of experimental farms is challenged to improve the strategic, tactical, operational and academic outcomes. The strategic results concern sustainability and image, and social and environmental responsibility; the tactical results are associated with the dissemination of work processes and the bringing of more competitive products to the business community; operating results are related to the financial results and to the business and academic outcomes that result from teaching, research and extension (Meinke et al., 2001).

The management of experimental farms and conventional rural estates have certain variables in common, such as selection, training, coaching and people management, available area, input management, maintenance of machinery and implements, crop selection and marketing (Brozová et al., 2008), and soil nutrient depletion (Pendera et al., 2004); all these variables are controlled by the decisions of the managers. To ensure that decisions take into account all these variables simultaneously to achieve the sustainability and profitability of the property is the challenge of their managers.

Based on this, it is found that the management of an experimental farm involves multiple variables, many actors, conflicts between objectives, the management of scarce resources and on-going demands for improved performance; however, managers commonly have little knowledge of how to make decisions. This set of characteristics inherent in experimental farms makes the context complex (Ensslin et al., 2010).

Thus, the following research question emerges: What are the criteria for performance management and how should they be organized and measured in the process of managing an experimental farm? The overall objective of this work for this environment is to identify, organize and measure the criteria, judged by the manager in charge as critical for the success of the experimental farm, evidencing the current performance and goals of the farm in each criterion and how to use this model to support the process generating and monitoring strategic alternatives for improvement. By taking into account these considerations, the specific objectives of this work are: i) to describe the actors in the context and in particular the decision maker who determines key values and preferences; ii) to identify and organize the criteria that the decision maker considers necessary and sufficient to assess the management of the farm; iii) to construct ordinal scales to measure the criteria according to the perceptions of the decision maker; iv) to evidence the status quo of the experimental farm management to facilitate its monitoring.

MATERIALS AND METHODS

This article describes a case study in which a performance management process was built, illustrated by a customized model for the manager of an experimental farm located in Florianopolis, Santa Catarina. This experimental farm belongs to the Universidade Federal de Santa Catarina – UFSC. To develop such a model, the study employed the multi-criteria decision aid - constructivist (MCDA-C) method. The data comprise primary traits obtained directly at the study site with the decision-maker through unstructured interviews conducted with the experimental farm manager in May to November, 2011 and authenticated in March and April, 2012. In this work, it is understood as primary data those aspects considered necessary and sufficient for the experimental farm management, such as: Classroom, food quarters, laboratories, storage, shelter, support area road network (Figure 7). The methodological approach is classified as qualitative in terms of the identification of criteria and quantitative in terms of the building of ordinal scales to measure to what extent each objective is being achieved. The logic of the research is therefore inductive. Non-structured interviews progressed from an initial list of the decision maker on relevant aspects to the context for the use of cognitive maps that allow structuring the information into means-end forms.

RESULTS AND DISCUSSION

Construction of the MCDA-C model

The MCDA-C methodology has as its main purpose the expansion of the knowledge of the decision maker in relation to complex, conflicting and uncertain contexts. This methodology makes use of tools to structure information that might allow explicit understanding of the consequences of decisions for aspects that the decision maker considers relevant (Bortoluzzi et al., 2010, 2011a, b; Ensslin et al., 2010, 2012; Giffhorn et al., 2010; Grzebieluckas et al., 2011; Lacerda et al., 2010, 2011a, b; Moraes et al., 2010; Tasca et al., 2010; Vianna and Ensslin, 2011; Zamcopé et al., 2012). So, MCDA-C is characterized as essential in this research for allowing, in a structured and systematic way, the conditions required for the evolution of knowledge about the problem in question to identify those aspects considered as necessary and sufficient for the decision maker. The model was set up in an initial phase that identified the subsystem of actors and the ascribing of labels representing what is sought in terms of values and preferences. Further, the objectives judged by the decision maker as necessary and sufficient to evaluate the context in accordance with the actors' values and preferences were identified, organized and measured

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Table 1. Subsystem of actors.

Parameter	Description
Stakeholders	
Decision maker	Professor at the Centre for Agricultural Sciences (Centro de Ciências Agrárias), UFSC and supervisor of the farm
Speakers	Rector and Pro-Rectors Professors Director of the Centre for Agricultural Sciences Research students
Facilitators	Authors
Actors	Other students Farm staff Society

following a particular order (Bortoluzzi et al., 2011a; Ensslin et al., 2012; Grzebieluckas et al., 2011; Lacerda et al., 2011a; Moraes et al., 2010; Tasca et al., 2010; Vianna and Ensslin, 2011).

Context, subsystem of actors and labelling

The experimental farms are seen as the centre of creation, development and dissemination of innovations and knowledge in the field of agricultural production. To meet demand for their innovations and knowledge, the experimental farms promote teaching, research and extension activities, qualifying professionals for the labour market (Nagaoka et al., 2012). In consequence, the performance of the experimental farm management may have an impact on the training of scholars, the evaluation of courses and the image of the university in society. In this example, the supervisor has limited time for managing the farm, which complicates the management process. Moreover, because it is a public experimental area, the farm is subject to laws and regulations that restrict its operations. The manager is aware that he will be asked about his performance but has not had an instrument to support him in his management activities, leaving him in a vulnerable position. Based on these considerations, we identified the supervisor as the person with whom the decision aiding tool would be implemented, which actors had power to intervene in the process and those with an interest in the decisions to be taken. This group of involved actors is presented in Table 1. Later, we assigned a label that represented the major concerns of the decision maker to the decision context to be analysed. The label of the case study was defined as: support for the decision-making process of Ressacada Experimental Farm - UFSC.

