

Identifying Initiatives for Solid Waste Collection using VFT as a PSM

Gustavo Barbi Vieira

Instituto Tecnológico de Aeronáutica

Praça Marechal Eduardo Gomes, 50 - Vila das Acácias, São José dos Campos - SP, 12228-900

Universidade Federal de São Paulo

Av. Cesare Monsueto Giulio Lattes, 1201, Eugênio de Melo, 12247-014, São José dos Campos-SP,
Brasil

`gustavogbv@ita.br`

Ygor Logullo de Souza

Instituto de Aplicações Operacionais

Praça Marechal Eduardo Gomes, 50 - Vila das Acácias, São José dos Campos - SP, 12228-970

`logulloyls@gmail.com`

Amanda Simões

Instituto Tecnológico de Aeronáutica

Praça Marechal Eduardo Gomes, 50 - Vila das Acácias, São José dos Campos - SP, 12228-900

`amanda.acsimoes@gmail.com`

Jônatas Araújo de Almeida

Universidade Federal de Pernambuco

Av. Marielle Franco, s/n - Km 59, Nova, 55014-900, Caruaru-PE, Brasil

`jonatasaa@yahoo.com.br`

Mischel Carmen Neyra Belderrain

Instituto Tecnológico de Aeronáutica

Praça Marechal Eduardo Gomes, 50 - Vila das Acácias, São José dos Campos - SP, 12228-900

`carmen@ita.br`

ABSTRACT

Human resource consumption in cities has generated large amounts of urban solid waste. When managed inefficiently, it can potentially harm the environment and human health. Furthermore, many objects could be recycled or reused, saving natural and financial resources and minimizing CO₂ emissions. This paper presents a Value-Focused Thinking (VFT) as a Problem Structuring Method (PSM) approach to improve “Solid Waste Management” (SWM) in a city. This work has two main objectives: (i) present a VFT model with a simulated example of local solid waste management within a city in Brazil; (ii) discuss how to commit to a set of the initiatives identified for solid waste management. We develop a model to deal with SWM based on three perspectives: Government, Society and Business. The resulting model enables a common understanding about SWM issues and also the identification of some initiatives to promote SWM in a city environment.

KEYWORDS. Value Focused Thinking (VFT). Problem Structuring Method (PSM). Solid Waste Management (SWM).

Paper topics: Operations Research in Agriculture and Environment;

1. Introduction

Sustainability is one of the main challenges in our societies today. Since Industrial Revolution, world society has been experiencing high rates of growth and development that surpass previous periods of human history. Nonetheless, this growth was usually based on exceeding amounts of natural resource consumption and also lacked concern about social equality, economic wealth, and quality of life distributed equally among society.

Human resource consumption in cities has generated large amounts of urban solid waste. However, there isn't yet an environmentally appropriate disposal to deal with it. Therefore this solid waste can potentially harm the environment and human health by contaminating soil, water bodies, and atmosphere. Furthermore, a great deal of potential resources is wasted, as many objects could be recycled or reused, saving natural and financial resources and minimizing CO₂ emissions (avoiding the greenhouse effect in the atmosphere) [Equipe Ecycle, 2023].

To deal with this issue, Brazil enacted Law n° 12.305 - National Solid Waste Policy (*"Política Nacional de Resíduos Sólidos"*-PNRS) in 2010 [Brazil, 2010]. PNRS was a milestone in the sector for it encompasses all kinds of solid waste (domestic, industrial, electronic, etc.) and also encourages the correct disposal of non-recyclable solid waste.

This paper presents how Value-Focused Thinking (VFT) as a Problem Structuring Method (PSM) can help government representatives to address initiatives to improve Solid Waste Management (SWM). This work has two main objectives: (i) present a VFT model dealing with a simulated example of local solid waste management within a city in Brazil; (ii) discuss how to commit to a set of options by examining the model and how to extract guidelines for implementing the initiatives identified for solid waste management;

The next sections of this paper are organized as follows: Section 2 presents a brief overview of PSMs and VFT (focusing mainly on the "VFT as PSM" approach [Françoze and Belderrain, 2022]). Section 3 presents an overview of the PNRS and depicts the main concerns regarding solid waste management from three different sources: PNRS, a consulting firm specialized in SWM, and a doctoral thesis from the University of São Paulo regarding indicators for urban SWM. In Section 4 we develop a model based on VFT as PSM to address the concerns identified in Section 3. In Section 5 we analyze the results extracted from the model regarding guidelines for implementing initiatives to address SWM within a local city. Finally, Section 6 concludes this study.

2. Literature Review

In this section, we present the definition of Problem Structuring Methods (PSMs) and describe some examples of these methods. We also indicate how Value-Focused Thinking (VFT) has been applied as a PSM approach.

2.1. Problem Structuring Methods and VFT

Problem Structuring Methods (PSM) were developed to address problems with the following characteristics: multiple actors, multiple perspectives, conflicting interests, important intangibles, and key uncertainties [Mingers and Rosenhead, 2004]. These methods grew out of practice since the mid-1960s by developing sophisticated tools to conceptualize and interact with the ongoing decision process. Hence, these methods were structured from the experience gathered in practical applications [Mingers and Rosenhead, 2004].

