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**Sustentabilidade em Instituições de Ensino Superior: Estudo de Caso da Gestão de
Resíduos Sólidos da Universidade de São Paulo – Campus de São Carlos**

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**Sustainability at Higher Education Institutions: Case Study of the Solid Waste
Management at the University of São Paulo – São Carlos Campus**

São Carlos
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**Sustainability at Higher Education Institutions: Case Study of the Solid Waste
Management at the University of São Paulo – São Carlos Campus**

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POR QUALQUER MEIO CONVENCIONAL OU ELETRÔNICO, PARA FINS
DE ESTUDO E PESQUISA, DESDE QUE CITADA A FONTE.

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Resumo

MOREIRA, R. M. (2018). Sustentabilidade em Instituições de Ensino Superior: Estudo de Caso da Gestão de Resíduos Sólidos da Universidade de São Paulo – Campus de São Carlos. Tese de doutorado – Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, SP, Brasil.

Instituições de ensino superior são espaços para implantação de estratégias de planejamento e melhores práticas sustentáveis no ensino, pesquisa, extensão, gerenciamento e operações, comportando-se como modelo para a sociedade. A inovação deste trabalho baseia-se na elaboração e implantação de ferramentas para auxiliar na tomada de decisão referente a gerenciamento de resíduos, considerando que a comunidade de instituições de ensino superior são potenciais agentes promotores de sustentabilidade. Além disso, estratégias para integrar a dimensão educacional das IES com o engajamento, as dimensões operacional e de políticas e gestão é o que diferencia o modelo aqui proposto de outros modelos existentes. É importante entender que as IES, diferentes das outras instituições, têm a obrigação de construir conhecimento e treinar sua comunidade para servir a sociedade. A responsabilidade da IES em preparar novos líderes, tem a oportunidade de aumentar a conscientização e a cultura sustentável, envolvendo sua comunidade nas atividades diárias, preparando-as para ver desafios diários e resolvê-lo através de abordagens mais sustentáveis. As ferramentas foram elaboradas usando interfaces de ciências sociais, engenharia e modelagem computacional. Os produtos desta tese são: A revisão da literatura sobre o gerenciamento de resíduos sólidos nas Instituições de Ensino Superior; A descrição da gestão de resíduos sólidos no campus da Universidade de São Paulo - São Carlos, um estudo que descreve os fatores de fortalecimento e fragilização do programa de reciclagem de Recicla da Universidade de São Paulo; Um modelo para a gestão de resíduos sólidos nas Instituições de Ensino Superior; O uso da questionários como ferramenta para avaliar a cultura de sustentabilidade na Universidade de São Paulo - Campus de São Carlos; O Índice de Gestão de Resíduos Sólidos para Instituições de Ensino Superior Brasileiras; e O uso da metodologia de modelagem baseada em agentes como uma ferramenta de tomada de decisão para iniciativas de reciclagem. As principais conclusões são que há uma lacuna em ferramentas para ajudar a tomada de decisão em relação ao gerenciamento de resíduos sólidos e que consideram as especificidades das instituições de ensino superior, o que leva à criação de ferramentas para atender a essas necessidades. Trabalhando para implantar ferramentas com interface entre as ciências sociais, engenharia, e modelagem computacional os pesquisadores puderam trabalhar em um campo inovador, rico e pouco explorado.

Palavras-chave: Modelagem Baseada em Agentes; Gestão Ambiental; Indicadores; Política ambiental; Reciclagem; USP Recicla; Educação Ambiental; Ferramentas de tomada de decisão.

Abstract

MOREIRA, R. M. (2018). Sustainability at Higher Education Institutions: Case Study of the Solid Waste Management at the University of São Paulo – São Carlos Campus. Thesis (Ph.D. degree) – São Carlos School of Engineering, University of São Paulo, São Carlos, SP, Brazil.

Higher Education Institutions are spaces for planning strategies deployment and sustainable best practices implementation in teaching, research, outreach, management and operations, behaving as a role model to society. The innovation of this work relies on deploying tools to aid waste management decision-making, considering that higher education institutions community are potential sustainability agent promoters, and that strategies to integrate HEIs educational dimension with engagement, operational, and policy & management dimensions, is this works innovation from other frameworks already deployed. It is important to understand that HEIs, different than other institutions, have the obligation to build knowledge and to train its community to serve society. HEIs responsibility to prepare new leaders, given the opportunity for raising awareness and sustainable culture by engaging its community in daily activities, by preparing them to see daily challenges and solve it through more sustainable approaches. This works tools were deployed using social sciences, engineering, and computational modeling interfaces. This thesis products are a literature review regard solid waste management at Higher Education Institutions; The description of the solid waste management at University of São Paulo – São Carlos Campus, a study describing strengthening and weakening factors for the University of São Paulo Recicla recycle program; A framework for solid waste management at Higher Education Institutions; The use of survey as a tool to assess culture of sustainability at the University of São Paulo – São Carlos Campus; The Waste Management Index for Brazilian Higher Education Institutions; and the use of Agent-Based Modeling methodology as a decision-making tool for recycling initiatives. The main conclusions are that there is a gap on tools to help decision-making regard solid waste management and that consider higher education institutions specificities, this lead to creation of tools to address these necessities. By working to deploy tools with social sciences and engineering interfaces, researchers can find an innovative, rich, and barely exploited field.

Keywords: Agent-Based Modeling; Environmental Management; Indicators; Environmental Policy; Recycling; USP Recicla; Environmental Education; Decision-making tools.

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List of Abbreviations

ABM – Agents-Based Modeling
ANOVA – Analysis of Variance
CCE - Electronic Computational Center
CECAE - Executive Coordination of University Cooperation and Special Activities
CEDIR - Waste Disposal and Reuse Center
ChEM - Chemical, Equipment, and Materials Reuse
EESC – São Carlos School of Engineering
EMS - Environmental Management Systems
ESALQ – Luiz de Queiroz School of Agriculture
HEI – Higher Education Institutions
HMM - Hazardous Material Management
IAU – Urban and Architecture Institute
ICMC –Mathematical and Computational Sciences Institute
IFSC - São Carlos Physics Institute
IQSC – São Carlos Chemistry Institute
ISO – International Standardization Organization
ISR – Institute for Social Research
LRQ – Chemical Waste Laboratory
PAP – People that Learn Participating
PDCA – Plan, Do, Check, Act
PNRS – Brazilian National Solid Waste Policy
SCIP – Sustainability Culture Indicators Project
SEF – Physical Space Superintendence
SGA – Environmental Management Superintendence
SPSS – Statistical Package for Social Sciences
SWaMI – Solid Waste Management Index
UFSM – University of Santa Maria
UNIOESTE – Santa Catarina West State University
UofM – University of Michigan
USP – University of São Paulo
USPSC – University of São Paulo – São Carlos Campus

WG – Working Groups

WRRO - Waste Reduction & Recycling Office

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Thesis¹ presentation

This thesis contains a general introduction chapter, a solid waste management at Higher Education Institutions (HEIs) chapter, and an exploratory and descriptive research regarding the solid waste management of the University of São Paulo – São Carlos campus (USPSC) and the USP Recicla recycling program. These chapters served as inputs for further three chapters writing, presented here as scientific articles. General findings are discussed at the Thesis Conclusion section.

Regard publications, one paper was published in the Journal of Management and Sustainability, the publications references can be found in the brief description of each chapter. One paper was published in the Revista Gestão e Sustentabilidade Ambiental (Environmental Management and Sustainability Journal), this thesis' 6th chapter was accepted as a chapter on the book “The University Campus of the Future: connecting the nexus energy, climate and sustainable development in university operations” part of the World Sustainability Series – Springer, organized by Prof. Walter Leal. The other chapters will be submitted after the committee observations. Also, the researcher contributed in the work:

ÁVILA, LUCAS VEIGA; LEAL FILHO, WALTER ; BRANDLI, LUCIANA; MACGREGOR, COLLIN; MOLTHAN-HILL, PETRA; ÖZUYAR, PINAR GÖKÇİN; MOREIRA, RODRIGO MARTINS. Barriers to Innovation and Sustainability at Universities Around the World. **Journal of Cleaner Production**, v. 164, p. 1268-1278, 2017. <https://doi.org/10.1016/j.jclepro.2017.07.025>.

A brief description of each chapter is presented below:

Chapter I – **Introduction**: Initial discussion regard thesis relevance and innovation.