Table 2. Five identified PAEs.

PAE	Description
1	Control experimental unit
2	Skilled operational labour
3	Days in the field
4	Excellence in teaching
5	Excellence in research

Primary evaluation elements, concepts and areas of concern

To obtain data relating to the value system, open interviews with the decision maker were recorded. His statements were analysed, allowing identification of the primary assessment elements (PAEss; Ensslin et al., 2001). These are the first aspects, references, actions, desires, goals and constraints of the problem externalized by the decision maker (Grzebieluckas et al., 2011; Keeney, 1992; Lacerda et al., 2011a; Moraes et al., 2010; Rosa et al., 2012; Tasca et al., 2010; Vianna and Ensslin, 2011; Zamcopé et al., 2012). By means of interviews with the decision maker, 127 PAEs were identified, of which five are presented in Table 2.

By starting with the PAEs, the MCDA-C methodology extends the knowledge of the decision maker with the construction of concepts. The concepts have both a preference pole (positive), which indicates the preferred direction of the decision maker, and an opposite psychological pole (negative), which concerns the (unwanted) consequence(s) of not achieving the objective underlying the preference pole. Table 3 presents the concepts for the first three PAEs, where the ellipsis (...) should be read as "instead of", representing the psychological opposite

Table 3. The First Three Concepts.

PAE	Concept
Control experimental unit	Being the control experimental unit ... Compromising those involved and failing to contribute to a good course evaluation
Skilled operational labour	Requiring and developing skills of operational labour ... Presenting poor work and compromising those involved
Days in the field	Ensuring opportunities for days in the field ... Missing the opportunity of revealing the farm to society

of the concept. The concepts that represent strategic concerns can be clustered in areas of concern. This brings together the first concepts that explain the values of the decision maker and the properties of the context taken into account when evaluating this area of concern (Bortoluzzi et al., 2010; Ensslin et al., 2000, 2012; Grzebieluckas et al., 2011;Lacerda et al., 2011a; Moraes et al., 2010; Vianna and Ensslin, 2011; Zamcopé et al., 2012).

The names given to the areas should be those that best reflect the main concern of the decision maker when expressing the concepts belonging to the group. It should be noted, however, that the concepts determine the name given to the area of concern (Bortoluzzi et al., 2011a; Ensslin et al., 2012; Lacerda et al., 2011b; Zamcopé et al., 2010).

Means-end maps and tree of fundamental points of view

The next step is the construction of maps of means-end relationships by using the concepts initially identified and grouped into categories for the model of fundamental points of view (FPVs). These maps detail the hierarchical relationships and influences between the concepts in terms of ways to discriminate the strategic objectives in terms of tactical and operational goals (Bana et al., 1999; Bortoluzzi et al., 2011b; Ensslin et al., 2000, 2010, 2012; Grzebieluckas et al., 2011; Lacerda et al., 2011a; Moraes et al., 2010). This process was repeated for each concept until the cause and effect relationships between them were identified. To facilitate analysis and understanding, the means-end maps are divided into clusters. The clusters are formed by grouping the branches for which the arguments reflect the same concerns of the decision maker. By investigating the branch, the decision maker follows a line of argument that leads to a particular means concept and thence to the goal expressed by the label of the problem. The name of each cluster is given in terms of the target focused on by the decision maker and expressed by the branches that compose it. Figures 1, 2 and 3 illustrate knowledge transfer from the means-end maps for “fixed” FPVs. This process yielded four clusters: i) full use of the infrastructure; ii) use conditions of the infrastructure; iii) full land use and iv) staff.

The “full use of infrastructure cluster” can be explained by the following sub-clusters: i) academic support infrastructure, ii) infrastructure logistics, and iii) the means of production infrastructure. The “use conditions of the infrastructure” cluster is explained by the sub-cluster maintenance. The “complete land use” cluster is explained by the sub-clusters i) design and ii) master design. The “staff” cluster is explained by the sub-clusters i) skills, ii) functions, and iii) update. The representation of the label, areas of concern and its respective FPV, is given the name hierarchical structure of value, as shown in Figure 4 for the model built for the study case. In the transition process of converting the Means-end maps into a hierarchical structure of value, each cluster is related to a point of view of the hierarchical structure of value as shown in Figure 4.

One concern to be considered is that the initial clusters should be tested to ensure that they represent aspects of the context in order to be essential, controllable, complete, measurable, operational, isolatable, not redundant, concise and understandable (Keeney, 1992; Ensslin et al., 2001, 2010).

Hierarchical structure of value and descriptors

The sub-clusters should follow the same properties as the first clusters and their initial transformation process is equivalent to that used for FPVs and these sub-criteria are called elementary points of view (EPV). This decomposition process continues until an EPV that represents a property of the context is attained and can be measured in an objective and unambiguous fashion (Ensslin et al., 2010). The hierarchical structure is shown in Figure 4.