PSMs were designed to help stakeholders to understand the relevant aspects of a problematic situation, by representing different points of view through diagrams, maps, and other visualization tools. Their main objective is to identify the relevant factors of the problem at the beginning of the decision-making process, according to the individual and group perceptions of those involved

in the decision process. Therefore, PSMs foster an enhanced understanding of the problem by the participants, helping a group to reach a negotiated agreement about the problematic situation [Ackermann, 2012]. The three PSMs most referenced in the literature are [Mingers and Rosenhead, 2004]:

- **Strategic Options Development and Analysis (SODA):** this method guides the eliciting and recording of individual perspectives of the problem situation to identify strategic options. It uses cognitive mapping as a modeling device to register the particular views of the stakeholders and also as a tool for building a merged map with a strategic view of the problem that provides the framework for group discussion toward a commitment to a set of actions [Ackermann and Eden, 2020; Mingers and Rosenhead, 2011];
- **Soft Systems Methodology (SSM):** SSM is a general method to promote debate about alternative system modifications. Analysts explore different perceptions based on contrasting world views to generate the definition of alternative systems and the details about their component activities for successful operation. The alternative system definitions provide divergent options that are useful for promoting debate about a possible system redesign [Wheeler and Checkland, 2000; Georgiou, 2015; Mingers and Rosenhead, 2011];
- **Strategic Choice Approach (SCA):** SCA focuses on managing uncertainty in strategic situations. Participants are encouraged by facilitators to model the interconnectedness of decision areas. An interactive process to compare alternative decision schemes enables the discovery of relevant uncertainties that help the identification of priority areas for partial commitment and the design of future explorations of information and contingency plans [Friend, 1989; Mingers and Rosenhead, 2011].

2.2. Value-Focused Thinking - VFT

Value-Focused Thinking (VFT) is an approach originally proposed by Ralph Keeney in 1992 to guide decision-makers toward “the creation of values” in decision-making processes. The author argues that any decision must focus primarily on the objectives that guide the identification of better alternatives and better decision situations [Keeney, 1992].

Values are fundamental to everything we do. Hence, we should focus our time and effort on understanding the values involved on the decisions that lie ahead. Identifying these values requires creativity and hard thinking about a decision situation [Keeney, 1992, 2020]. Thus, the main goal of VFT is to describe the fundamental values of the stakeholders involved in the decision problem.

VFT is often more complete than most PSMs in linking goals to specific actions with measurable outputs [Keisler et al., 2014]. Therefore, VFT helps to describe the fundamental issues of organizations in their operating context and guides the elicitation of objectives that must be achieved to overcome those issues. These objectives specify the values for a given decision in detail [Keeney, 2008].

Briefly, VFT comprises the following steps: Identifying objectives, Structuring Objectives, Creating Alternatives, and Decision Opportunities. First, stakeholders (entities in VFT’s terminology) respond to some structured questions (VFT devices) to express their values about the problem. Then, analysts try to understand the precise meaning of the values with the stakeholders by converting them to a formal structure (verb + object) called “objective”. Then, analysts guide stakeholders through the WITI Test (*Why Is This Important?*), which makes it possible to identify

