

Structuring the resource allocation in response natural disaster phase using the Value-Focused Thinking (VFT)

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Abstract - Many countries experiences every year several natural disasters or human catastrophes which takes thousands of millions souls. A lot of mechanisms to predict many kinds of these natural disasters have been developed in the attempt to minimize the amount of victims and it has reached such a successful level. However, even with all these predictive systems, natural disasters still happen and will continue to occur. After a disaster happened the response phase is the mainly way to save affected people. Many countries, organizations and other actors involved in this phase work alone without integration. This way, such phase becomes a difficult and expensive work. This paper aims to suggest a start point to structure and organize the response phase of a disaster, with a systematic application of the Problem Structuring Methods (PSM), focused in the resource allocation for victims rescue.

Keywords - problem structuring methods, natural disaster, resource allocation.

I. INTRODUCTION

According to the Centre for Research on the Epidemiology of Disasters (CRED), in the last five years our planet suffered 1.939 natural disasters, like floods, droughts, earthquakes etc. The total number of affected people reached almost nine hundred millions, between killed, injured and homeless, resulting in approximately US\$ 820 billion of material damages, observed in Table 1.

TABLE 1: EM-DAT: THE OFDA/CRED INTL DISASTER DATABASE
 SOURCE: ADAPTED FROM EMGY EVENTS DATABASE EM-DAT

Period	Disaster	Disasters	Killed	Injured	Affected	Homeless	Total affected	Total damage
2009/2013	Natural	1.939	398.246	1.026.546	891.411.731	6.086.486	898.524.763	\$816.781.617.000

Using the definition from International Federation of Red Cross and Red Crescent Societies[5] a disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. Though often caused by nature, disasters can have human origins. A disaster occurs when a hazard affects vulnerable people. The combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk results in disaster.

Such events, defined by Altay and Green (2006), consist of a disaster management cycle composed by four distinct phases: mitigation, preparation, response and recovery. The first and second phases are positioned before the occurrence of the disaster, while the response and recovery phases

happen after the occurrence. That disaster management cycle can be observed through Fig 1.



Fig 1: Disaster management cycle

This work deals with the response phase which begins after the disaster occurrence and have the objective of execute help and support actions to victims. The number of death and injured people can be reduced by a fast and more efficient rescue.

In many places and regions, it is observed the low or absence of capabilities to execute these fast and efficient actions. They have not even an efficient system of rescue and support. What exist is a lot of goodwill people, organizations or institutions trying to help, disorderly and singly, using excessive or not enough resources to provide an efficient service.

From this context, is possible to extract some characteristics from this problematic situation, because there is a complex problem with multiple actors, many uncertainty and even some conflicts of interest.

Such characteristics give a perfect environment for application of Problem Structuring Methods (PSM)

This paper contains 5 sections. The next section present a review of the PSM applied in response phase resource allocation problem. The section 3 gives an example of the application of such methodologies. In section 4 the expected result from previous section is presented and the paper is concluded at section 5.

II. THE PROBLEM STRUCTURING METHODS

According to [1] the problem structuring methods (PSMs) raises from the necessities of managers and researchers to face some new problems which could not be solved by the such existing quantitative OR methods, known as Hard OR.

The traditional or classical Operational Research (Hard OR) was an excellent way to solve well structured problems, in organizations or systems with a tight hierarchy and with a well defined and repetitive task generating reliable data and with a general consensus of priority [10]. Nevertheless, these traditional methods could not support problems that didn't have measurable units perform data or a well-defined problem, which constitutes some categories of decision problems involving politics, power and social demand of organizational life [1].

So, Soft OR school which can be characterized by the stipulations of the usage of the Systems Age Thinking principles for problem structuring, Hermeneutic-Phenomenology principles for the qualitative modeling and used for a organization or system where all the actors participate actively in the problem structuring and problem solving process [11], came to deal with the whole laid by the Hard OR.

PSMs can be conceptualized as a set of Soft OR approaches for a proper construction and resolution of a problematic situation [11]. [13] give some characteristics of these methods based on systems thinking, with primarily qualitative constructed models that may take account of several criteria without trade-offs for optimization and can be integrated with hard and soft data.