Chapter II – **Methods**: Methodologies used for the exploratory research and interviews; Methodology description of the culture of sustainability surveys.

Chapter III – **Solid waste management at Higher Education Institutions**: Literature review regard solid waste management at HEIs.

¹ In Brazil, the final document of a Ph.D. program is called thesis. In the US this document is called dissertation. This work will use the term thesis.

From the literature review, we can present two published papers, found in annex three and four:

- MOREIRA, R.M.; CETRULO, T. B.; CORTES, A. D. M.; CETRULO, N. M.; MALHEIROS, T. F. Sustainability Assessment of Policies: Brazilian National Solid Waste Policy Case Study. **Revista Gestão e Sustentabilidade Ambiental**, v. 6, n. 2, p. 79 -96, 2017. DOI: 10.19177/rgsa.v6e220177996.
- MOREIRA, R.M.; CETRULO, T. B.; CORTES, A. D. M.; CETRULO, N. M.; MALHEIROS, T. F. Brazilian National Solid Waste Policy applied as a tool to enhance an university campus waste management. **Journal of Management and Sustainability**, v. 7, p. 101-111, 2017. DOI: <https://doi.org/10.5539/jms.v7n3p101>.

Chapter IV – **Solid Waste management at the University of São Paulo – São Carlos campus and USP Recicla recycling program:** The solid waste management at USPSC is described; USP Recicla’s strengthening and weakening factors are presented and discussed.

Chapter V - **A Sustainable Solid Waste Management Framework for Higher Education Institutions:** The framework presented here aims to fill the gap regard current waste management systems lack of specificity for HEIs. This framework considers community’s waste prevention, reuse, and recycling culture, support policy deployment and decision making and offers a tool to diagnose and monitor waste management systems.

Chapter VI – **Assessing Sustainability Culture at the University of São Paulo – São Carlos:** The survey was developed in collaboration with researchers at the University of Michigan (UofM) and was based at surveys conducted as part of UofM’s Sustainability Cultural Indicators Program.

MOREIRA, R.M.; MALHEIROS, T.F.; MARANS, R.W.; WEBSTER, N.J.; HUPP, A.L. (2017). Assessing Sustainability Culture at the University of São Paulo –São Carlos; The University Campus of the Future: connecting the nexus energy, climate and sustainable development in university operations. **World Sustainability Series**, Walter Leal (org.). Springer.

Chapter VII - **Solid Waste Management Index for Brazilian Higher Education Institutions:** This paper introduces the Solid Waste Management Index for Brazilian

Higher Education Institutions, calculated through a set of criteria that considers HEIs' Education, Engagement, Operations, and Policy and Management main pillars, presenting the application findings for three Brazilian HEIs and one from the United States. The criteria that composes this index were selected through an extensive waste management literature review, and contains information from scientific articles, HEIs sustainability reports, and certification organizations.

Chapter VIII - Agent-Based Modeling as a decision-making tool for recycling initiatives: After an immersive literature review and two universities case studies regarding management and operational aspects of its recycling initiatives, the researchers identified that this field of research required a modeling tool capable of deploying scenarios and strategical planning. In this sense, the main purpose of this research is to fill the gap regarding a modeling tool addressed to decision makers concerning the growing field of recycling at universities that seek to enhance strategically their existing, or implement new, initiatives.

Chapter IX – General Conclusions: A critical discussion regard the thesis main findings, together with challenges faced during the thesis deployment, and possibilities for future research are presented.

Research Question

The researcher main purpose with this thesis final document is to support HEIs decision makers aiming to standardize its solid waste management according to best practices examples inserted on teaching, research, outreach, management and operations. In this sense, the question that leads this work raises:

- How to implement or enhance a sound solid waste management system at HEIs.

Objective

- To deploy three decision making support tools to enhance HEIs solid waste management system.

Specific objectives

- 1) To study solid waste management at Higher Education Institutions;
- 2) To identify key dimensions and criteria for HEIs solid waste management;

- 3) To deploy a framework composed with tools to support decision-making regard solid waste management for HEIs;
- 4) To execute exploratory researches and a case study at the University of São Paulo - São Carlos campus and the University of Michigan;
- 5) To use the agent-based modeling methodology to build a decision-making tool to support recycling initiatives implementation.

Chapter I - Introduction

Higher Education Institutions are spaces for planning strategies deployment and sustainable best practices implementation in teaching, research, outreach, management and operations, behaving as a role model to society (PALMA et al., 2011; BERO et al., 2012).

For Brazil specific scenario, laws have criteria that are applied to HEIs, which require its *campuses* to adequate its activities to minimize negative environmental impacts (GUIMARÃES; TOMAZELLO, 2003; TAUCHEN; BRANDLI, 2006). Some of these examples are Law nº 12.375/2010: Enacts the Solid Waste National Policy and requires Waste Management Plans elaboration for all organizations and Law nº 5.940/2006: Enacts recyclable waste segregation disposed by federal organizations at its source. This waste must be sent to recycling companies.

These laws can be translated in tools to enhance sustainability at HEIs, although none of them are specific for HEIs campuses reality. Sustainability discussions are being inserted and strengthened in operational and management activities in the past decades as a response to negative environmental impacts, specially, with waste generation growth and inadequate waste disposition (BALDWIN; DRIPPS, 2012; FELDER; PETRELL; DUFF, 2001; LIM; HAMILTON; JIANG, 2015; MALAKAHMAD et al., 2010; MASON et al., 2003; ROUSE, 2006; THOMAS; PEROSA; MARTÍN, 2012).

Solid Waste management is a complex subject due to involving diverse dimensions, actors and complex problems, aiming to prevent, reuse and recycle solid waste. This work seeks to converge this discussion on the same direction by inserting solid waste management in HEIs teaching, research and outreach, in a way that these practices to tackle HEIs operational and management challenges, by facing students and community, future leaders and decision makers, in potential sustainability agents.

The solid waste management system proposed by this work adopts tools as reports publication, with results and experiences, so these best practices may be replicated by enterprises and cities; to deploy prevention, reuse and recycling strategies using HEIs teaching, outreach and research activities, and raise cultural values and awareness through them. In this sense, this work presents a framework and tools that were build considering HEIs peculiarities, innovating in crossing its communities' behavior and physical aspects regard solid waste, prevention, reuse and recycling.

In this context, this work presents itself as a response for the necessity of a focused solid waste management framework for HEIs campuses. This research innovates by filling a gap at tools to support HEIs decision-making, that is the lack of a specific tools that exhausting study and works inside the waste management dimension. This work considers individual and communities behaviors. Araujo and Viana (2012) conclude in their work that for waste management plans efficiency and efficacy, actions beyond operational prevention, reuse and recycling, such as awareness instruments and interventions are needed. Figure 1 presents the research map that leads this work. Figure 2 presents a conceptual map: Sustainability applied to university campuses.

Figure 1 - General research map.

Figure 2 - Conceptual map: Sustainability applied to university campuses.

Chapter II - Methods

Through a literature review, a first version of the framework was deployed, but this version was too raw and the researcher felt the need of some practical experience input, what drove the exploratory research and interviews with HEIs solid waste management stakeholders from the University of São Paulo, and University of Michigan, also reports and papers aided the framework evolution.

New aspects and dimensions were added in this post exploratory research version, for example, it was identified in the interviews that engagement and human resources availability are major keys for environmental programs continuity, directors and other decision-makers discontinuity may be a weakness factor that influence socioenvironmental programs. The interviews were deployed with end of the processes stakeholders that faced and overcame these obstacles, that were first identified through the literature review. The interviews raised the importance of bringing best practices examples regard solid waste management for a wide variety of realities and how management occur in each of them.

Moreover, new tools were added, such as the Culture of Sustainability Survey, its importance was raised by a research group lead by Professor Robert Marans, from the University of Michigan. Operational focused interventions, e.g. to add more bins, are not enough to guarantee a sound waste management, cultural aspects and trends must be identified and analyzed, further crossing data with operational data allows to identify if physical interventions are effective or not.

Also, the Solid Waste Management Index (SWaMI) for HEIs was deployed. The SWaMI presents a diagnosis and monitoring key tool for environmental management. The index allows presentation, in a graphic way, of the solid waste management situation in four dimensions, Education, Engagement, Operations, and Policy and Management, therefore, it allows benchmarking HEIs' buildings, departments, unities, campuses and even between universities, this may vary according to data availability.