The ordinal scales are constructed in an interactive process with the decision maker and should be those that best represent what the decision maker sees as relevant. In this process, one must identify the reference levels, or anchors: the “good level”, which represents the level

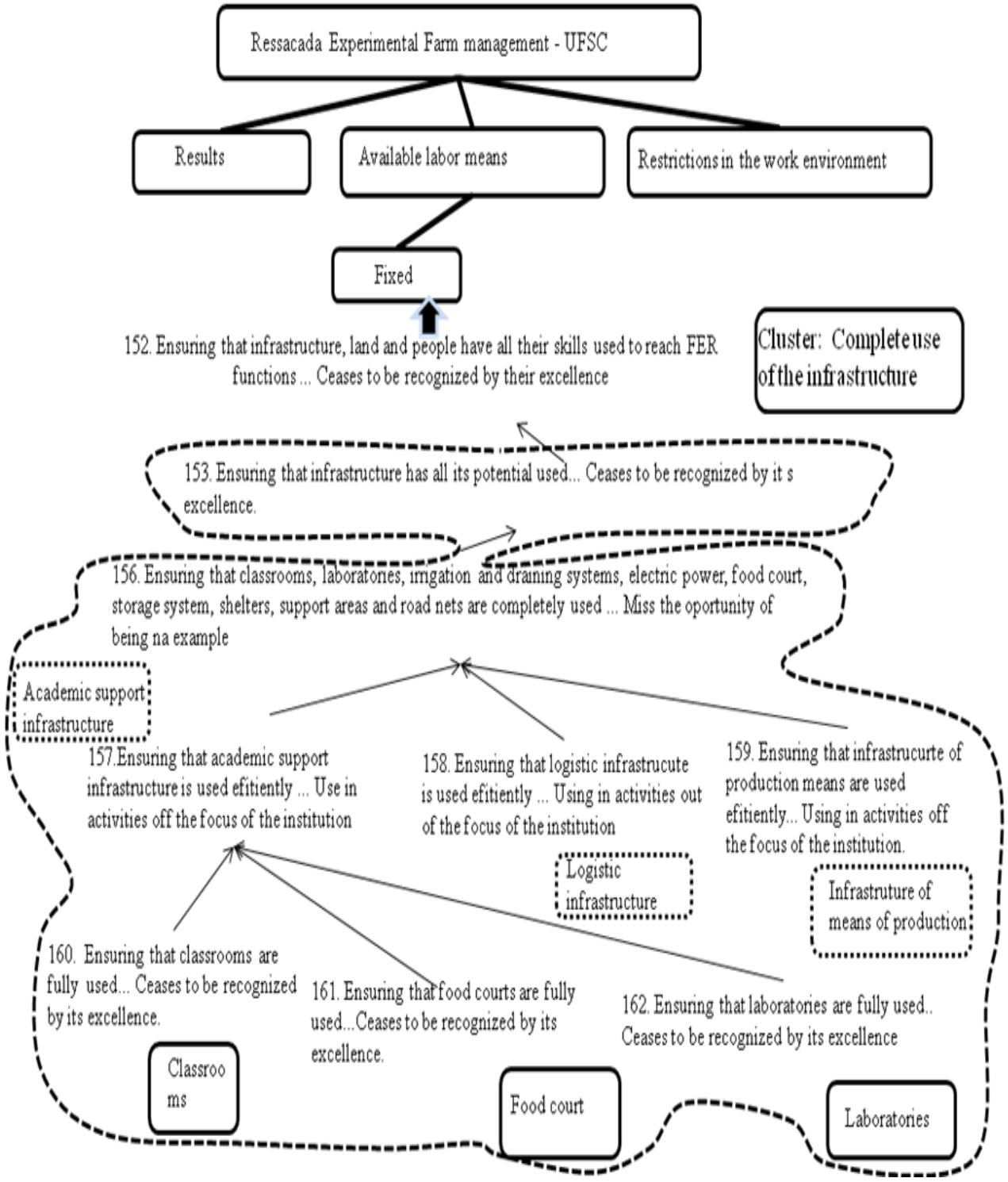

Figure 1. Means-end map for the “complete use of infrastructure cluster”

above which the decision maker judges the performance to be excellent, and the “neutral level”, below which performance is compromised. Between these two points, the performance represents challenges (Ensslin et al., 2010). Ordinal scales were constructed for the “fixed” EPVs and comprised 16 descriptors, which can be seen