The general idea of the PSM is reach the most complete situational awareness about the problematic situation to capture and express it in some form (cognitive maps, rich pictures, casual maps, decision graphs etc). From this representation, the situation will be explored, using techniques/analyses to development of an enhanced understanding, to enable a shared language to be developed, and through using the representation(s) to act as transitional objects helping a group negotiate towards a set of improvements and actions to resolve the situation [1].

The problematic situations for which PSMs aim to provide analytic assistance are characterized by: multiple actors, differing perspectives, partially conflicting interests,

In 1996, under a Soft OR context, Ralph L. Keeney stated that the conventional way to solve a problem situation nowadays (decision making) focus on alternatives, which means that when facing a decision problem, it is natural to think first what are the alternatives to solve it and only after to think about our values to make the choice among these.

Decisions situations usually arises from others action: enemies, government, stakeholders, friends and anyone else; or by circumstances: recessions, opportunities and natural disasters. Faced with these decision problems and forced by the time pressure, we make the "best" choice among some that we have at hand. Such a situation is referred by [8] as *alternative-focused thinking* and is a reactive way to face the problem.

A proactive way to solve a problem situation is to think about values first because is it what matters in any situation. Only later, after define these values and find the "fundamental objectives", is supposed to think about

alternatives, which are means to achieve the objectives arisen from the values [6].

With these concepts in mind, Ralph L Keeney developed the Value-Focused Thinking (VFT) as a way to identify desirable decisions situations and then reap the benefits of this situation by solving them. The VFT make use of the individuals values and judgments to extract important types of objectives. After the statement of these objectives (strategic, fundamentals and means ones) it's possible to think about alternatives to achieve them.

Another important concept about VFT is that the hard thinking focused in values will bring up not only better alternatives but it will also guide to the identification of desirable decision situations which are known as *decision opportunities*.

Significant effort is allocated to articulating values. This articulation of values in decision situations comes before any other activities. The articulated values are explicitly used to identify decision opportunities and to create alternatives. With this concept in mind, the value-focused thinking help to create better decision situations with better alternatives, which should lead to better consequences.

[6] use some "steps" for structuring a problem where the first one is to identify objectives, using some techniques like think about objectives without limitations, thinking on a "Wish List". It's possible to make use of alternatives - asking about desirable and undesirable alternatives for a stated objective and it will become new source of objectives. Another way to identify an objective is to make use of consequences, where consequences that matters is quite easy to identify associated objectives. The Keeney complete list of techniques to use in identifying objectives can be viewed on Table 2.

The VFT make use of three different kinds of objectives, always focusing on values. They are the *strategic objective*, the *fundamental objective* and the *means objective*.

The objectives are not fixed concepts and they may change depending on which decision context it refers. The most "valuable" or the first principle of some person or organization in one specific context will be the *strategic objective*, the highest fundamental objective level, the one which will guide all of the others objectives.

The *fundamental objectives* are specifications of the immediately upper level fundamental objectives, and they are the end, the mission to be achieved.

To achieve the fundamental objectives, there are some means, ways or methods to do it, which are known as *means objectives*.

Almost all experts on decision making say that it is crucial list your objectives. But they are not specific about how to do it or how to use the objectives to guide your thinking. Value-focused thinking includes numerous procedures to assist in this way. First, several techniques help compile an initial list of objectives. Second, these objectives are categorized as means or ends objectives and logically structured. Third, several procedures assist in using the objectives to create alternatives. Fourth, the objectives are examined to identify worthwhile decision opportunities.

Identifying objectives. The most obvious way to identify objectives is to engage in a discussion of the decision situation. The process requires significant creativity and hard thinking, you begin by asking the decision maker, "What would you like to achieve in this situation?" The responses

provide a list of potential objectives and a basis for further probing.