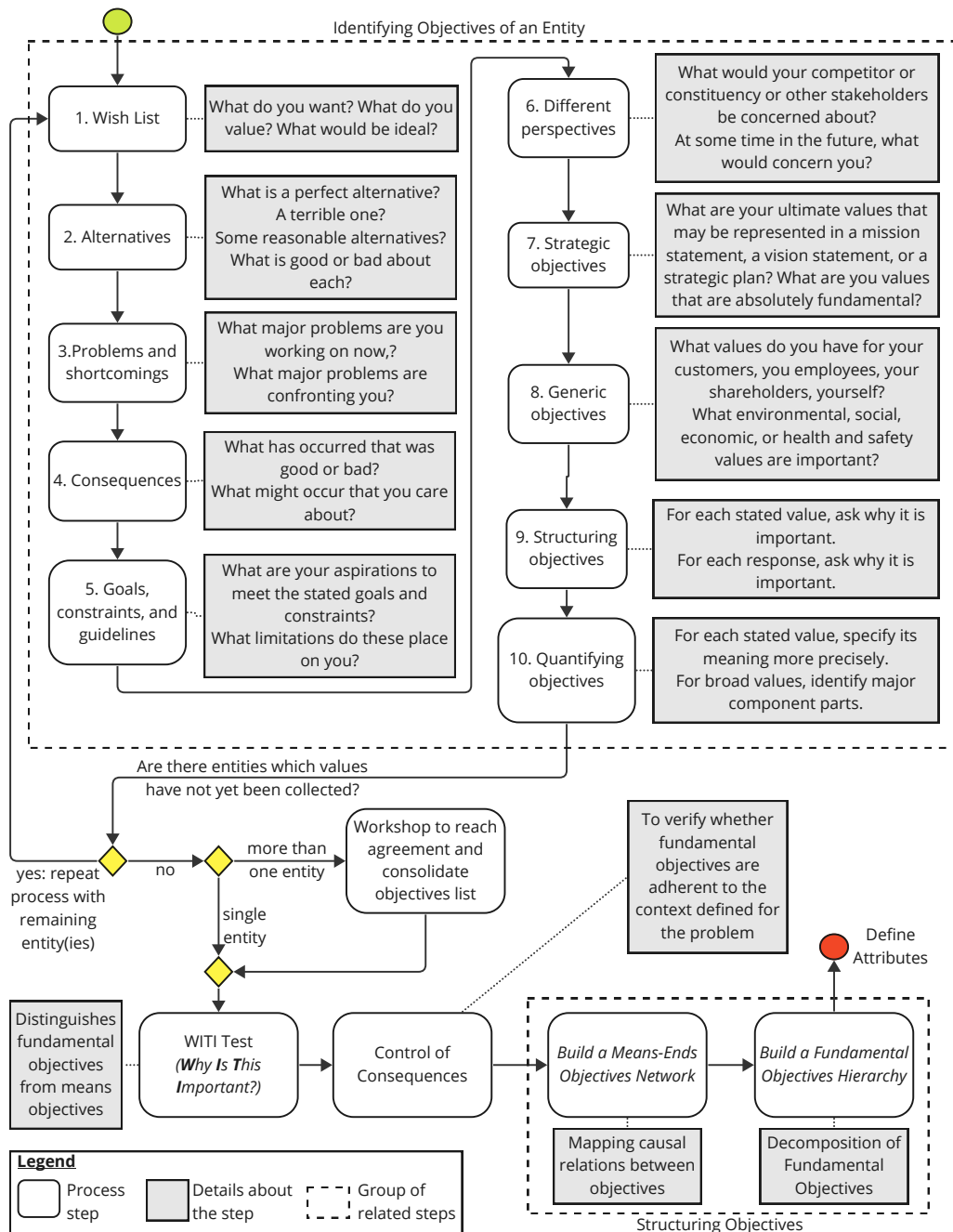


Figure 1: Overview of VFT steps for identifying and structuring objectives

the cause-effect relationships between them [Keeney, 1992]. Figure 1 presents the usual VFT steps for identifying and structuring objectives.

From the mapping of cause-effect relationships, the objectives are structured in a network of means-ends objectives and are classified into three specific types [Keeney, 1996]:

- **Strategic objectives**: a general guide for the entire decision-making process. They guide decisions made by many different individuals and groups throughout the organization;

- Fundamental objectives: these objectives represent the main focus of the decision. They represent the concerns of all stakeholders regarding the decision problem. They also guide the identification of attributes to measure the consequences of alternatives;
- Means objectives: these objectives are relevant for their implications regarding other (more fundamental) objectives in the decision context. They are also helpful for stimulating thinking about alternatives.

2.3. VFT as a PSM

Françoza and Belderrain [2022] present a framework to guide the adoption of VFT similar to those adopted by traditional PSMs. The framework has four steps that focus essentially on the “Front-End of VFT” approach [Keeney, 2020]: (i) identify values; (ii) convert values into objectives; (iii) hierarchy of objectives; and (iv) build a means-ends objective network.

The main goal of “VFT as PSM” is to build a network of means-end objectives to help stakeholders to deal with a problematic situation. Therefore, stakeholders can state a common definition of the problem and reach consensual agreements regarding possible initiatives for its resolution [Françoza and Belderrain, 2022].

Figure 2 presents an alternative version of the Framework proposed by [Françoza and Belderrain, 2022] for “VFT as PSM”. In this version, “Step 3: Hierarchy of Objectives - WITI Test” was replaced by “Step 3: Generate a Structured Cloud of Objectives - WITI Test”. We modified Step 3 because, in our understanding, this is an intermediate step towards building a means-ends objective network (detailed in Step 4 of the original framework), whereas a hierarchy of objectives has a different meaning and purpose in the original VFT approach. Nevertheless, we highlight that the procedures conducted throughout this work adhere to those proposed by [Françoza and Belderrain, 2022].

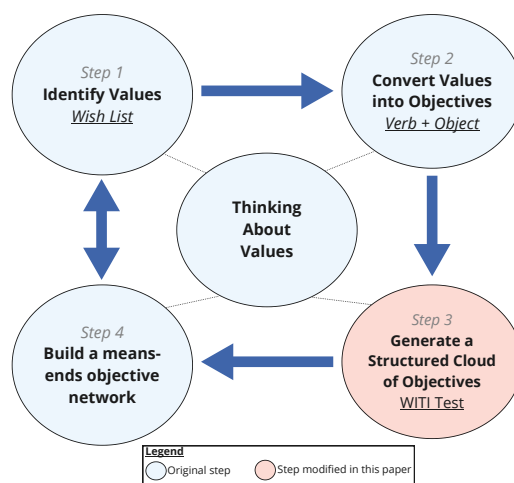
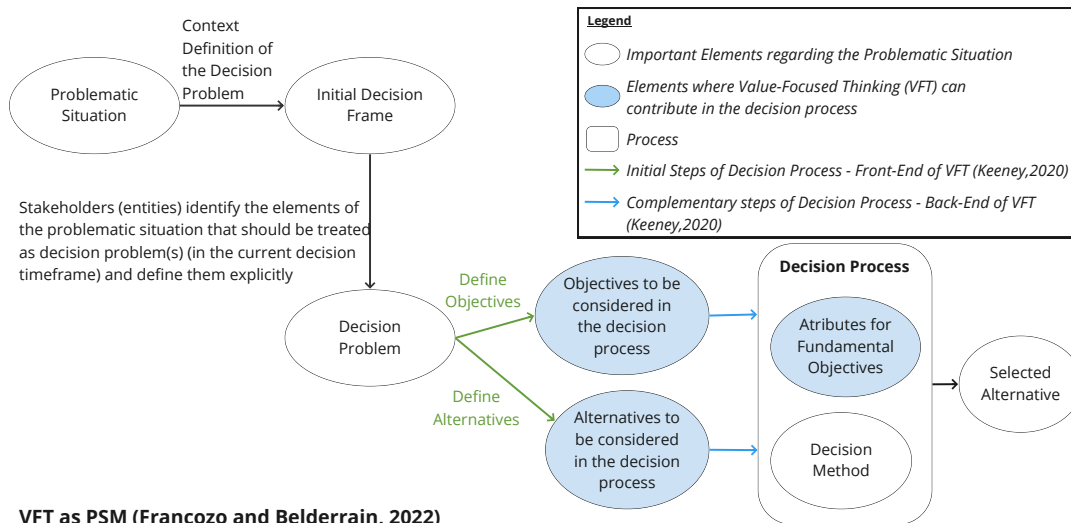