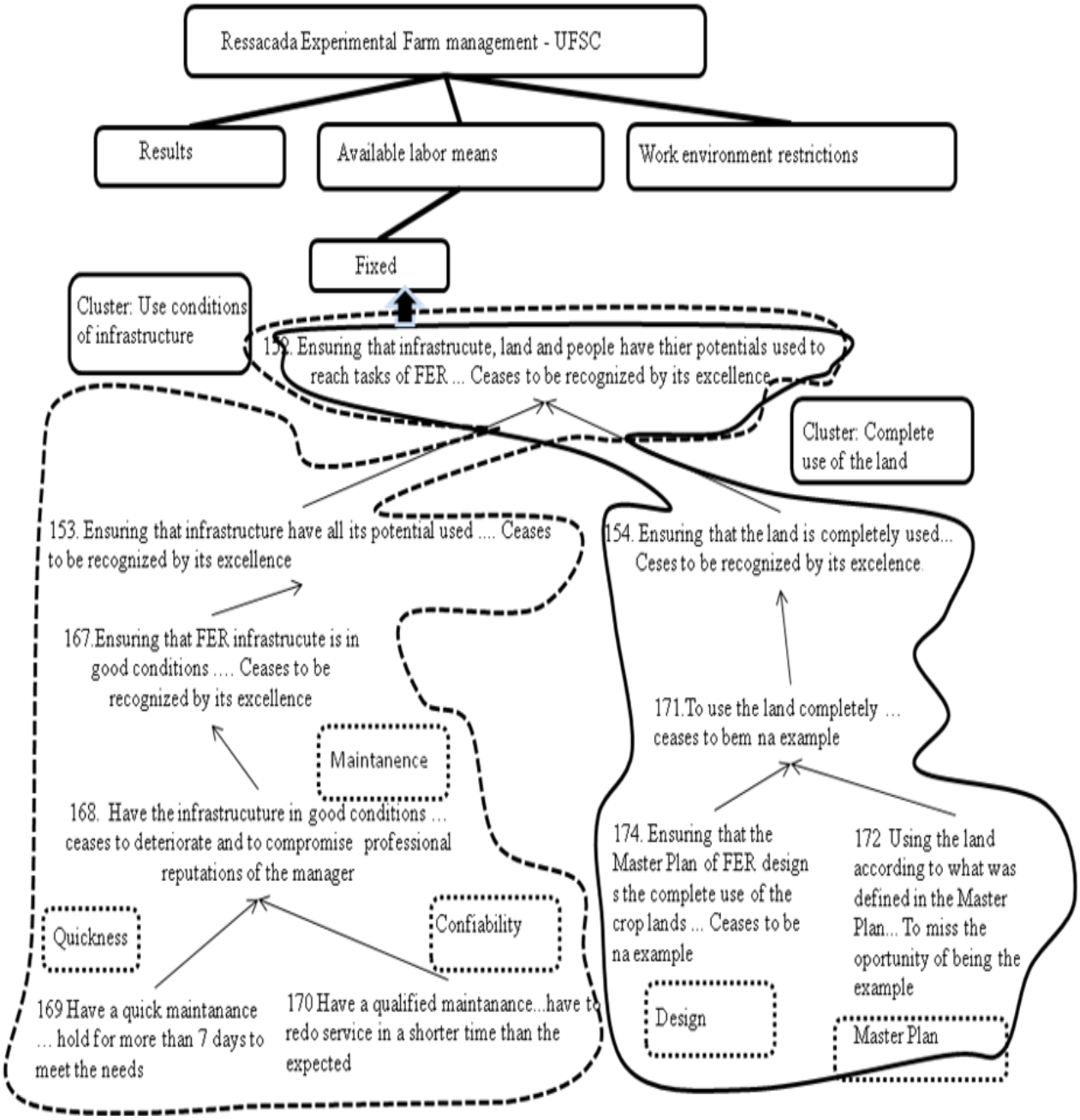

Figure 2. Means-end map for the “use conditions of the infrastructure” and “complete land use” clusters

in Figures 5, 6, 7 and 8. Good and neutral levels are displayed in these four figures for each descriptor of the EPV considered.

Depiction of the status quo of the experimental farm management for the FPVs considered

Upon completion of the construction phase of the descriptors, the MCDA-C methodology enables the ordinal profile of the current situation to be visualized in relation to each aspect considered relevant by the manager (Bortoluzzi et al., 2010). This profile represents the diagnosis of the current situation, presented concisely but completely according to the manager’s perceptions (Lacerda et al., 2010); this is aimed at enabling a monitoring function in the management task. Figures 5, 6, 7 and 8 illustrate the performance profile of the “fixed”