During the researchers exchange period for the University of Michigan, it was deployed a computational model using NetLogo's platform language to aid decision making regard recycling physical interventions.

Research Classification

The research deployed in this thesis is classified as exploratory, according to Gil (2007), exploratory researches aim to make the researchers more familiarized with the subject of research, to plainly observe and analyze all dimensions and influences.

The specific methods used in this research are described below:

Literature Review

The literature review focused on raising solid waste management best practices based on Bibliometric methods for papers research and selection, as proposed by Hibbs et al. (1984), Broadus (1987), Burton (1988), Hood; Wilson (2001), Hood; Wilson (2003), adapted to social sciences and sustainability research by Newig et al. (2008), Newig (2009) and Brandt et al. (2013);

Exploratory Research and Interviews – Waste Management at the University of São Paulo – São Carlos campus, and the University of Michigan

The research presents a qualitative and descriptive approach to describe and analyze procedures and interactions regard the studied subject, suiting Bulmer's (1977) methods for strategic researches, described by using social sciences to orientate towards concrete problems raised in society. This type of research aims to elucidate specific aspects e its instruments are basic research, both in theory and methods, but it directs results to management actions in ways to benefit society.

For this section of the thesis, according to Gil (2007), based on technical procedures used for data collection and analysis, the method used can be classified and a case study, a deep and exhaustive research, with detailed description and analysis of one or few research subjects.

Culture of Sustainability Assessment Survey

The culture of sustainability assessment survey deployment and application was carried accordingly to the methods used in the Sustainability Indicators Project proposed by the Institute for Social Research. The methods are detailed in Chapter V;

A Sustainable Waste Management Framework for Higher Education Institutions

A literature review was used to gather information and deploy the framework, the exploratory research and interviews gave practical inputs. Interviews were deployed with waste management stakeholders from University of São Paulo and University of Michigan.

Interviews were deployed using the semi structured method, leading the interview direction but also allows the interviewed to discuss about the subjects.

Waste Management Index for Higher Education Institutions

Methods are described at chapter VI.

Agent-Based Modeling as a Decision-making Tool for Recycling Initiatives

Methods are described at Chapter VII.

Chapter III - Solid Waste Management at Higher Education Institutions

HEIs have the potential of generating solid waste with large diversity and quantity, the types generated inside the same campus may vary from household, to industrial, to healthcare waste (FURIAM; GÜNTHER, 2006), and in some cases, some types of waste may not have the adequate disposal, a recurrent example of negligence is related to chemical residues that are highly hazardous, presenting great levels of danger to public health when not managed adequately.

Oliveira Júnior (2012, p. 49) deployed a study at the Federal University of Lavras that shows a solid waste generation of approximately 2,500 liters of chemical waste, Veiga (2013) presents in his study that at the University of São Paulo – Ribeirão Preto campus, from the 199 laboratories that participated in the research, around 67% generated chemical waste, in liquid and solid forms. At the Federal University of São Carlos a study deployed by Saqueto (2010, p. 71) presents that the campus generates a total of 670 liters of chemical waste per month, from this amount 218 liters are disposed inadequately, and only 9 liters are recycled. A study deployed by Imbrosi et al. (2006), at the University of Brasilia identified that from the 278 active laboratories at the campus, 144 generated chemical residues, from this amount 61% disposed these chemical residues “down the sink” or in garbage bins. Araujo and Viana present in their study, deployed at the School of Arts, Sciences and Humanities of the University of São Paulo – São Paulo campus (EACH-USP) that 233kg of food waste was generated at the unity restaurant, from this 84% had potential for composting, the authors raises how this value foments the importance for awareness and environmental education programs to prevent waste and adequate management.

These works allow to perceive how solid waste generation at HEIs may present potential environmental risk (ARMIJO DE VEGA; OJEDA BENÍTEZ; RAMÍREZ BARRETO, 2008; BALDWIN; DRIPPS, 2012; MASON et al., 2003; SMYTH; FREDEEN; BOOTH, 2010). Besides the potential polluting risk, these data show the lack of standardization regarding HEIs waste management systems. Nonetheless, it is worth noting that waste management efficiency will vary according to financial, social, cultural, politic and environmental aspects of a community. Population size, campus size and types

of teaching, research and outreach activities have direct influence over waste management (CORRÊA et al. 2010). Cruz et al., (2009) raise the discussion of how waste management is neglected inside HEIs decision making and how this trade-off cause negative impacts to public health.

Brazilian IES perform solid waste management without standardization and sometimes inadequately with law criteria proposed by the National Waste Policy (BRASIL, 2010), not performing the requirements of reverse logistics, not fomenting prevention in its community, without consortiums with recycling companies, and without reuse initiatives. By the researchers experience in observation, the lack of standardization causes divergences in the waste management quality inside even the same campus.

For example, through an exploratory research at the USPSC regarding an environmental education program it was observed that the different unities and departments have different solid waste management practices, some have more dynamic initiatives than the others, translating in a more effective program, even though it is deployed at the same campus, under the same program directives. Some unities have a very articulated program, highly participative and acting transversally throughout the department, other unities have a fragile program, with lack of engagement and unarticulated.

In the USPSC, by implementing initiatives to tackle a sound solid waste management the campus recycled 89.000 Kg (USP Recicla Reports, 2008 to 2014), other example is the Federal University of Ceará that recycled 73.755 Kg of waste between 2009 to 2014 (UFC, 2014). A study deployed by Scheneider (2012), at the University of Caxias do Sul shows that by implementing an environmental management program, between 2002 and 2010, 370 liters of chemical waste was adequately disposed, not contemning the environment.

These data show that Brazilian universities are walking towards environmental adequacy by adopting some tool as environmental management programs, (EMP) (TAUCHEN, 2006; ALSHUWAIKHAT; ABUBAKAR, 2008). Examples of universities pursuing environmental adequacy and sustainability are the University of Passo Fundo, RS, Brazil that implemented a EMP based on the International Organization for Standardization (ISO 14.000) norms, decreasing significantly its environmental impacts at the environment (TAUCHEN; BRANDI, 2006). The University of Monterrey, Mexico, adopted the sustainability report system proposed by the Global Reporting Initiative (LOZANO, 2004), postulating goals that mobilized all the university community towards

reducing natural resources consumption. Sustainability Certifications present a sound and successful leading tool for HEIs to adequate its activities according to sustainability principles, the tools that arise in this scenario are the Sustainability Tracking, Assessment & Rating System (STARS) and Green Metrics, organizations that postulate criteria that will lead the HEI to perform a self-assessment and producing sustainability reports. Hence, these tools do not exhausting study the waste dimension of a HEI, not being sensible enough to support decision making regard this subject (BOLAANE, 2006).

Laws, EMPs, and Certifications that considers waste management often are superficial, and do not tackle all the HEIs peculiarities that this complex subject is composed, as cultural behavior and how educational and operational interventions may influence each other and influence waste prevention, reuse and recycling, the large diversity regard the waste generated hazardousness level, the changes in its community with semesters. Also, these tools do not consider the potential that students, faculty and staff have to integrate the waste management, and how waste management systems must consider their culture and behaviors, identifying fragilities and opportunities to raise cultural values regard prevention, reuse and recycling, turning this community in sustainability agents (KELLY et al., 2006; SUTTIBAK; NITIVATTANANON, 2008; ZAIN et al., 2012; ARAÚJO e VIANA, 2013)

Baldwin e Dripps (2012) conclude that a waste management implementation does not depend only of the waste diagnosis and classification, these practices are not enough, the authors discuss that the most important is to understand behavior patterns that are responsible for generating residues. Zhang et al. (2011) presents in its work that by implementing a waste management system, that was composed by a step of survey application, savings of £125 thousand. Zain et al. (2012), through application of surveys regard students engagement, identified which changes were necessary at the campus to enhance the HEI recycling system, authors also present that people behavior is one of the main causes for the recycling program lack of efficiency. Marans e Schriberg (2012) conclude that survey application to assess communities' awareness, commitment and behavior is an efficient tool to monitor, throughout years, aspects regarding culture of sustainability.

The framework presented in this work use these experiences raised in the literature review to guarantee transparency in decision making, stakeholders engagement to identify and empower potential sustainability leaders, in this way, they will monitor they environment and enhance the HEI waste management quality. These aspects are pointed

as key for a sound waste management, it is seen that technologic innovation alone does not accomplish an adequate management (JABOUR et al., 2013).