TABLE 2: TECHNIQUES TO USE IN IDENTIFYING OBJECTIVES

<p>1. A wish list. What do you want? What do you value? What should you want?</p> <p>2. Alternatives. What is a perfect alternative, a terrible alternative, some reasonable alternative? What is good or bad about each?</p> <p>3. Problems and shortcomings. What is wrong or right with your organization? What needs fixing?</p> <p>4. Consequences. What has occurred that was good or bad? What might occur that you care about?</p> <p>5. Goals. Constraints and guidelines. What are your aspirations? What limitations are place upon you?</p> <p>6. Different perspectives. What would your competitor or your constituency be concerned about? At some time in the future, what would concern you?</p> <p>7. Strategic objectives. What are your ultimate objectives? What are your values that are absolutely fundamental?</p> <p>8. Generic objectives. What objectives do you have for your customers, your employees, your shareholders, yourself? What environmental, social, economic, or health and safety objectives are important?</p> <p>9. Structuring objectives. Follow means-ends relationships: why is that objective important, how can you achieve it? Use specification: what do you mean by this objective?</p> <p>10. Quantifying objectives. How would you measure achievement of this objective? Why is objective A three times as important as objective B?</p>

There are several techniques listed in Table 1 that stimulate the identification of possible objectives. These techniques provide redundant guidance for identifying objectives, but redundancy is not a shortcoming. It is much easier to recognize redundant objectives when they are explicitly listed than it is to identify missing objectives.

When asking an individual to express objectives, make it clear that what is needed is a list of objectives without ranking or priorities. To expand the list, you may ask, "If you had no limitations at all, what would your objectives be?" Similarly, you may ask what elements constitute the bottom line for the decision situation and for the decision maker.

Many words, such as tradeoffs, consequences, impacts, concerns, fair, and balance, should trigger questions to make implicit objectives explicit. If a decision maker says "Tradeoffs are necessary", ask tradeoffs between what and what. If a decision maker says "The consequences should be fair", ask fair to whom, and what is fair. If the decision maker (DM) seems to stop and think, ask what the thoughts are. Responses to these questions may lead to other queries as appropriate.

Often one begins to think hard about a decision situation only after some alternatives become apparent. Articulating the features that distinguish existing alternatives provides a basis for identifying some objectives. For example, in considering alternative sites for an airport, one feature that differentiates the alternatives might be the disruptions to citizens due to high noise levels. This suggests the obvious objective of minimizing disruption from noise. You might ask respondents to list desirable and undesirable features of alternatives and use these to stimulate thought about objectives.

To find fundamental objectives, it is suggested to make use of strategic objective carefully considering how alternatives in the current decision context may contribute to the strategic objectives. The response indicates potential fundamental objectives for the problem at hand.

The use of generic objectives different from strategic objective because refers to the concerns for ALL decision makers in a SINGLE decision situation or one decision context, where major categories of objectives concerns for example economics, health and safety, environmental impacts. Discussion about each category should lead to the development of specific objectives. (Strategic Objective = single DM for all situations).

After objectives identification, the second step should organize these objectives, making use of structuring objectives - after all objectives are defined, separate the fundamentals from de means objectives.

The WITI test (Why is this objective important in the decision context) is used to separate fundamentals and means objectives. If the answer is that the objective is one of the essential reasons for interest in the situation it is candidate for fundamental objective. Whereas the answer is important because of its implications for some other objective, it's a mean objective. Attempt to control the consequences in the identification of key objectives, which must be in the same decision context.

In a fundamental objectives hierarchy, the lower-level objective is a part of a higher-level objective. The higher-level objective is defined by the set of lower-level objectives directly under it in the hierarchy. This lower level objective should be mutually exclusive and collectively should provide an exhaustive characterization of the higher-level objective. There should be at least two (max 4) lower-level objectives connected to any higher-level objective.

Deciding what is important requires value judgments. Value judgments are required to construct fundamental objectives hierarchy. In a case of public problems the public's values, or value expressed by representatives (such as legislators or regulators), are those appropriate to construct the fundamental objectives hierarchy [6].

The means-ends objectives (means-ends network), on the other hand, may have a complex relationships (lower-levels may conduct to many others higher-levels, not only to its immediately upper-level above). "What would you like to achieve in this situation".

Deciding how to achieve a higher-level objective requires factual knowledge. Judgments about facts are required to construct means-ends networks. So in the upper case, individuals with expertise about technical or factual aspects of the decision situation are often much better qualified than the public or its representatives to construct the means-end objectives network [6].