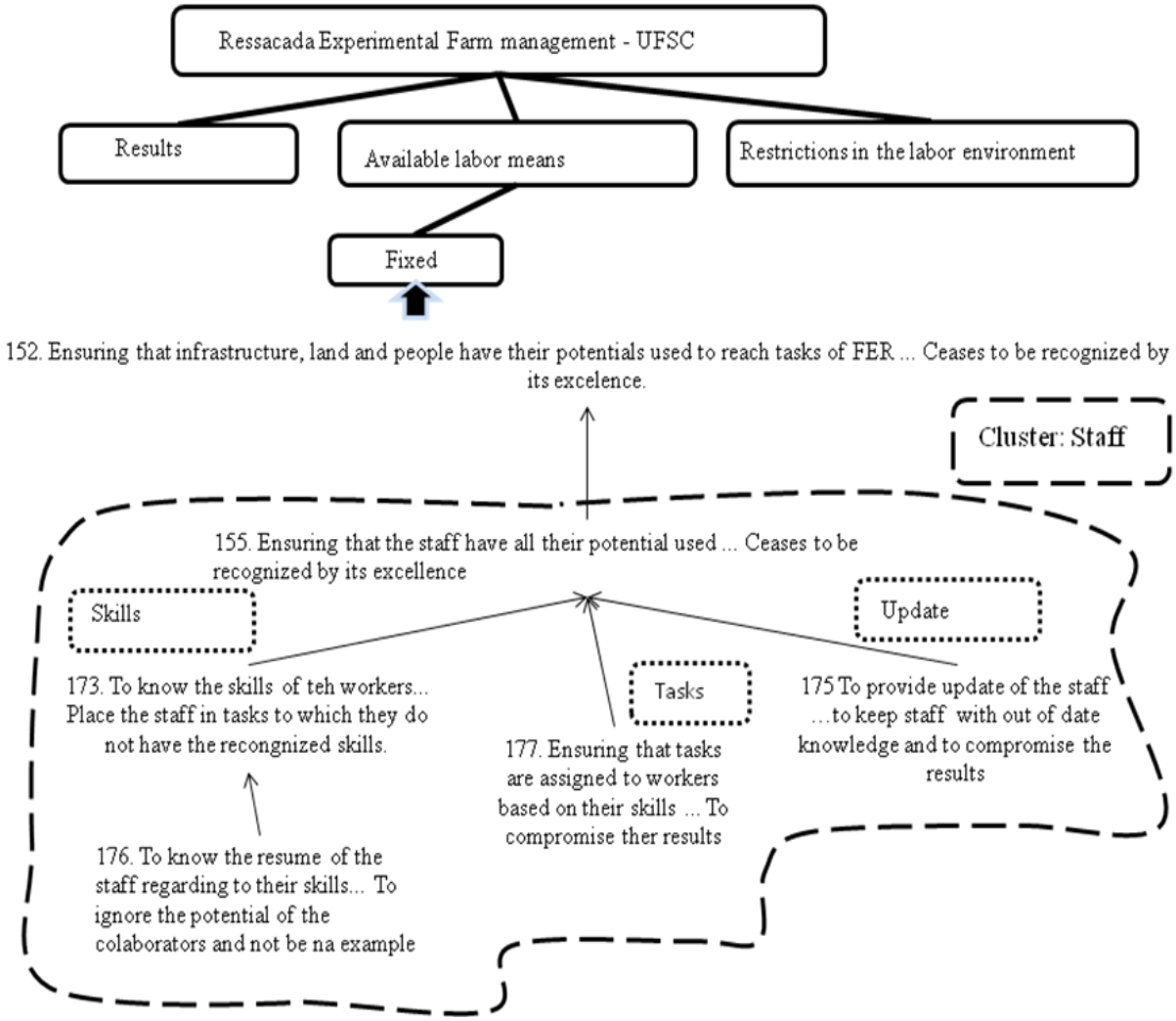

Figure 3. Means-end map for the “staff” cluster.

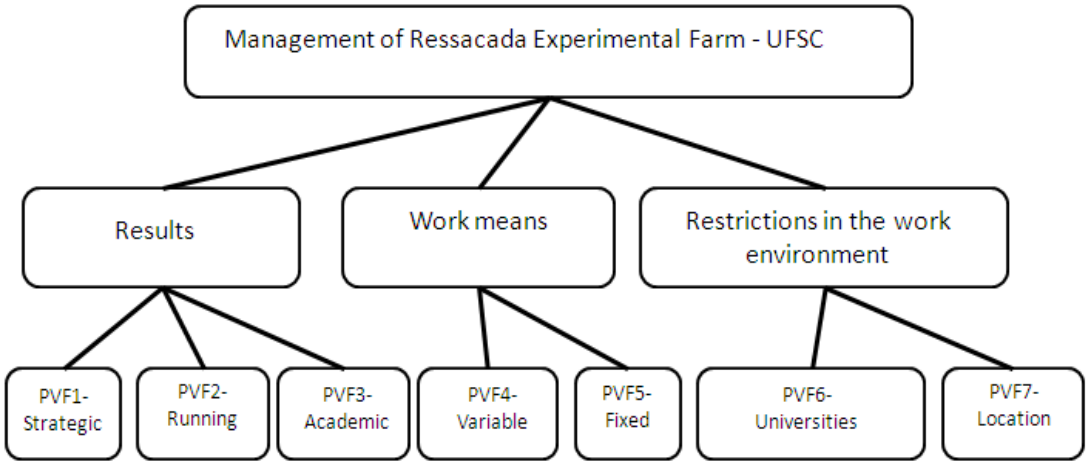

Figure 4. Hierarchical structure of value.