Chapter IV - Solid Waste Management at the University of São Paulo and the USP-Recicla Recycling Program

The University of São Paulo (USP) was founded in 1934 and currently has 11 campuses distributed throughout the state of São Paulo, occupying a total of 76 million m², from this amount 12 million m² are ecologic reserves. Its organizational structure counts 31 administrative sectors, 48 schools and research institutes, 49 libraries, four hospitals and four museums.

The USP has a large history of implementing sustainability and environmental initiatives. Nonetheless, aspects regard these actions and initiatives continuity and fragilities are themes that deserve to be raised when discussing this subject.

One of the USP most important socioenvironmental programs is the USP Recicla, with more than 20 years of activity, it acts raising environmental education and awareness regard waste management in seven USP campuses distributed throughout São Paulo state.

How does USP Recicla Works?

The USP Recicla – da Pedagogia à Tecnologia program started its activities in 1993 at the USP – capital campus, at the city of São Paulo, Brazil, later it extended its actions to other USP campuses. Today, this program is the University's most successful socioenvironmental program and is a role model to other universities and organizations throughout the country, with several publications and successful initiatives. A partnership with the USP Agency for Innovation has the purpose to articulate and facilitate its activities inside the university.

The program reflects Rio 92 Conference and Agenda 21 postulations, with its actions focused in environmental education regard solid waste management. The programs actions tackle to educate through lectures to freshmen students, welcoming researchers, and third party staff. It has several practical initiatives with interventions at strategic spaces within the university by identifying bins and prevention of solid waste at the university's restaurant.

The program goals are the following (USP Recicla, 2016):

- To stimulate the USP community to incorporate values, attitudes and behaviors environmentally adequate, with focus in waste management.
- To collaborate with the establishment of conservation, restauration and improvement of the environment policies at the USP, within and at interfaces of the university.
- To contribute for strengthening USP students concerns regard socioenvironmental subjects.
- To constitute an integrated and shared management process at USP, becoming a role model for society.
- To support and foment initiatives promotion to tackle the goals above to articulate in USP daily research, teaching, outreach and management activities.

USP Recicla's mais products are presented in Annex 2.

USP Recicla – Challenges and Perspectives

The USP Recicla program, in its 26 years, acted in more than six campuses and currently mobilizes more than 500 people in its activities (SGA, 2017), offering environmental specialization courses, plus deploying environmental education actions and interventions.

Methods

Data collection

The information of this chapter was collected through literature review, semi structured interviews and survey application, through online platforms, to current and former participants of the program, annual reports and meetings documents from programs commissions, plus non-scientific articles found on the internet, as the USP Environmental Management Superintendence website.

The survey applied is available in Annex 3. At the end of this survey there was the choice for the interviewed to schedule a meeting with the researcher for a deeper discussion. The questionnaire was sent to key actors from the program's history in different USP campuses, the survey was developed and applied through GoogleForms.

A total of 13 responses were obtained from different USP campus and unities. From this amount, four interviews were conducted. Interviews were conducted in the first semester of 2016 and had the duration of 30 to 45 minutes, recorded and transcript. Interviews material were used at this chapters' discussion and analysis section. Names will not be mentioned.

Interviews results discussion and analysis

To discuss the interviews results, analysis categories were created with data from the surveys, Percentages of responses are presented for each aspect that the respondents found relevant for the programs strengthening and weakening, the analysis discuss data from interviews, researcher observations and documents.

Discussion and analysis

USP Recicla structure

The USP Recicla was implemented and further consolidated, initially, at Ribeirão Preto, Piracicaba, Pirassununga and Bauru campuses. The organizational structure works through building commissions, composed by one coordinator and four other people inside each campus unity where the program was installed to foment decentralization.

This model tries to give each unity more independence due to the unities knowledge of its own needs, of how much waste is produced and what needs to be done with it, one interviewed mentions: "The commissions are voted inside each unity. So, mathematics department has a different reality then chemistry or engineering departments. So, for example, it is easier to know which waste has which destination."

According to interviews data, the program works better at the countryside campuses, as São Carlos, Ribeirão Preto and Piracicaba campuses, this is due to these campuses hiring environmental educators, they act as environmental leaders inside decision making and works towards mobilizing the community.

USP Recicla trajectory in the USP – São Carlos campus

At USP-São Carlos campus the USP Recicla activities started in 1996, with the hiring of an environmental educator to work exclusively for the program, and since 2004 it has a Commission inside each unity of the campus, in a total of seven commissions.

There is also a Local Commission, to represent the campus, constituted by USP Recicla coordinators of each unity.

The building where the programs activities began, at pilot scale, was the Administrative Building E1, from the São Carlos School of Engineering, that also included the Center for Technological Education for Engineering and the campus administrative town hall.

The program succeeds in its activities and it was implemented at the Mathematics and Computational Sciences Institute and the Chemistry Institute.

The USP Recicla from São Carlos campus is one of the most active of all campuses. Its environmental education initiatives act inside administrative buildings, restaurants and housing buildings, plus other several activities of awareness distributed throughout the year.

The electronic addresses for the main projects executed by the USP Recicla from São Carlos campus may be found in Annex 4:

- Segregation enhancement
- Composting
- Sustainable events
- Mobility
- Sustainable housing
- University's Restaurant waste
- Indicators

The program also had a partnership with the municipality in a segregation and recycling Project, promoted by three recyclable collection enterprises, due to decision-makers discontinuity these three enterprises became one. After a functional and structural reorganization of this enterprise, in march of 2016, when this data was collected, the USP Recicla still had a partnership with this enterprise. There was also a partnership with a municipal garden, where organic waste generated at the university's restaurant was sent for composting, but due to decision makers discontinuity the partnership was also canceled.

Through annual reports the program published its experiences and results for the community. It was published four reports, related to years 2008/2009, 2009/2010, 2010/2011 and 2011/2013.

In March 2016, there was a partnership between São Carlos municipality and the enhancement of solid waste segregation, this project still ongoing, and goes from intervention in the campus physical structure increasing and identifying recyclable bins to environmental educational and awareness interventions through short courses and lectures regarding solid waste prevention, reuse, and recycling within and outside the university.

Reports results referring to 2008/2009 activities (USP Recicla, 2009) are presented at table 1.

Table 1 - USP Recicla Program Report 2008/2009.

Report 2008/2009	
People involved	74 people
Projects	5 projects
Lectures	39 lectures
Public reached by lectures	1282 people
Educational interventions for university's community	13 interventions
Public reached by Educational interventions for university's community	481 people
Educational intervention for external public	31 interventions
Educational intervention for external public	1557 people
Paper recycled	35.340 kg

Reports results referring to 2009/2010 activities (USP Recicla, 2010) are presented at table 2.

Table 2 - USP Recicla Program Report 2009/2010.

Relatório 2009/2010	
People involved	80 people
Projects	5 projects
Lectures	18 lectures
Public reached by lectures	846 people
Educational interventions for university's community	9 interventions
Public reached by Educational interventions for university's community	582 people
Educational intervention for external public	16 interventions
Educational intervention for external public	759 people
Paper recycled	21.049 kg

Reports results referring to 2010/2011 activities (USP Recicla, 2011) are presented at table.

Table 3 - USP Recicla Program Report 2010/2011.

Relatório 2010/2011	
People involved	80 people
Projects	7 projects
Lectures	17 lectures
Public reached by lectures	819 people
Educational interventions for university's community	1 interventions
Public reached by Educational interventions for university's community	12 people
Educational intervention for external public	12 interventions
Educational intervention for external public	685 people
Paper recycled	no information

In 2011, the USP Recicla program launches its website with goals to bring the community closer to the programs reality (USP Recicla, 2011).

Reports results referring to 2011/2012 activities (USP Recicla, 2013) are presented at table 4.

Table 4 - USP Recicla Program Report 2011/2012.

Relatório 2011/2012	
People involved	90 people
Projects	6 projects
Lectures	22 lectures
Public reached by lectures	763 people
Educational interventions for university's community	1 intervention
Public reached by Educational interventions for university's community	200 people
Educational intervention for external public	11 interventions
Educational intervention for external public	1035 people
Paper recycled	17.370 kg

Reports results referring to 2012/2013 activities (USP Recicla, 2013) are presented at table 5.

Table 5 - USP Recicla Program Report 2012/2013.