Figure 2: VFT as PSM Framework - Adapted from [Françoza and Belderrain, 2022]

“VFT as a PSM” [Françoza and Belderrain, 2022] focuses on a common definition of the problematic situation and guidelines for consensual initiatives to tackle the problem (or some of its parts). Therefore, it differs from traditional VFT since there is no immediate need to generate a value model for a specific decision problem (or decision opportunity). Figure 3 presents a conceptual model that compares traditional VFT [Keeney, 1992, 2020] and “VFT as PSM” [Françoza and Belderrain, 2022].

VFT - traditional Approach for Decision Problems (Value Model Generation) (Keeney,1992; Keeney,2020)



VFT as PSM (Françoze and Belderrain, 2022)

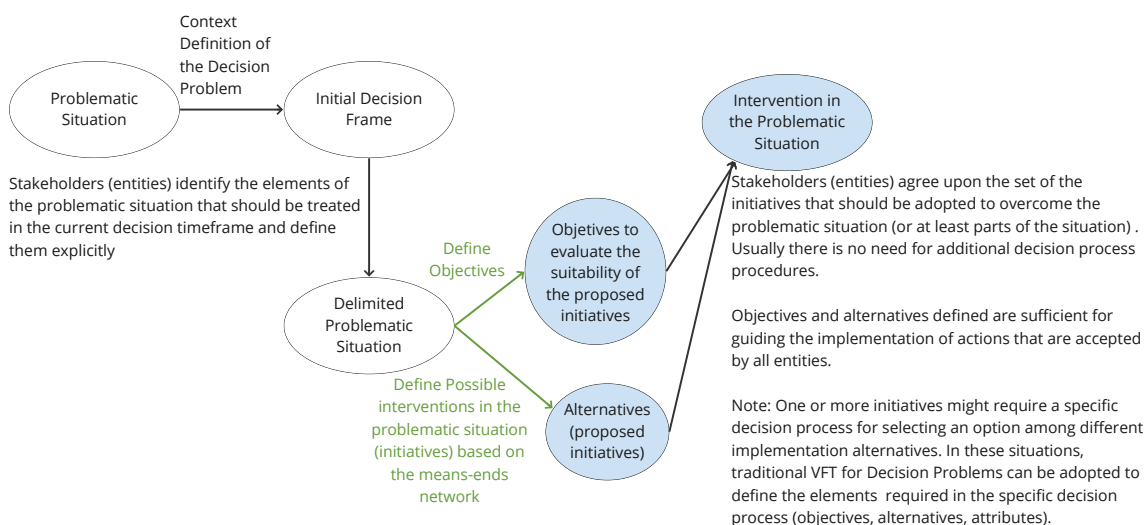


Figure 3: Conceptual diagram comparing traditional VFT and VFT as PSM

3. Solid Waste Collection - SWC

This Section presents three perspectives regarding solid waste management:

- **Governmental:** an overview of the Brazilian Solid Waste Nacional Policy (*“Política Nacional de Resíduos Sólidos”*.-PNRS), depicting the main goals of the Brazilian Government regarding solid waste management (SWM) [Brazil, 2010].
- **Society:** A Doctoral Thesis about “Selective collection of urban solid waste: operational aspects and populational’s engagement” presented by Dr. Jacqueline Brighenti (University of São Paulo) [Brighenti, 2004]. We selected key topics highlighted throughout distinct chapters of this thesis regarding SWM as a source for identifying values for our proposed model;

- Business: an article published by a consulting firm specialized in SWM named “*EOS Organização e Sistemas*” [EOS Organização e Sistemas, 2020].

These texts are available publicly on the internet and represent distinct points of view regarding SWM. We extracted the information based only on the interpretation of the authors of this paper after reading these sources. Although we didn't have the opportunity to interview or somehow interact directly with the representatives of these organizations or with the author of the Doctoral Thesis, these sources allowed us to depict relevant aspects related to SWM. These aspects are the inputs for the model presented in Section 4.