It is also important the measure of the fundamental and means objectives to enhance the process and benefits of value-focused thinking. The measurements of their achievement can provide useful insights and clarify its meaning, and this may lead to the creation of desirable alternatives, maybe even an obvious "solution" to a problem.

[6] use the attribute concept meaning the degree to which an objective is achieved is measured. Like the objectives, the assignment of attributes to measure them always requires value judgments that can lead to important insights from value-focused thinking. He specifies three types of attributes, i.e., natural, constructed and proxy ones.

The natural attribute usually have a common and direct sense. If an objective is minimizing cost, the attribute "cost measured in dollars" is a natural attribute. The objective of minimize fatalities has the "number of fatalities" as a natural attribute.

A constructed attribute is the one developed specifically for a given decision context, which there is no natural attribute. Eventually, by the time and use, a constructed attribute may tend to take on the features of natural ones, i.e., Richter scale for earthquake magnitudes. Sometimes, it's very difficult to identify or find a natural or constructed attributes. In this case, will be needed the development of an indirect attribute, known as proxy attribute.

Another interesting approach from the Soft OR is the cognitive mapping (CM). It is a technique which explores individuals perspectives about a situation, extracting their world viewing and representing them on a map, which will help operational researchers working on a variety of different tasks. These tasks include; providing help with structuring messy or complex data for problem solving, assisting the interview process by increasing understanding and generating agendas, and managing large amounts of qualitative data from documents. Whilst Cognitive Mapping is often carried out with individuals on a one to one basis, it can be used with groups to support them in problem solving [12].

Cognitive Mapping is a technique used to structure, to analyze and make sense of accounts of problems. These accounts can be verbal - for example, presented at an interview, or documentary. Cognitive mapping can be used as a note-taking method during an interview with the problem owner and provides a useful interviewing device if used in this way. Alternatively, CM can be used to record transcript of interviews or other documentary data in a way that promotes analysis, questioning and understanding of data [12].

The technique is founded on George Kelley's theory of personal constructs (Kelly 1955). The theory suggests that we make sense of the world in order to predict how, all things being equal, the world will be in the future, and decide how we might act or intervene in order to achieve what we prefer within that words - a predict and control view of problem solving [12].

III. THE PSM AND THE RESOURCE ALLOCATION PROBLEM

The decision problem in this paper which will be analyzed is the natural disasters rescue victims resources allocation on its response phase. According to [6], the first step to structure a problem in the case of a problem decision is recognizing a decision problem. From the decision context we extract the strategic objective, which will provide

guidance to all decisions and decisions opportunities. An important part of the decision problem is the definition of the decision context, which is the response phase of a catastrophe.

Dealing with a problem of public interest, the adequate stakeholders to evaluate and create the fundamental objectives are the own public (or their representatives).

Here, we have some useful tools, like separated interviews to compound a congregate cognitive map or a workshop, enabling the discussion about the decision situation. To the present, the author conducted some separated interviews with different people, composed and validated a congregated cognitive mapping to illustrate the public opinion about the decision context values and fundamental objectives.

So, this step, which requires a group of public representatives, was concluded to specify values or objectives. As suggested by [6], a simple question may be used to initiate this process (identify objectives): "What would you like to achieve in this situation?" For our problem, the group easily agreed about the identification and specification of two values: 1. Save the maximum number of human lives; 2. Reduce to minimum the cost of the response phase. These values may be viewed as the fundamental objectives that are supposed to conduct to the accomplishment of the strategic objective.

The time of response is a fundamental task to save lives in the response phase. So, the same group, thinking about value number 1, designated as a fundamental objective, agreed about these others still fundamental objectives, which may also be viewed as betters "specifications" of the value number 1 and so on: 1.1. Maximize number of rescued victims and 1.2. Minimize rescue team fatalities. Exploring 1.1, they thought about: 1.1.1. Rescue injuries; 1.1.2 Rescue homeless (the ones which have conditions to move themselves) people and 1.1.3. Extraction of the deaths (to avoid epidemics). The number of alternatives may vary and depend on the creativity of the group.

Working on the fundamental objective number 2 (Reduce to minimum the cost of the response phase) the same way as did with number 1, we have 2.1 Optimize the resources allocation; and 2.2. Improve voluntary participation.