Relatório 2012/2013	
People involved	31 people
Projects	6 projects
Lectures	14 lectures
Public reached by lectures	1282 people
Educational interventions for university's community	13 interventions
Public reached by Educational interventions for university's community	350 people
Educational intervention for external public	31 interventions
Educational intervention for external public	1557 people
Paper recycled	14.889 kg

Figure 3 – USP Recicla activities progression at São Carlos Campus from 2008 to 2013.

USP Recicla Structure and operationalization

After 2013, a change occurred in USP Recicla structure, accordingly with one interview “before there was the USP Recicla for the whole campus, hence, now, it is fragmentized. For each unity, there are one acting USP Recicla.” Due to this structural change, some unities are still trying to adequate its activities, therefore, they are not producing the annual reports, also, any training was given for the unities’ commissions regard how reports need to be deployed, and which kind of information they must contain. Most importantly, people complain about overload of tasks. Any of the people interviewed could answer if reports will be published annually or biannually.

The program, until 2013, counted with an environmental educator that responded directly to the USP Agency for Innovation, designated specifically to deal with the Program’s actions. The São Carlos educator during her period working with the program engaged several students, faculty and staff in the program, published several papers, books and book chapters regard solid waste management and environmental education.

In March 2016, USP Recicla was linked to the São Carlos Chemical Residues Laboratory (LRQ). The recyclables collection company did weekly visits to the programs warehouse, where all the recyclable waste was stored. The responsibility for logistics and disposal of recyclables became responsibility of the LRQ crew, that deal with paper, paper boxes, plastics, light bulbs, electronics, chemical waste, and laboratory equipment. One of the interviewed rises the issue “Nowadays is hard to tell which residue is LRQ’s responsibility and which is USP Recicla’s.”

According to one of the interviewed there is no consensus regarding what are USP Recicla’s responsibilities, while some believe that the program must focus its practical action only to recycling, some other believe that the program’s responsibilities must go further, beyond operational recycling, its main responsibility is environmental education and awareness. One of the interviewed say that programs commissions must focus in awareness and engaging its community to build cultural values regard solid waste prevention, reuse and recycling.

Some people believe that USP Recicla is just distributing cups (one of the most famous program’s activities), others discuss that the program must focus its efforts in engagement. For example, one of the interviewed people cites that his motivations:

“My unit is small, it is composed by 30 people, and it Works with outreach. Our engagement with the program was Always trying to implement proposals regard solid waste prevention, recuse and recycling. Our rooms have boxes to discard paper that will be sent to recycling. We have discussed regard ways to decrease paper consumption with documents, and to buy printers that print front and back. Also, for some years now we do not use disposable cups, event at our events. At the end of 2015 we implemented an exchange rack where staff could put objects that they did not wanted and get others of its interest.

With the outreach program, we worked with visits to the landfill and to the Department’s Agroecological garden that have a compost site with worms to prepare organic residues, also with material reuse as PET bottles to built a garden and tires as vases. We deployed projects with São Carlos schools with the state research agency support. But my biggest motivation to keep participating at the programs activities is to turn the USP to a sustainable university.”

It was perceived, with all the interviews, that the main motivation for engaging the program is previous engagement with environmental activities.

Since 2013 rearrangement, where each unity must have its own independent commission, the structure at São Carlos Campus is the following:

The program at the Mathematical and Computational Sciences Institute is linked to Management and Planning Department. At the Physics Institute it is linked to the unit’s Environmental Management Commission. At the Chemistry Institute it is linked to the Administrative Issues Commission. At São Carlos School of Engineering the program is linked to Quality and Productivity Commission.

USP Recicla Program challenges

People interviewed were from the different USP campuses, exploring the different realities for each unity that the person interviewed represented.

Figure 3 presents the percentage regard the engagement time at the program activities of the respondents.

■ Between 1 and 5 years ■ More than 15 years ■ Between 5 and 10 years ■ Between 10 and 15 years

Figure 4 - Percentage regard the engagement time at the program activities of the respondents.

Figure 5 presents the responses regard the aspects that contribute for the program weakening.

Figure 5 - Responses regard the aspects that contribute for the program weakening.

For being a decentralized program and with interdisciplinary actions, throughout its existence face several challenges. Nevertheless, integration and transversally acting was always one of the programs obstacles, like cited in one of speeches:

“If there is no high administration support, administration staff, and cleaning crew, the program becomes unsustainable.”

The main fragile aspects of the program are:

- Lack of Human Resources: the program presents low number of exclusively dedicated people to the programs initiatives. The USP Recicla Program is present at more than three units at the São Carlos Campus, with several outreach programs, partnerships with municipalities and recyclable collectors associations, and, even with all these projects the number of exclusively dedicated people to the program is low. The USP Environmental Management Superintendence (EMS) tries to mitigate this problem by offering internships to act for the program. Nevertheless, since the scholarships for interns last only one year the program becomes fragile due to always must train these people. Besides interns, the program always counted with volunteers for its continuity.

One of the points of weakening for the program is how third party employees, hired for cleaning, change. The training regard recycling bags, how to collect and how to dispose them not mixing different types of solid waste are recurrent problems faced by the program.

- Lack of Financial Resources: according to one of the interviewed, the program always works with limited resources, since the discussion regard socioenvironmental issues is not a priority for the university high administration. Hence, with the EMS creation more efforts have been made to deploy the programs activities. One of the tools deployed to support these efforts was a proposal call launched at 2013 to foment, specifically, sustainability projects. According to one of interviewed, when EMS was supposed to give the selected projects the money, the University faced an economic crisis and could not give for the researchers the financial resources.

- Lack of Infrastructure: in interviews, one of the raised points for programs weakening was the lack of a specific physical space dedicated to the program, according to one of interviewed of one of the units where the USP Recicla program was inserted, this affected the identity of the program, since the program was always changing its location, the lack of a specific room difficulties the access by the community.

- Conflict of interests: the program counts with a complex network of interpersonal relations, where several sectors of the university must communicate with each other, in this sense, people that work at the program must work at mediators. Besides this, due to USP Recicla not having a well-defined leadership, roles of charging and incentive are often given as trustworthy positions. This generates several conflicts in interpersonal relationship within the program.

- Politic Will: Lack of support by decision makers and section heads can become a limiting factor for employee engagement. According to one of the people interviewed speech

"Even if you have super-busy people, that super donate their time to make it happen, if you do not have a leadership person who releases you, you will not go, will not do [...] we as employees, we are hired as CLT, then we need to give satisfaction to the immediate boss, and he is the head of the area, so this type of organization chart that already exists in every enterprise and USP follows that model, right, it weakens. When you have not only an immediate boss, but a section chief, the unit, which does not encourage the business to.

[...]

Even if the units' director releases the person, but his immediate boss finds it unnecessary, the incentive for it will be minimal. Because wanting or not, it's a period of your work schedule that you are focusing on something that does not belong to your section, so if your immediate boss sees no importance in that, he can chase you for it. "

- Politic Discontinuity: One of the points raised by one of the people interviewed, when asked about the USP Recicla Program's partnership with the municipality, was the political discontinuity and conflicts of interest. According to his speech, for example, in one of the campuses there was a partnership between the municipality and the municipal garden, where the university sent organic and composted material to serve as fertilizer for the food grown there. However, new elections occurred and due to the change of mayor, the partnership was discontinued.

In addition, political discontinuity is also cited through unit leaders, who may influence the discontinuity of the program. It is seen that even a program with strong name and relevant actions on campus end up succumbing to political will of decision makers.

Another example is that in the city there were initially three recycling cooperatives, due to change of mayor and conflicts of interests, these three cooperatives merged into one, which caused several problems, as the weakening of recycling initiatives in the city, affecting, also, the USP Recicla Program actions.

Some other factors can also influence and hinder the walk of programs focused on solid waste prevention. One of the people interviewed cites, as an example, the case of the H1N1 flu outbreak, where the program on its campus was very fragile in this regard, as it was encouraged not to use durable materials to avoid contamination, buying only disposable cups.

However, some units are more engaged, better structured and more proactive than others. For example, some units have manuals for managing their solid waste, produce guides, and distributing them for the community. While others are more unstructured, and without significant productions.

In summary, the main point of the people interviewed regarding the challenges the USP Recicla has been the lack of community engagement actions by the commissions as well as lack of organization and structure within these commissions.

In addition, because the environmental theme is not one of the university's priority areas, the program often encountered difficulties, as shown in the speech of one of the interviewed people.