We emphasize that this is a simulated case. Hence, we can't ensure accuracy regarding the current SWM context, considering that there is a difference between the timeframe where the sources were published (society's perspective is from 2004, the PNRS is from 2010, and the business perspective is from 2020). Research from other recent sources would possibly present some differences regarding the values for each perspective. Nevertheless, this does not invalidate “VFT as a PSM” as an approach for complex problems. Quite the contrary, we encourage practitioners to apply it as it can highlight relevant insights about these problematic situations.

The following subsections present the information collected from these three sources.

3.1. Governmental Perspective: Brazilian National Solid Waste Policy

In 2010, the Subcommittee for Legal Affairs of the Civil House of the Presidency of the Republic of Brazil enacted the Law nº 12.305. This law institutes the National Solid Waste Policy (“*Política Nacional de Resíduos Sólidos*” - PNRS) and defines its principles, objectives, instruments, and the guidelines for integrated management of solid waste [Brazil, 2010].

We summarize the 15 goals in PNRS here as follows: (i) protection of public health and environmental quality; (ii) non-generation, reduction, reuse, recycling and treatment of solid waste, and environmentally appropriate final disposal of waste; (iii) adoption of sustainable patterns of production and consumption of goods and services; (iv) adoption, development and improvement of clean technologies; (v) reduction of hazardous waste; (vi) incentive for the recycling industry; (vii) integrated solid waste management; (viii) promote technical and financial cooperation between different levels of government (federal, state and municipal) and the business sector; (ix) permanent technical training in the area of solid waste; (x) regularity, continuity, functionality and universalization of the provision of public urban cleaning and solid waste management services; (xi) priority in government procurement for recycled and recyclable products and also for services that are compatible with socially and environmentally sustainable patterns; (xii) integration of independent collectors of reusable and recyclable materials in actions involving shared responsibility for the life cycle of products; (xiii) implementation of the evaluation of the life cycle of the products; (xiv) promote the development of environmental and business management systems aimed at improving production processes and the reuse of solid waste, including energy recovery and use; (xv) promote environmental labeling and sustainable consumption;

3.2. Society Perspective: “*Selective collection of urban solid waste: operational aspects and populational's engagement*”

We described this perspective based on our notes from reading a doctoral thesis from the University of São Paulo [Brighenti, 2004]. The main objective of this thesis is: “to evaluate operational aspects and populational's engagement in programs for the selective collection of urban solid waste, using the municipality of Vitória-ES as a case study”.

We highlight the following values (listed by the chapter of the thesis where they were identified):

- **Introduction:** (i) Minimize environmental damage caused by solid waste; (ii) Minimize public health problems; (iii) Generate solutions based on cooperation between government and society; (iv) Adopt appropriate solid waste management techniques; (v) Avoid high costs that make its execution unfeasible; (vi) Avoid as much garbage as possible on the ground, using reduction, reuse and recycling techniques (Minimize solid waste); (vii) Adopt policies to encourage the use of returnable, reusable and recyclable packages; (viii) Avoid waste of raw materials; (ix) Promote recovery of solid waste; (x) Transform society's behavior regarding waste generation; (xi) Promote preservation of the environment; (xii) Reduce health and environmental impacts; (xiii) Promote standardization of selective waste collection services (focus on reducing, reusing and recycling); (xiv) Selective waste collection is an environmental management tool that must focus on recovering recyclable material for recycling purposes;
- **Literature Review:** (xv) Minimize disease transmission; (xvi) Minimize contamination of watercourses and groundwater; (xvii) Build a sustainable city; (xviii) Integrated Management of Solid Waste; (xix) Minimization of waste generation; (xx) Maximizing reuse and recycling; (xxi) promotion of treatment and final disposal of solid waste in an environmentally safe way; (xxii) Maximizing coverage of urban cleaning services; (xxiii) keep the original characteristics of recyclable materials; (xxiv) rationalization and optimization of equipment, systems, and methods for regular collection and final disposal; (xxv) Solid waste management contribution to the extend landfills lifetime; (xxvi) job and income generation; (xxvii) preservation of natural resources.

3.3. Business Perspective: “Why is selective collection of solid waste important for sustainability?”

This perspective presents the point of view of a consulting firm focused on sustainability and knowledgeable about solid waste management. We highlight the following values collected from an article published in 2020 by this organization [EOS Organização e Sistemas, 2020]: (i) Reduce the extraction of natural resources; (ii) Decrease in soil, water, and air pollution; (iii) Recycling of materials that would go to the trash; (iv) flood prevention; (v) Energy and water savings; (vi) Reduction of production costs, with the use of recyclables by industries; (vii) Decreased waste; (viii) Creation of strong cooperatives; (ix) Employment and income generation through the commercialization of recyclables; (x) Improvements and reduction of expenses in public cleaning; (xi) Maximize social sustainability; (xii) Maximize economic sustainability; (xiii) Maximize environmental sustainability;

4. Proposed Model

In this section, we describe the steps for generating the proposed model, based on the values for each perspective presented in section 3. We applied the four steps of the framework presented in Figure 2.

4.1. Step 1 - Identify Values (Wish List)

We depicted the values for the problematic situation “Solid Waste Management” in Section 3. Figures 4 and 5 present these values highlighted in different colors (green for Government Perspective, red for Society Perspective, and blue for Business Perspective).