We can observe that when working with value-focused thinking, it is necessary to think about values. It means that, sometimes, we need to take a step back to take a look on the origins of the decision problem, to find out the true value that will guide our present objectives and alternatives, instead of go direct to the possible constrained-free alternatives we already know.

We may observe that the fundamental objectives are specifications from the immediately upper level objective, always with the strategic objective as the highest fundamental objective. These lower levels are important to clarify and even discover new others objectives.

For example, the fundamental objective number 2.1 (Optimize the resources allocation on response phase) was expanded as: 2.1.1. Minimize the rescue activities cost; and 2.1.2. Optimize the victims support cost. Table 3 lists some possible fundamental objectives for response phase resource allocation problem.

This step may continues until the group feel comfortable that all alternatives (or objectives) about the values of the

strategic decision context were exposed, covering all the fundamental objectives for this specific decision context.

TABLE 3: FUNDAMENTAL OBJECTIVES HIERARCHY FOR RESPONSE PHASE RESOURCE ALLOCATION

1.	Save the maximum number of human lives.
1.1.	Maximize number of rescued victims.
1.1.1.	Rescue injuries
1.1.2.	Rescue homeless
1.1.3.	Extraction of the deaths
1.2.	Minimize rescue team fatalities.
2.	Reduce to minimum the cost of the response phase.
2.1.	Optimize the resources allocation.
2.1.1.	Minimize the rescue activities cost.
2.1.1.1.	Maximize victims search system
2.1.1.1.1.	Minimize information speed
2.1.1.1.2.	Maximize victims search speed
2.1.1.1.3.	Maximize victims search speed
2.1.1.2.	Minimize victims rescue system costs
2.1.1.2.1.	Minimize rescue units allocation speed
2.1.1.2.2.	Maximize rescue units allocation efficiency
2.1.1.2.2.1.	Maximize rescue units availability
2.1.1.2.2.2.	Minimize rescue units routing time
2.1.1.2.2.3.	Minimize rescue units routing distance
2.1.1.2.2.4.	Maximize the number of victims rescued/rescue units
2.1.2.	Optimize the victims support cost.
2.2.	Improve voluntary participation.

The process of structuring objectives results in a deeper and more accurate understanding of what one should care about in the decision context. It also helps to clarify the decision context and to define the set of fundamental objectives. This leads to clearer distinction between fundamental and the means objectives.

Structured objectives provide the basis for any use of quantitative modeling. The fundamental objectives hierarchy indicates the set of objectives over which attributes should be defined.

An example of the fundamental objectives hierarchy may be seen in Fig 2.

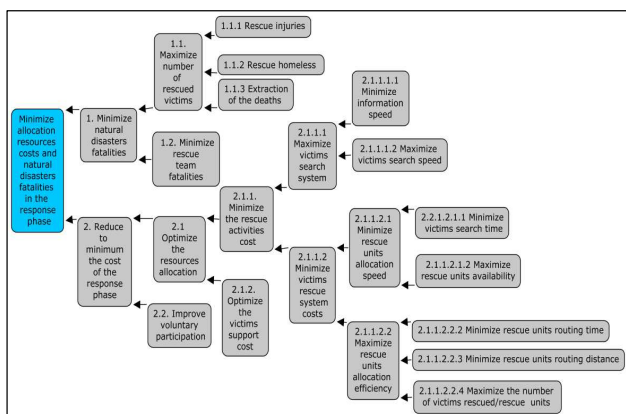


Fig 2. Fundamental Objectives Hierarchy

With the fundamental objectives in hands, a second group must be formed to deal with the means objectives. It's supposed to join the best and more experienced individuals, from all stakeholders involved, with expertise

about technical or factual aspects in the decision context. Members from fireman, police, rescue-teams, army, navy, air force and any other organization or institution with active participation in the specific decision context. It should have pilots, medics, rescuers, investigators, guards among others.

Each fundamental objective should be exposed at one time. The facilitator should explain the objective of the meeting and stimulate the group to think with no limit and no constraints, to enable the largest number of creative ideas. All the alternatives indicated by the individuals for each objective should be collected to form the means-ends objectives networks.