"The environmental area always presents a conflict of interest and is still perceived by some managers as a necessary evil, which hampers progress."

USP Recicla success factors

A Figure 6 presents responses regard the aspects that contribute for the program success.

Figure 6 - Responses regard the aspects that contribute for the program success.

Nonetheless, not only of challenges were made the USP Recicla pursuit, several factors influenced the program to consolidate itself as a socio-environmental role model for universities and companies. The USP Recicla Program is a program focused on environmental education and community engagement, it works both with mobilization and in operational approaches of the logistics and solid waste management of the campus. As the speech of one of the people interviewed shows:

"We (USP Recicla) advise the cleaning staff that they will collect this separate material and that they will bring it here to our warehouse. These people are meant to do that. My shed is always full. Now, if the guidance is passed on another level (in units). We do not know that. Now, what was thrown at the orange bin or at the little box the cleaning lady collected it! Now what was not geared to be thrown there and has already been thrown to the regular trash, this we do not have the control. This is a matter of guidance. It's a usual thing, once you get used to it, it's easy.

The students are floating. Every year we give the little mugs to new students. If we do not give them a year, that year the guy will not

know if the mugs even exist, so it's something that must be constant. Soon the student leaves and new ones come in, then you must say everything again. "

In addition, some key points can be identified in the speeches of the various people interviewed, these are the main ones:

- Infrastructure: As said by one of the people interviewed:

"Infrastructure is indispensable, being a material presupposition of importance equivalent to the availability of financial resources. I remember that IQSC had (and must still have) an important space for the reception of recyclable materials. The existence of this space was of paramount importance for structuring our initiatives. "

- Community engagement: the program has always presented a high commitment from academic community, in most of interventions it counted with the support of several volunteers among teachers, students and employees. In addition, the commissions of the program within the units are composed of volunteer teachers and staff engaged in solid waste management and who play the role of multipliers of socio-environmental actions.

In addition, USP Recicla has always sought to engage the community through raising a sense of identity, and belonging to something greater. An example cited by one of the people interviewed was the use of the mug, where the incoming students used the mug because of the influence of veteran students.

One of the people interviewed reinforces community engagement as a pillar of the Program's success at his campus.

"I believe that the people involved, always committed and engaged, played a relevant role in program implementation and continuity on the campus of Ribeirão Preto, mainly due to the encouragement and presence of the environmental educator. I also consider the organizational structure of the program itself, that is, the composition of Unit commissions, linked to a campus commission, which in turn was previously linked to a Steering Committee on the USP capital campus. This structure exists until the institution of the Superintendence of Environmental Management of USP, which today has evaluated the future of the program. In the middle of the course of the program I consider a negative impact the extinction of the Executive Coordination of University Cooperation and Special Activities (CECAE), organ where the USP Recicla program was thought, generated and instituted. "

- Political will: The program, mainly in its beginning, and after the creation of the Superintendence of Environmental Management, has had enough support of political will. One of the interviewees cites, for example, that it is necessary, motivation by the immediate heads of the sections in addition to directors and coordinators. This is an important factor, because according to this person's experience, the incentive of his immediate boss was extremely motivational for his participation.

In the specific case of the Institute of Mathematical and Computer Sciences, one of the people interviewed mentioned that after the creation of the Office of Planning and Management in 2013, there was a greater commitment and support from the decision-makers to the program, "Strong supporter inside the ICMC unit." The agency has functioned as a mediator in the procedures related to the Program's activities within the unit.

- Trained human resources: even with a low contingent, the few people who were hired as environmental educators made a total difference in the program's progress, being able to engage and mobilize several people, both inside and outside the university, inside and outside Brazil. In addition, sharing program's experiences in congresses and through scientific articles, encouraging and helping other universities to implement socio-environmental programs, related or not, with the theme of solid waste management and environmental education. One of the interviewed people points out that "Human resources are the engine of the program, and the main node to be solved, since most people do not care to participate with high levels of commitment."

- Financial resources: Some of the people interviewed cite the economic crisis that the university faces as a factor that contributed to some of the program's activities success. This, due to the promotion of the reduction of consumption of consumer and durable goods, for example, reduced printing, involving paper and toners and recovery of some chemical waste with potential for reuse.

One of the people interviewed points out that "Financial resources are imperative for any educational program."

- Support through University Ordinances and Resolutions: Only one of the people interviewed cited this item in their speech.

"Support through ordinances and resolutions is of paramount importance. When the Internal Commission of USP Recicla in IQSC happened to appear next to other commissions and collegiate bodies in the own website of the unit, we ended up feeling more

strengthened and recognized. Financial resources are imperative for any educational program [...] Unfortunately, I do not recall that my unit demonstrates so much political will for the actions of the program. It was clear that the leaders of the unit did not understand the importance and scope of USP Recicla, even ignoring that the actions of the program go far beyond what its name suggests (recycling actions only). "

All the dimensions highlighted here are of fundamental importance to the success of the program, some are more relevant than others, but should not overlap.

Short description regard USP Recicla in other USP campuses

USP Recicla Programa at the Luiz de Queiroz School of Agriculture (ESALQ)

The USP Recicla ESALQ branch was instituted in November 14, 2012, published at the São Paulo Official Diary by the Portaria ESALQ nº. 15, that institutes the USP Recicla program.

To the commission members it was asked to elaborate the planning goals and execute strategic actions at USP/ESALQ, related to environmental education and Solid waste shared responsibility, in addition to support and participate at Work Groups, produce reports and half-yearly actions to present to the local coordinator and unit's director.

One of actions proposed by the USP Recicla/ESALQ, was the Informatics Waste Disposal and Reuse Center (CEDIR), that started its activities in December 2009. This initiative is linked to Eletronic Computational Center (CCE), and it has as mission to allow the adequate disposal of USP's informatics and telecommunication waste.

USP Recicla/ESALQ projects may be found in annex 1:

- Folder Minimização de resíduos em eventos e reuniões (2007)
- Plano Diretor Socioambiental (PDS) Participativo do Campus "Luiz de Queiroz" (2009).
- Guia para Gerenciamento de Resíduos – Campus "Luiz de Queiroz" (2010) .

Poli Recicla Program from USP Politecnic School (Poli)

The POLI experience according to its website states (POLI RECICLA, 2016):

“Poli USP Recicla program started its activities in the second semestre of 2006, integrating the USP Politecnic School, within responsibility of COCESP (Campus Coordination of São Paulo), and dedicate to promoting a sustainable waste management within the university.

The school has a community of 17,000 people, distributed in eight buildings, the waste generated complexity includes since office waste to different types of research and teaching laboratories, lead the project to start its activities through a diagnosis regard the current situation proposed by State Waste Policy and other pertinent laws.

We have the following activities:

- Light bulbs management
- Batteries management
- Laboratory waste management
- Segregation of non hazardous waste

[...]”

The Poli Recicla is managed by a commission composed by 2 teachers (3 years), 3 staff (3 years) and 2 students (1 year) that seek, through a participative way, to propose simple and efficient solutions to waste management.

The Poli Recicla has a great history of results, one of its main initiatives was the fluorescente light bulbs collection, that, since it was implanted in 2006, until 2012, sent more than 25 thousand units for decontamination, in this same period it was collected 3 tons of batteries. In this period, 1,4 tons of recyclable electronic material was sent for reuse.

USP Recicla Program at Ribeirão Preto campus

The USP Recicla Ribeirão Preto started its activities in 1996, since this period it deployed several activities related to waste management within and outside the campus.

One of its most palpable products is the waste management guide “Guia Tá na Mão: Olhando os Resíduos e Repensando as Práticas – Gestão de Resíduos no Campus da USP de Ribeirão Preto”, more details can be found in annex 4.

Other USP socioenvironmental initiatives

People that Learn Participating (PAP)

Prepared by the Environmental Management Superintendence of USP in 2014, works through the Multiplier Network methodology. Where USP staff, technicians and third party employees, were responsible for socio-environmental education of other professionals within university. The project counts with the coordination of an environmental educator directly linked to the EMS.

The program's main idea is to critically train USP employees on issues related to socio-environmental themes. So that all knowledge produced within the USP regarding sustainability is applied and disseminated to employees and their work colleagues.

The program is divided into levels, where the first level, PAP1, was composed of 20 employees who were initially involved with the socio-environmental theme of USP, among them some teachers. The PAP2 had 180 multiplier participants.