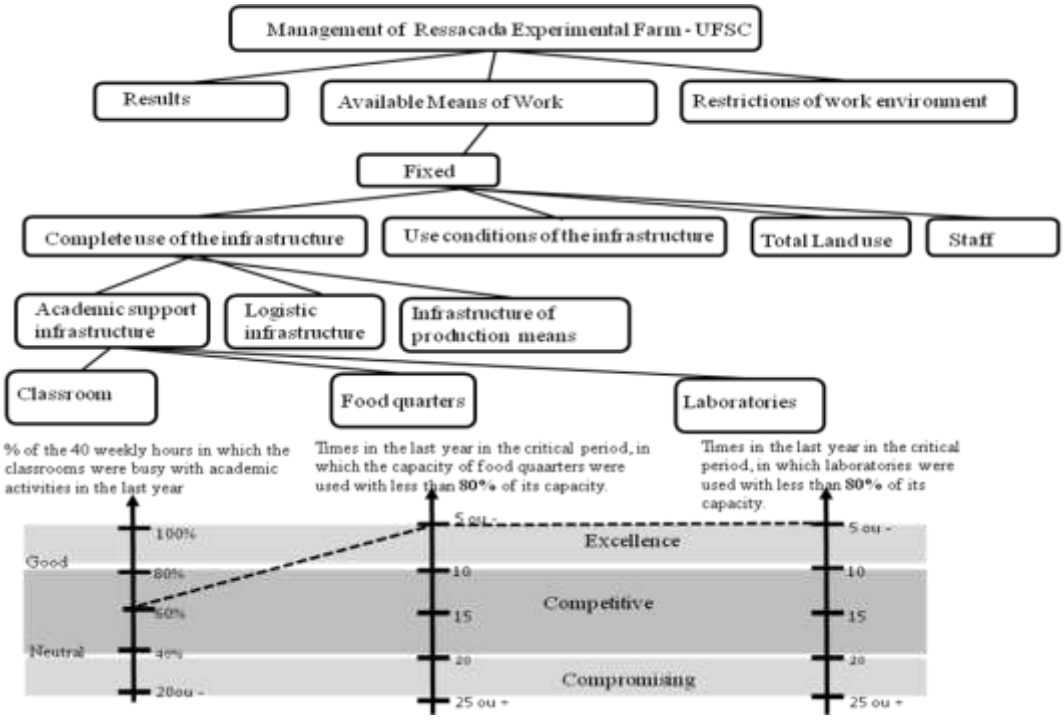

Figure 5. Profile of the status quo impact for FPVs for descriptors (1 to 3).

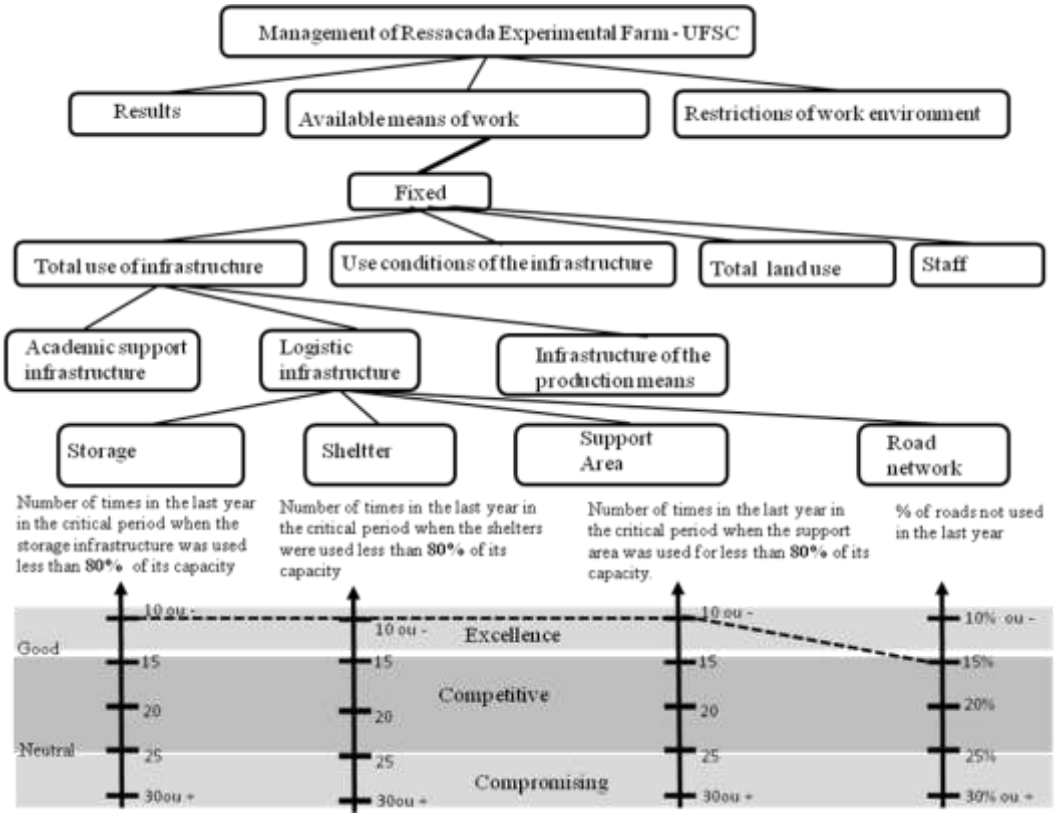

Figure 6. Profile of the status quo impact for fixed the FPVs for descriptors (4 to 7).