4.2. Step 2 - Convert Values into Objectives

Figures 4 and 5 present the objectives obtained from converting the values identified in Step 1. We show them in the inner part of the “*Unstructured Cloud of Objectives*” (dotted box). First, we arranged values with similar meanings in close positions. Then, we applied a single conversion process to consolidate the different value perspectives in a set of “consensual” objectives.

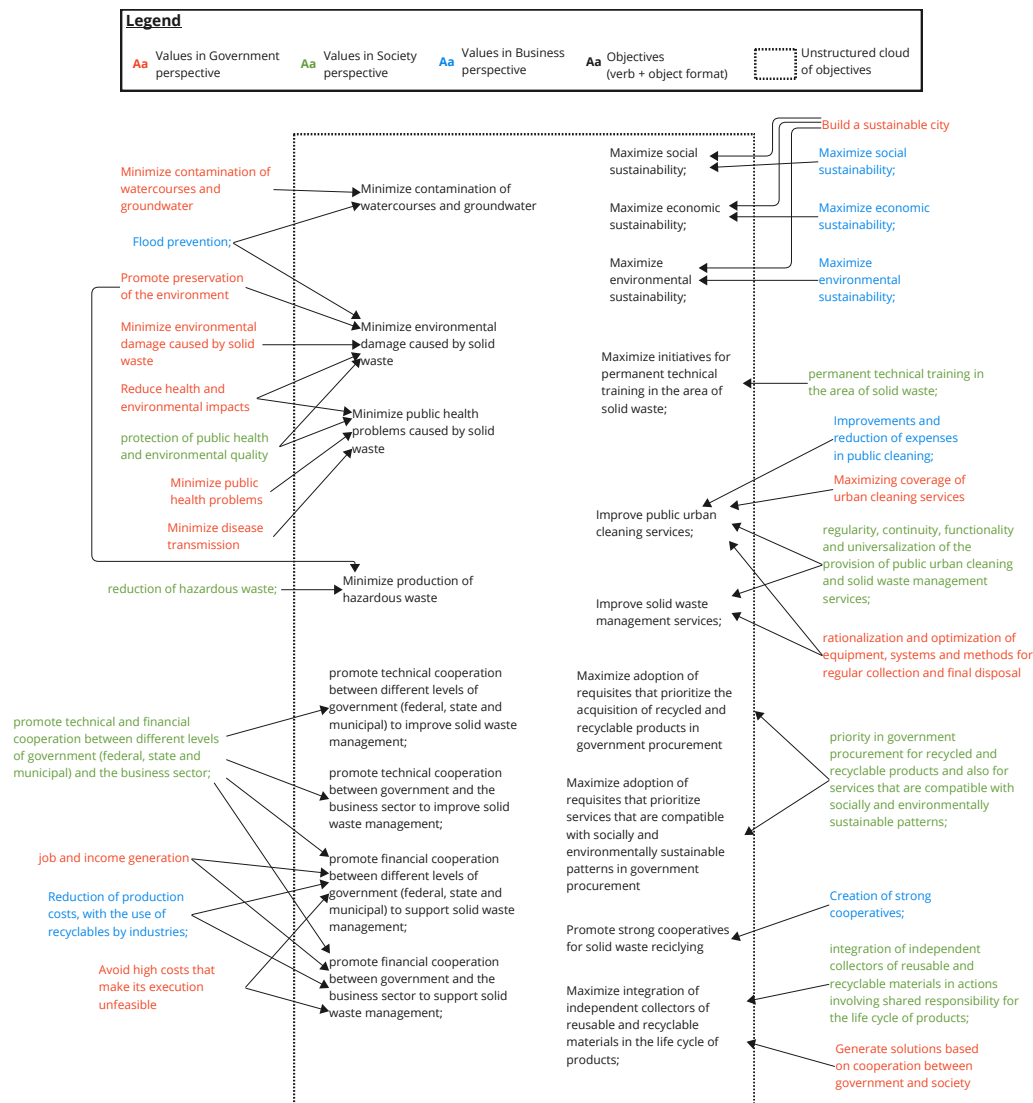


Figure 4: Unstructured Cloud of Objectives - part 1

4.3. Step 3 - Generate a Structured Cloud of Objectives

We applied the WITI Test (Why Is This Important) to identify the relationships between the objectives presented in section 4.2. Since this is only an intermediate step to building the Means-Ends Objectives Network, we present the identified relationships in the final model (Figure 6).

4.4. Step 4 - Build a Means-Ends Objective Network

After identifying the relationships between objectives, we generated the Means-Ends Objectives Network presented in Figure 6. We grouped these objectives (and their corresponding relationships) into three “clusters of objectives”: “*Environmental Sustainability*”, “*Social Sustainability*” and “*Economic Sustainability*”.