Each PAP2 participant was responsible for training 30 more servers. Thus, it is expected that all 17 thousand USP employees will be presented to the program. PAP3 is being deployed.

Environmental Management Superintendence and the USP Environmental Policy

The USP's Environmental Management Superintendence (SGA) began its activities at the end of 2012. Since then, it has shaped the university's socio-environmental identity, as well as fostering and supporting the journey towards sustainability by consolidating its vision, mission and strengthening initiatives.

The SGA became a milestone in the discussion of the socio-environmental theme of USP as an agency with mission and budget exclusively focused on this theme. Functioning as a strategist organ, it elaborates demands that must be fulfilled by campuses, units and museums that compose the university.

The SGA launched in 2013 an invitation to stimulate sustainability projects in the university, where several projects, in all the campuses were granted with financial subsidy. In 2014, it innovated when it started the discussions regard the creation of USP's Environmental Policy, where the USP's environmental identity was defined, based on the postulation of the principles, guidelines, mission and goals for the university's socioenvironmental management themes.

Table 6 (SGA, 2015) shows the details of USP's environmental policy.

Table 6 - USP Environmental Policy Details.

TERM	DEFNITION	WHO DOES IT?
Environmental Policy	Set of principles, objectives, guidelines and management instruments of the USP Environmental Program that includes: USP's environmental policy, thematic policies, the Environmental Management Plan and Thematic Plans, the Environmental Directors Plan and the Environmental Programs.	SGA Working Groups (WG) Physical Space Superintendence (SEF) WG Coordinators Management Councils Internal Commissions
USP Thematic Environmental Policy	Set of principles, objectives, guidelines and instruments established by the institution, to outline its environmental directions.	Working Groups and SGA
Environmental Management and Actions Plans	It is an instrument for the implementation of USP's environmental policy, which includes diagnostics, objectives, prognosis, targets, indicators, monitoring and evaluation of environmental policy. It is composed of all thematic plans.	WG Coordinators SEF SGA
USP Environmental Management Plan	It is an instrument for the implementation of each USP environmental policy, which includes diagnostics, objectives, prognosis, targets, indicators, decision making, monitoring and evaluation of environmental policy. Each thematic environmental policy will have its Management Plan.	WG SEF SGA
Environmental Management Plan	It is a governance instrument that aims at the environmental sustainability of campuses and social inclusion; With planning of the use of the territory, planning of the future and compliance with the legislation, and that must be elaborated in each campus of USP. This plan will be	Campus Environmental Standing Committee (SGA, SEF, Boards of Directors)

	developed based on the documents of the Environmental Policy and Environmental Management Plan of USP.	
Environmental programs	Set of actions developed by the Complementary Units, Museums, Integration Organs, Organ and Prefectures of the campuses for the application of the Master Plans of each Campus for the prevention and resolution of environmental problems.	Internal committees

There are 12 Thematic Working Groups that have met periodically and treated in several areas, and the presentation of its first draft occurred in September 2015. The themes are: Water and effluents, Sustainable buildings; Environmental education; Emissions; Energy; Fauna; Mobility; Waste; Sustainability in management; Land use - green areas - ecological reserves.

USP Solid Waste Policy

In 2014, discussions regard the USP's Solid Waste Policy elaboration were initiated, by a SGA initiative, a working group was created composed by faculty and staff from various campuses and specialists regard the theme. The Solid Waste Management Working Group (Waste WG) aimed at structuring guidelines for solid and liquid hazardous waste management within the University of São Paulo.

This policy was based on the criteria proposed by the Brazilian National Solid Waste Policy. It provides principles, objectives and instruments, as well as guidelines on solid, including hazardous, waste generators and applicable economic instruments.

Its premise is that the units will be executing such guidelines according to their specifics.

According to SGA website, (SGAb, 2016):

"Waste WG has been working to:

- 1) To know the diversity of waste through a mapping and construction of a waste matrix;
- 2) Redeem the guidelines that already exist inside the campuses;
- 3) Prepare a diagnosis of the current situation within the units;
- 4) Delimit from the workgroup name for "Hazardous Solid and Liquids Waste Working Group" by leaving the effluent and water part to another commission that addresses more specific issues and is represented by area experts. "

Exploratory Research University of Michigan Recycling Program

The University of Michigan (UofM) Recycling Program acts, currently, under Custodial and Grounds Department, responsible for buildings and open spaces that compose Ann Arbor campus. This department is responsible for more than 26 mi m² of property.

The department mission is the following:

"Our mission is to serve, with excellence, by providing custodial services, pest management, waste management and recycling, grounds maintenance, and landscape design services in the support of a safe, functional, and attractive campus environment."

The activities of the University of Michigan Recycling Program are carried out by the Waste Reduciton & Recycling Office (WRRO), which strives to provide operational and

educational waste reduction and recycling programs that reduce the University's environmental footprint within the community Local, state and global. WRRO also encourages students, faculty, staff, and visitors to apply the skills learned through these programs on and off campus, now and in the future.

University of Michigan's Recycling Program Challenges

Figure 7 presents the percentage of response when respondents were asked which factors influenced or influenced the weakening of the University of Michigan's recycling program.

Figure 7 - Percentage of responses, about factors that may weaken recycling initiatives in universities, of people interviewed in UofM.

Lack of Resources and Lack of Engagement

One of the major challenges described in interviews conducted at the University of Michigan on aspects that influenced its recycling program, was the lack of engagement by

university employees. As can be seen in the following speech *“When there is a lack of administrative and financial support from upper administration and campus stakeholders, it is difficult to move programs forward”*.

The interviewees mentioned that employees engagement does not occur proactively, there is still no top management support for their participation in the activities. As for the students participation, they are interested, attend and interact with the intervention activities proposed by the program. However, participation is limited to specific events, the Earth Festival event was cited, where the program has an interactive space with didactic activities on awareness and recruitment. However, after recruitment, due to engagement being voluntary, the evasion rate is large.

Lack of human resources

UofM's recycling program lacks human resources to carry out activities such as drafting reports, mobilizing agents, quantifying recyclable waste, preparing dissemination material, and people for intervention activities.

Two of the interviewees mentioned that one way to mitigate such problem would be to hire more people to participate exclusively in the program, but they do not foresee this in the near future, because high management provides a palliative initiative to make more human resources available to the program by hiring trainees.

Lack of politic will, Conflic of interests, and Lack of Ordinances and resolutions

The lack of political will has great influence in the success of any type of initiative in any type of organization. Similar to the University of São Paulo, respondents at the University of Michigan also point out that lack of interest from top management weakens the success and continuity of the recycling program. As can be observed in the speech of one of the interviewees *“Lack of interest/desire by leaders will negatively impact any waste reduction programs success”*.

Still, conflicting interests among decision makers are fragile, the interviewees' speech mentioned issues such as the discontinuity of activities with the change of the Presidents of the University of Michigan, as well as how the program lost strength in one of the institutes after the change of the Director of this institute.

One of the interviewees mentioned how the postulation of waste reduction objectives, supported by the president of the university, helped consolidate and engage the activities of the program.

Lack of infrastructure

The Recycling program always had a room to work, this raised a sense of identity for the program, where the community could reach and give comments and suggestions regard waste issues, one of the interviewees says.

Regarding this aspect, one of the interviewees speech tells that “*The disappearance of the glass market has resulted in UofM no longer accepting glass for recycling.*” This example of the glassware market, where the university provided a space for glass collection where craftsmen and other organizations could buy these materials, after this initiative was discontinued due to orders from the upper management the university stopped to recycle glasses.

Still one of the people interviewed mentions that one of the main challenges is to find entities to buy the collected recyclables, “*additionally, we can only recycle items that have a market for them in this area. If there were more markets, we could expand the items accepted for recycling.*”

University of Michigan Success factors

Figure 8 shows the percentage of response when respondents were asked which factors influenced the weakening of the University of Michigan's recycling program.

Figure 8 - Percentage of responses, on factors that may strengthen the recycling initiatives in universities, of the people interviewed in UofM.

Politic will, Conflict of Interests and Universitites Ordinances and resolutions

As identified at the University of São Paulo, respondents at the University of Michigan mention that the support of the university leaders is of fundamental importance for the success of the initiatives, where one of the interviewees points out that *“Leadership in all levels/areas is critical in reaching the university. recycling/waste reduction goals”*.