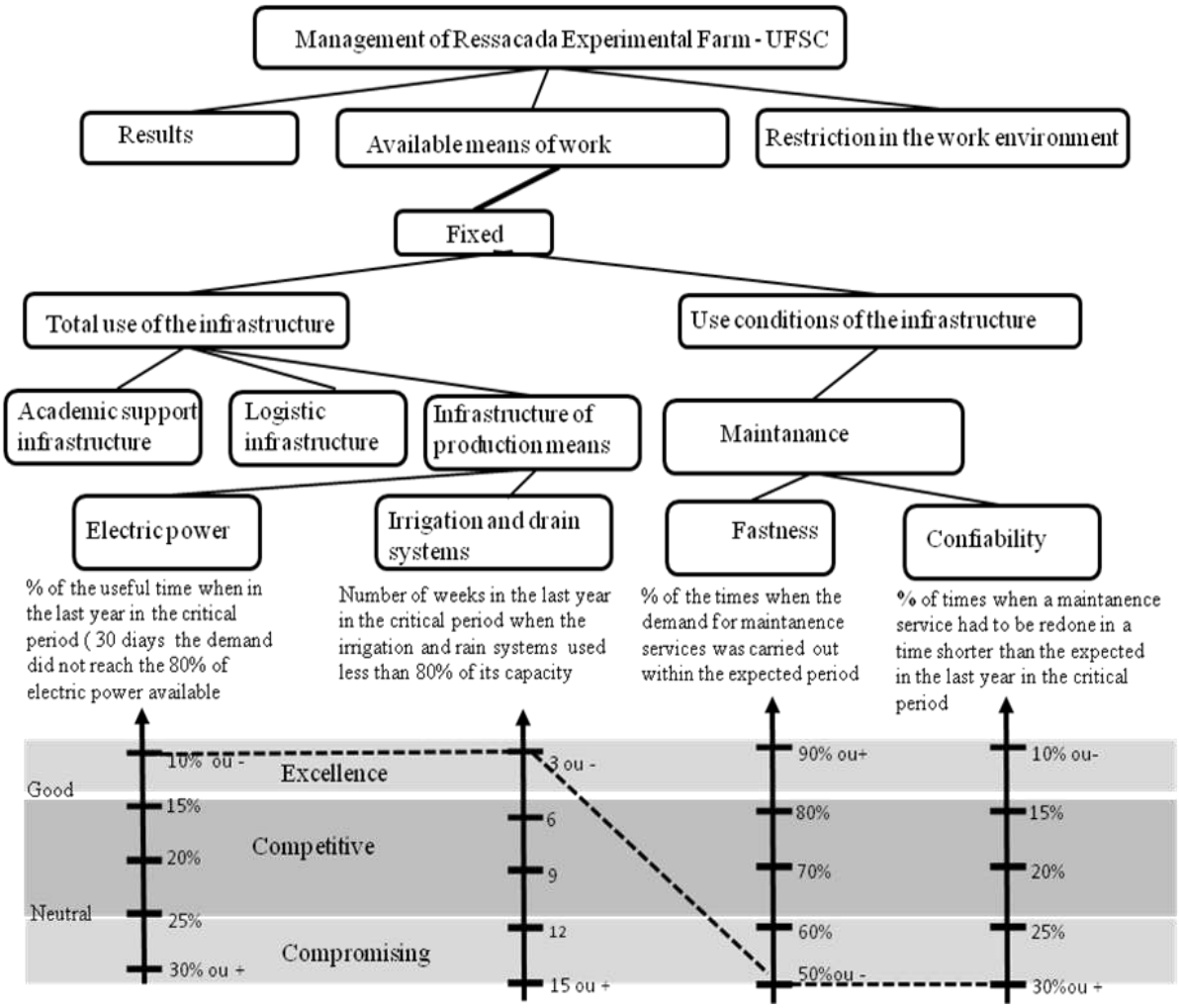

Figure 7. Profile of the status quo impact for the fixed FPVs for descriptors (7 to 10).

FPVs for the experimental farm analysed. We can see that the farm has excellent performance in relation to the following categories: feeding area, laboratories, storage, shelters, support area, electricity power, drainage and irrigation system, and updates. However, the classrooms and road networks present challenges in terms of performance and the others present compromised performance.

The model, built on the values and preferences of the decision maker, allows visualization of the impact of management on what the manager considers it necessary and sufficient to take into account, as shown in Figure 8. This understanding helps the decision maker to identify where the main competitive advantages and opportunities for improvements.

It should be noted that the scales constructed are simply semantic descriptions or alpha-numeric symbols (Barzilai 2001; Bortoluzzi et al., 2011a; Ensslin et al., 2001, 2012; Grzebieluckas et al., 2011; Lacerda et al., 2011a; Moraes et al., 2010; Tasca et al., 2010). Therefore, it would be wrong to use these scales for any function involving arithmetic operations (sums, means, etc.) since they are not numerical. The MCDA–C recognizes the differences between ordinal scales and cardinal and to accomplish the transformation between the two, the participation of the decision maker is again required to provide information concerning the differences in attractiveness among the levels of each scale. This activity can be performed using various methods, such as direct scores, bisection or the Macbeth approach, among others (Bortoluzzi et al., 2011b, Ensslin et al., 2001; Grzebieluckas et al., 2011; Lacerda et al., 2010; Vianna & Ensslin 2011; Zamcopé et al., 2010, 2012). However, discussing the process of transforming ordinal scales into cardinal scales is beyond the scope of this paper.