5. Discussions

The model presented in Figure 6 indicates valuable insights for initiatives regarding Solid Waste Management within a city. Firstly, we can infer that any intervention toward efficient solid

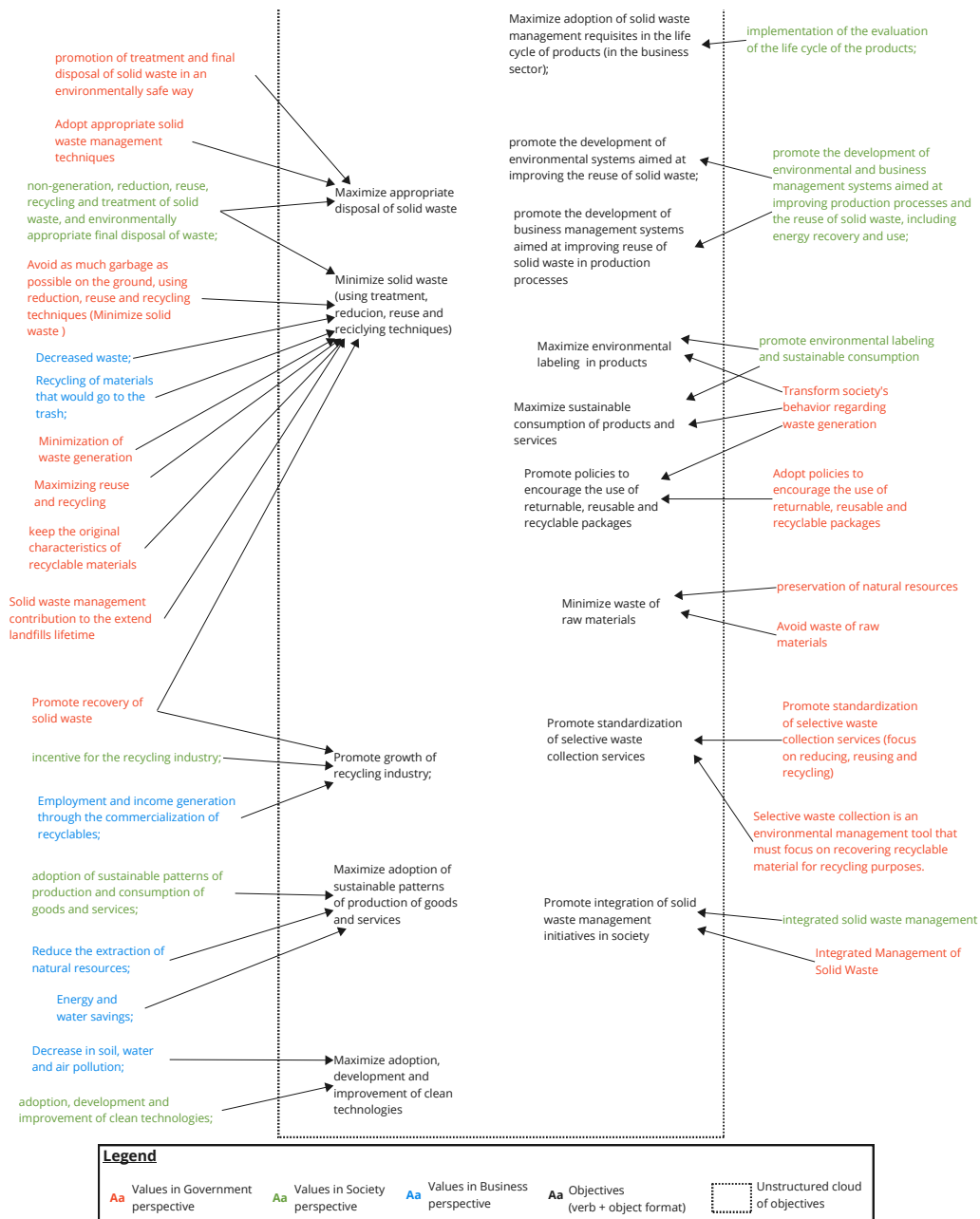


Figure 5: Unstructured Cloud of Objectives - part 2

waste management has to address concerns regarding environmental, social, and economic sustainability since these are the fundamental objectives indicated by the stakeholders.

The means objectives highlight some possible features of the alternatives that can be adopted in this context. Hence, a set of plausible actions for any intervention should comprise most (or all) of the following:

1. **Environmental Sustainability “Cluster”:** (a) Maximize appropriate disposal of solid waste; (b) Promote the development of environmental systems to improve the reuse of solid waste;