As an example of this step, we could begin putting in debate the first fundamental objectives, from Fig.2, asking "how do we minimize natural disaster fatalities in a response phase of a catastrophe?". The alternatives will come, like: a) It's desirable a very fast execution of the rescue; b) It must be allocated the maximum number of rescue-teams/units; c) It must be allocated a safe and adequate place to receive the deaths, injuries and homeless.

All new alternatives should be explored, forming lower-levels means objectives through the question of "how do we...?". For example, following the alternative "a)", "how do we execute a very fast rescue?". The answers should come like a.1) we must have a very efficient system to activate and designate the rescue-units when it's needed; a.2) we must to have an always ready rescue-unit to be designated; a.3) minimize de rescue units routing time and so on.

Exploring "a.1)", how do we make a very efficient system to activate and designate the rescue-units? we may have: a.1.1) having a command and control center; a.1.2) having an algorithm (software) to support the decision about what unit-rescue will be designated to what; and so on. This step is observed in Fig 3.

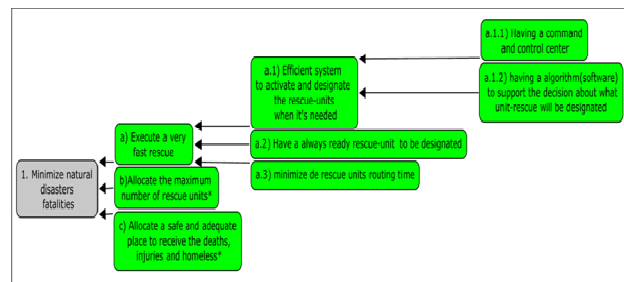


Fig 3. Means-ends Objectives Network

With these examples, we already have a well structured problem, well defined fundamental objectives and means objectives which will guide how to achieve the formers.

Fig 4 shows the relationships between several objectives hierarchies and an objectives network for the natural disaster response phase resource allocation problem.

The application of Value-Focused Thinking (VFT) enable the use of quantitative techniques (use of attributes and quantifying objectives with a value model) which will contribute to clarify the objectives already expressed by the previous qualitative ones. As for a while our paper's purpose deal only with the problem structuring and we are focusing the Soft OR. We stop at this point with the reached objective of structuring a complex problem with multiple actors, differing perspectives, partially conflicting interests, significant intangibles, perplexing uncertainties [10].

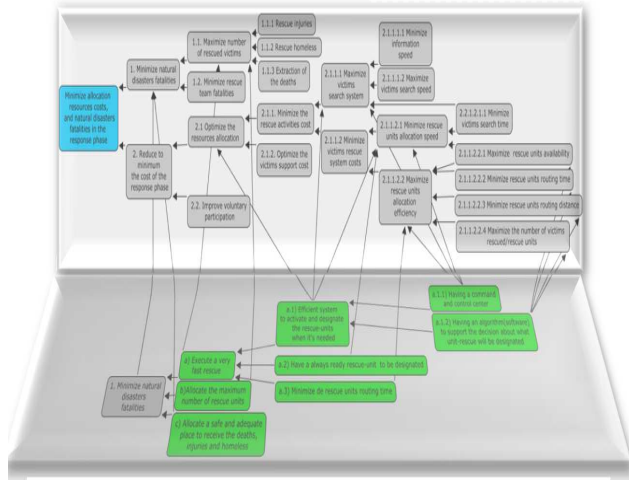


Fig 4 Relationships between objectives hierarchies and a objectives network for the natural disaster response phase resource allocation problem.

IV. EXPECTED RESULTS

As said before, this paper aims to suggest a way to structure such a complex problem like a disaster response phase resource allocation using the value-focused thinking (VFT).

It's expected to provide a guideline or a starting point to interested organizations, institutions or anyone whose work with natural disasters management to improve, review or begin to planning, organize or structuring a system or a command and control center for crisis management.

Obviously, we wish to support the decision-maker to take a fast and effectiveness decision to minimize the number of victims from a natural disaster enabling the improvement of the rescue services and giving more safety for the population.

IV. CONCLUSIONS

The PSM arose to support and try to solve some kind of problematic situation where the traditional or Hard OR couldn't be applied. This problematic situation, also known as a "messy", is usually characterized by the presence of a complex problem, with multiple actors, eventual interest conflict, significant intangibles and uncertainties.