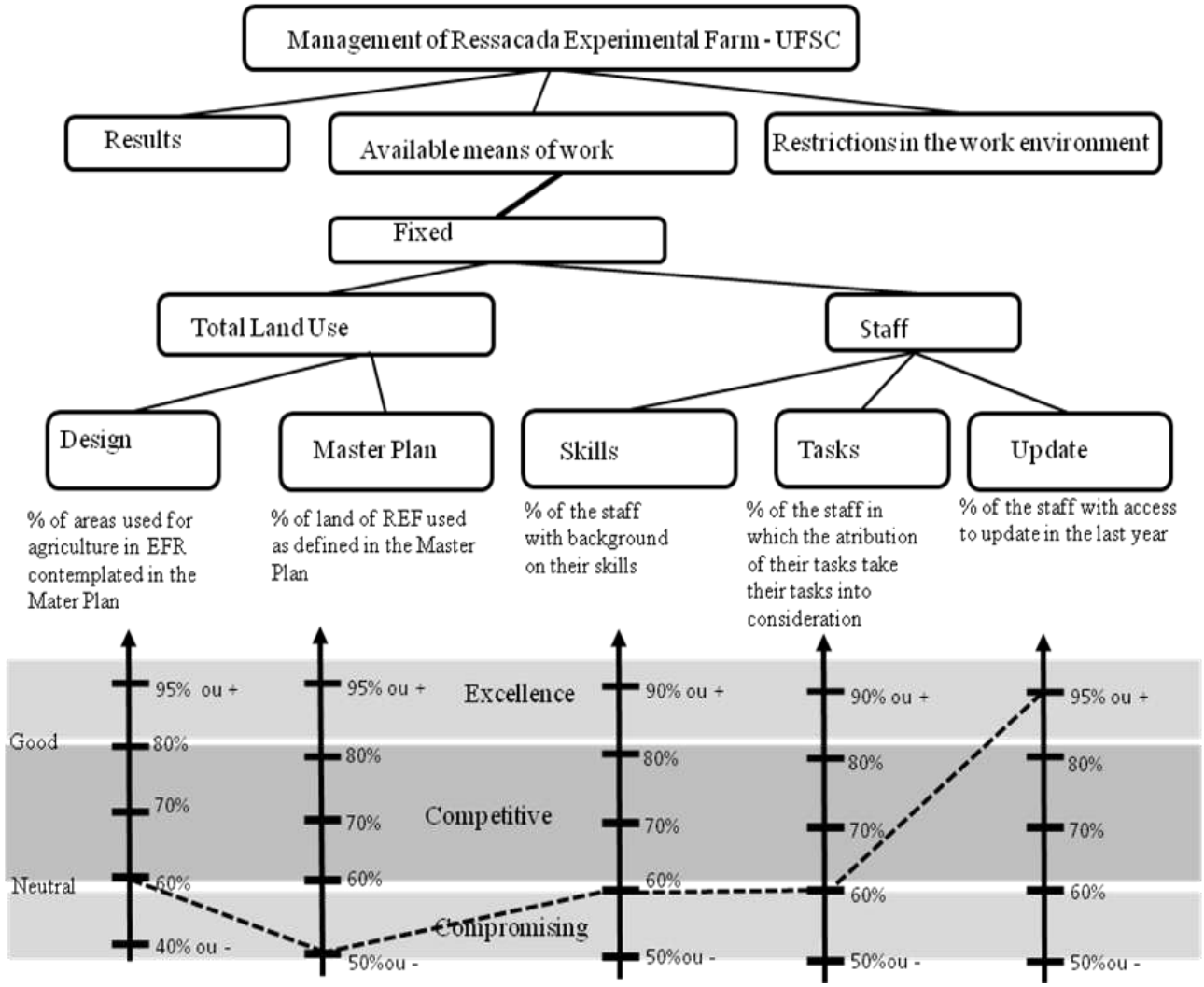

Figure 8. Profile of the status quo impact for the fixed FPVs for descriptors (11 to 15)

Conclusions

The objective of this study was to construct a process, illustrated by a model, to support the management of an experimental farm so as to highlight, organize and measure aspects of performance that, in the view of the manager, are the most relevant, then extending the current goals, practices and performance by moving from the current status to that designed. This is a study of a specific case. The data comprise primary traits obtained through unstructured interviews with the manager of the experimental farm. The intervention instrument employed was the multi-criteria decision aid - constructivist (MCDA-C) tool, which allowed us to identify, organize and measure the aspects judged necessary and sufficient by the decision maker to monitor and improve the performance of the experimental farm in a transparent and scientifically based fashion. The model constructed allowed the manager: i) to identify those aspects of performance necessary and sufficient to evaluate current management of performance and ii) to evidence current strengths and opportunities for improvement. Armed with this understanding, provided by the model constructed, the manager was provided with the necessary elements to seek alternatives to improve performance in those categories that present compromising performance, such as the master plan and the reliability plan.

This study was carried out in a real environment. The experimental farm is located in Florianopólis, Santa Catarina and belongs to the Universidade Federal de Santa Catarina - UFSC; it is used as an agricultural enterprise, school, and experimental and research centre. The research allowed the manager to explicate the management model to facilitate the setting of goals,

performance monitoring, and the formulation of alternatives to achieve the goals set.

The study began by contextualizing and describing the actors involved, as well as labelling the case study, thus fulfilling objective (i). As described in the following sections, the decision maker engaged in an interactive process with the facilitator to identify, organize and clarify those criteria that must be taken into account in the management ofperformance, namely: strategic, operational, academic, fixed, variable, university and location. Thus objective (ii) to identify the criteria that the decision maker considers necessary and sufficient to evaluate management - was met. This also answered the research question: What are the criteria to be considered in the management process of an experimental farm?

Figures 5, 6, 7 and 8 present the ordinal scales constructed and the status quo for these scales, meeting the specific objectives (iii) and (iv) for the FPVs considered “fixed”. Among the contributions of this work, the following stand out: i) the research has a practical aspect in terms of providing a model that illustrates, organizes and measures in an orderly manner those aspects considered by the decision maker to be necessary and sufficient for full compliance with all his or her duties as manager of the experimental farm; ii) the model allows the manager to justify his or her decisions to other stakeholders, based on specific values (accountability); iii) the model constrains the amount of information in terms of what is necessary and sufficient for management in the particular context. This process created the conditions for disseminating the practices and performance sought by the decision maker, how these are to be measured and the goals among all those involved in the experimental farm. Thus, they in turn can base their decisions specifically on the strategic options adopted.

The limitations of this and other such studies relate to the long-term nature of the process and also the level of participation required of the decision maker. Finally, it should be noted that although the model is customized - that is, the model represents the values and preferences of a specific decision maker – the process employed is generic and can be used by other managers.

Conflict of interests

The authors have not declared any conflict of interest

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