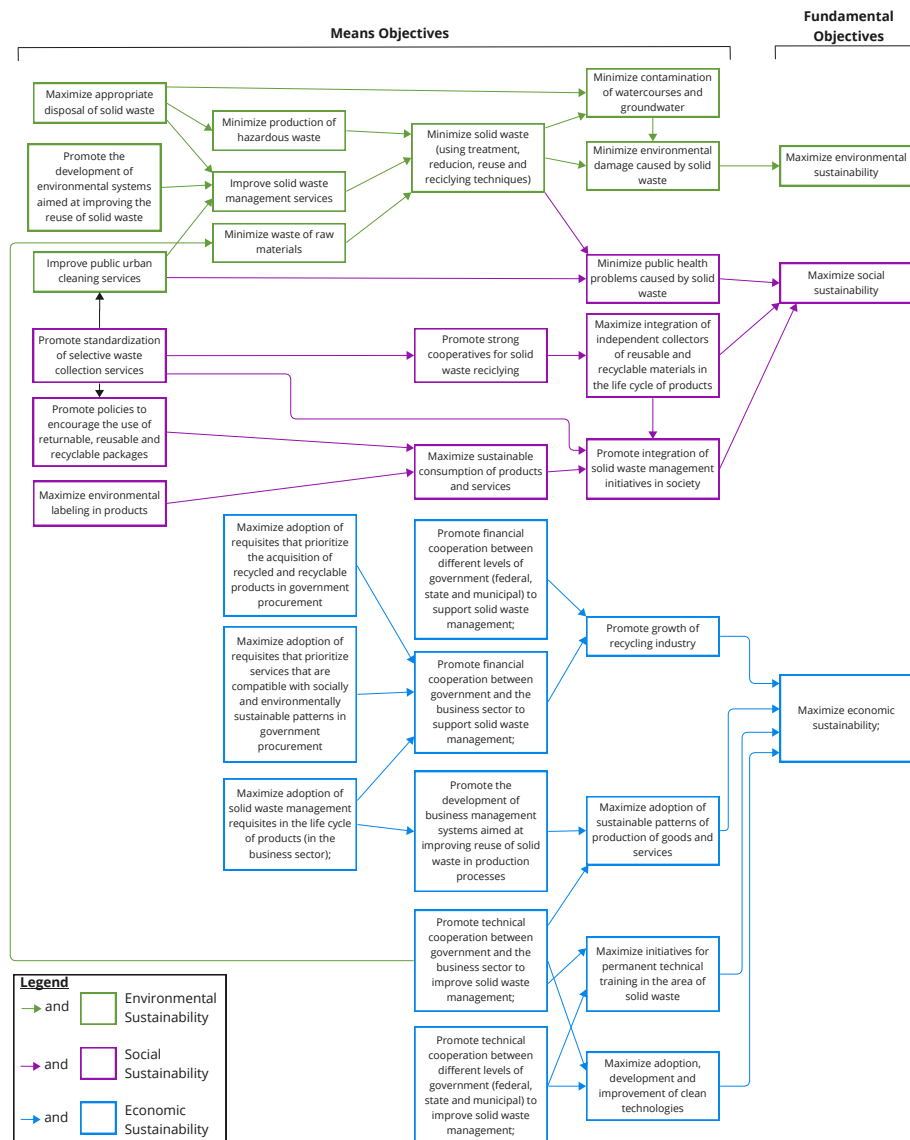


Figure 6: Means-Ends Objectives Network

- (c) Improve public urban cleaning services; (d) Minimize waste of raw materials;
- Social Sustainability “Cluster”:** (a) Promote standardization of selective waste collection services; (b) Promote policies to encourage the use of returnable, reusable, and recyclable packages; (c) Maximize environmental labeling in products; (d) Promote strong cooperatives for solid waste recycling; (e) Maximize integration of independent collectors of reusable and recyclable materials in the life cycle of products; (f) Maximize sustainable consumption of products and services;
 - Economic Sustainability “Cluster”:** (a) Maximize adoption of requisites that prioritize the acquisition of recycled and recyclable products in government procurement; (b) Maximize adoption of requisites that prioritize services that are compatible with socially and environ-

mentally sustainable patterns in government procurement; (c) Maximize adoption of solid waste management requisites in the life cycle of products (in the business sector); (d) Promote financial cooperation between different levels of government (federal, state and municipal) to support solid waste management; (e) Promote technical cooperation between government and the business sector to improve solid waste management; (f) Promote technical cooperation between different levels of government (federal, state and municipal) to improve solid waste management.

The decision-makers can then delegate these actions to specific city hall departments or external organizations willing to contribute to the SWM improvement. The collective nature of model development enables a better understanding of the problematic situation of SWM and promotes the collaboration of all stakeholders.

Some of these options might require a decision process to choose among possible alternatives. For instance: “2.c- Maximize environmental labeling in products” could require a choice among different labeling technologies from distinct vendors. Therefore, in this case, a decision process should take place, and the traditional VFT approach (presented in Figure 1) might be helpful to generate a value model to choose among the available alternatives.

6. Conclusion

This paper presented a “VFT as PSM” model to show how it can help stakeholders with a consensual definition of a problematic situation and to reach commitment regarding a set of actions to solve it. We applied this model to identify governmental initiatives for Solid Waste Management (SWM) within cities.

First, we made a brief overview of PSMs and VFT. Then, we presented a set of values in the context of Solid Waste Management identified from three sources with different perspectives: Government, Society, and “Economic”. Lastly, we built a Means-Ends Objectives Network to identify the fundamental objectives and the possible initiatives to deal with Solid Waste Management in a city.

This work has two limitations: (i) the values identified were not validated by the representatives of the original sources. Therefore, there can be misunderstandings regarding specific topics in our model; (ii) the interviews with the representatives of the sources could also highlight different values (and objectives) that are not explicit in the written texts examined throughout this work.

Finally, there are some promising paths for future work, such as: (i) future exploration of the decision process regarding some of the initiatives identified in section 5; (ii) value identification from other types of stakeholders (for instance: people that live in the surroundings of landfills, representatives of recycling companies, etc.); (iii) apply “VFT as PSM” approach in other sustainability contexts, such as urban planning (with environmental and social responsibility), reduction of CO₂ emissions in a geographic region, among others.

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