The solutions provided by the PSM usually refer to the clarification, identification or characterization of a problematic situation.

Such a methods from the Soft OR (PSM) focuses the problem structuring and to find and define objectives. It's possible and recommends the use of not only one, but several methods, methodologies, tools and/or techniques of PSM in some situations. For any particular complex problem, which is supposed to contain many stakeholders and uncertainty, there is likely to have a dynamic system composed of many small systems (problems) in a big decision context. Each of these small "pieces" will maybe require some specific method, methodology, tools and/or technique of the PSM.

Thereafter, with these objectives in hand, we can apply some Hard OR to find any best local solutions to achieve some of these objectives. This mixture of Soft-Soft OR and Hard-Soft OR methods to find and probably solve (or improve) a problematic situation is known as Multimethodology.

Applying this multimethodology, using the Soft-Soft OR methodology of value-focused thinking and the cognitive maps tool, we designed a guideline or a starting point to organize, planning, structuring and/or improving a response phase allocation resource problem.

With such a complex problem, it's possible to work as deep as we want even every particular operations and procedures details definition. This is one opportunity for future works.

It's also possible, for future works, thinking about Soft OR and PSM, the application of other multimethodology combination as the use of Soft System Methodology, SODA maps, Future Scenarios etc.

Other interesting multimethodology approach, should aggregate Hard OR as linear programming to network optimization and transportation assignment problems to rescue units allocation, goods and drugs distribution, medical services allocation, etc.

This Soft-Hard OR mixture should be a powerful application of Operations Research to reach the best and most complete solution and decision analysis tool to a complex problem that could not be completely solved with individual Soft or Hard OR analysis separated.

REFERENCES

- [1] F. Ackermann, "Problem structuring methods 'in the Dock': arguing the case for Soft OR", *European Journal of Operational Research*, vol. 219, n. 3, p. 652-658, 2012.
- [2] EM-DAT. The OFDA/CRED International Disaster Database. Brussels, Belgium: Université Catholique de Louvain, 2014.
- [3] I. Georgiou "Mapping railway development prospects in Brazil", *Transport Reviews*, vol. 29, n. 6, p. 685-714, 2009.
- [4] I. Georgiou, "Messing about in transformations: structured systemic planning for systemic solutions to systemic problems", *European Journal of Operational Research*, vol. 223, n. 2, p. 392-406, 2012.
- [5] IFRC. "What is a disaster", 2013. Disponível em: <<https://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/what-is-a-disaster/>>.
- [6] R.L. Keeney, "Value-Focused Thinking: A Path to Creative Decisionmaking", United States of America, Harvard University Press, 1992. 416 p, ISBN 0-674-93197-1.
- [7] R.L. Keeney, "Value-Focused Brainstorming", *Decision Analysis*, vol. 9, n. 4, p. 303-313, 2012.
- [8] R.L. Keeney, "Value-focused thinking: Identifying decision opportunities and creating alternatives", *European Journal of Operational Research*. vol. 92, n. 3, p. 537-549, 1996.
- [9] J. Mingers, J. Rosenhead, "Problem structuring methods in action", *European Journal of Operational Research*, vol. 152, n. 3, p. 530-554, 2004.
- [10] J. Rosenhead, "Past, present and future of problem structuring methods", *J Oper Res Soc*, vol. 57, n. 7, p. 759-765, 2006. ISSN 0160-5682. Disponível em: <<http://dx.doi.org/10.1057/palgrave.jors.2602206>>. Acesso em: 24 fev. 2014.
- [11] R.V.V. Vidal, " Operational Research: A multidisciplinary field", *Pesquisa Operacional*, vol 26, n. 1, p. 69-90, 2006.
- [12] C. Eden, F. Ackermann, "Cognitive mapping expert views for policy analysis in the public sector", *European Journal of Operational Research*, vol. 152, n. 3, p.615-630, 2004
- [13] C.T. Bornstein, J. Rosenhead, " The role of operational research in less developed countries: A critical approach", *European Journal of Operational Research*, vol. 49, n. 2, p. 156-178, 1990.