The interviewees mentioned the consolidation of several activities and the increase in demand for the program after the postulation of the university's sustainability objectives in 2010 in an open letter written by the university president at the time. Since then the search for a more sustainable university has been part of its mission. In addition, the objectives encourage the community to embrace the mission and identity of the university on sustainability aspects, says one of the interviewees.

Infrastructure

Infrastructure was one of the main points raised during the interview, related to financial resources and support through internal legislations of the university, interviewees mention that a space where the university community can go to engage, take questions, and even take their waste would facilitate the program's work.

Financial resources, Human Resources, and Engagement

The aspects regard Engagement, Financial Resources and Human Resources were the most cited in the interviews, one of the interviewees reinforces that community engagement is a key factor for the success of the university's recycling program, "Engagement is essential for a successful recycling program because we need students, faculty, and staff to be knowledgeable about waste reduction and recycling and for them to be motivated to participate. "

As for the program's support, the university has no waste policy or environmental policy, however, in 2010 the university president postulated several goals for 2025, and these goals provide support for the program, as explained by one of the respondents "University Policies Support our program, such as the President's sustainability goals for 2025. "

University of Michigan waste management activities description

Who collects the non-hazardous waste at UofM?

UofM's waste collection is carried out by the outsourced company PBGS Waste Management Services, which performs the collection and other environmental services of the buildings and various properties of the university. The team works from 5am to 1pm, six days a week to collect and dispose of non-hazardous waste and recyclable materials.

Who collects the hazardous waste at UofM?

Hazardous waste collection, such as health and laboratory waste, is the responsibility of the Occupational Safety and Environmental Health department, in the Hazardous Material Management (HMM) program, this department provides services and supervises hazardous waste generators for Compliance with the regulations regarding the collection, packaging and identification of these hazardous wastes. Under the residues under your supervision are: Chemical Waste, Radioactive Waste, Biological Waste and Universal Waste.

HMM, supported by other programs, also responds to chemical spills, biologicals, radioactive materials and wastes from potential environmental impacts that occur on campus facilities or on campus grounds.

ChEM Reuse Program

The Chemical, Equipment, and Materials Reuse (CHEM) Program is a UofM Sustainability Initiative where a stock of overdue chemicals, equipment and unused materials have been created that are available for use in research and teaching laboratories. The ChEM program aims to:

- Protect the environment by reducing the overall volume of hazardous waste sent for disposal.
- Reduce the cost of purchasing new materials if those in stock are acceptable for your research or teaching needs.

The program allows UofM research and teaching laboratories:

- Get free chemicals, equipment and materials available from your stock.
- Donate excess chemicals, equipment and materials to this redistribution program to others that people can find a purpose.

How much is the cost to manage waste at UofM?

The collection of recyclables is carried out free of charge, different from the collection of other waste, the cost of waste management services in UofM is presented in detail in table 7.

Table 7 - Costs description for waste management at UofM, by type of waste managed.

Type of Waste/Service	Value by 3m³
Compacted waste	\$45.00
Non compacted waste	\$20.28
Landfill disposal	\$84.00
Waste excess	\$54.00

How and what is recycled at University of Michigan

UofM has a broad spectrum of waste generation, however, it also shows itself as a model presenting recycling routes for all waste produced. Table 8 presents the waste management services within UofM.

Table 8 - Waste management services description within UofM.

Type of waste	What to do?
Bottle taps	The WRRO office launch the Cap-ture program, a pilot program to collect metal and plastic bottle caps.
Glass	Since January 1, 2016, suspended glass waste collection. The glass market decreased for the past years and now they are completely out of service. Nevertheless, the WRRO have launched initiatives for prevention and reuse.
Batteries and hazardousness material	Batteries are collected at UofM specific points and send to third party companies for adequate disposal. This initiative is coordinate by HAZMAT, or the Hazardous Management Program that collects also other hazardous waste such as fluorescent light bulbs and paints
Paper boxes	All cardboard can be disposed of for recycling in recycling bins. Not Recycled: Boxes lined with wax or ink and hardcover books.
Hard cover books	To recycle hard cover books, one should contact the Waste Management Services. They are collected separately for recycling and should not go in the blue bin intended for recycling paper
Official documents	Official documents are crushed. The University of Michigan has a Strategic Supplier Agreement with Corrigan Moving Systems for the destruction of confidential documents. This service is provided only for University employees.
Construction demolition, and renewal waste	The reuse and recycling of waste generated from construction, demolition and renovation projects is an excellent step towards a holistic recycling program at UM. This waste is the responsibility of the Property Disposition department, in order to have access the user should contact the Waste Management Services department.
Construction demolition, and renewal waste reuse	A large amount of material generated from renovation and demolition projects can often be reused. Furniture, doors, windows, and electronic equipment are among the most commonly reused items. UofM units and departments that generate reusable items should contact the Property Disposition department.

Construction demolition, and renewal waste recycling	After separating the reusable items, now it's time to recycle the rest of the materials, such as: scrap; Metals, paperboard, pallets, wood scrap (untreated wood only), concrete (may include rebar).
Reuse and recycling of electronic medias	Waste Management Services collects electronic media for recycling. This includes CDs, DVDs, 3.5 "and 5" floppy disks, audio and video cassettes, film reels, slides, and vinyl records.
Electronic waste	The Waste Management Services department collects the electronic waste.
Foam	The Waste Management Services department collects this type of waste.
Computers	All electro-electronics purchased by the University, when discarded, working or not, should be referred to the Disposal Department. This includes items such as computer monitors, CPU, TV, cell phones, and any item with a circuit board (this includes all items with a digital display).
Laser Toner & Ink Jet	To recycle cartridges, the user must contact Mikan Corporation, UofM's strategic supplier for remanufactured cartridges.
Milk and juice boxes	Milk and juice boxes can be recycled in recyclable waste baskets.
Metal	Can be recycled in recycling bins and waste bins.
Metal scraps	Small amounts of scrap are collected at no cost. For large quantities of scrap, the units may request the use of roll off for collection and recycling, the value of the scrap sale is returned to the unit.
Office Materials	The Office Supply Amnesty Day of 2016 is scheduled for June 30. On this date, Waste Management Services teams will collect gently used office supplies on campus buildings and make them available at no cost to the University and local nonprofits. This program supports the University of Michigan's sustainability goal of reducing landfill waste by 40 % by 2025.

Paper	Can be recycled in recycling bins and waste bins.
Plastic	Plastics can be recycled in the "mixed" recycling basket.
Wood waste and pellets	Untreated wood pellets and waste (crates, sawn wood) are collected by the Waste Management Services upon request. This service is only available on the campus of the University of Michigan Ann Arbor.

Exploratory research contributions for the Waste Management Framework based on interviews

Through interviews and data collection that were added by the literature review, it becomes evident the need for a waste management system, focused on the HEI peculiarities that students, staff and faculty can be incorporated in the management process as sustainability promoters, also, it was identified gaps regard tools that discusses, in a department focused approach, technical, organizational and financial strategies in resources usage regard waste prevention management.

This stage of the exploratory research brought several inputs to the framework, maturing it. Key factors were the importance and key role of community's engagement and availability of proactive human resources.

A HEI that commits itself to adopting better sustainability practices must overcome these weaknesses.

In this chapter it were discussed two programs that have already been consolidated. The analysis raised some pertinent discussions regard waste management within HEIs, the main ones being:

Institutionalizing recycling programs is the solution for a strong waste management?

Yes and no.

Yes, it will strengthen and support the discussion, providing financial and human resources.

However, engagement is of the utmost importance. There, the "No" comes in. Without community involvement, the main factor of the program's fragility is found, not only in the USPSC, but also in exploratory research and in the Interviews conducted by the doctoral student, as well as in the work of Perkman et al. (2012), where the authors state that, as far as industry-academia partnerships are concerned, the engagement of the academic community is positively related to individual characteristics that define senior and scientific researchers, indicating that engagements in sustainability aspects influence the Their individual academic activities.

The university is not an island and must seek partnerships with the municipality

It is extremely important that the IES consolidates a partnership with the municipality. Especially in educational aspects, where students can interact through extension and internship programs within the city hall, learning how to work at the end of waste management processes and policy implementation, as well as their tools, such as command and control actions; Providing awareness courses and training multipliers within the city; The researchers of the HEIs should integrate in the decision making, adding concepts of the academy to the decision making of the municipality.

In addition, operational aspects should be considered, through consortium notices, as an example cited by one of the interviewees where USP-São Carlos, from an agreement with the City of São Carlos, takes its pruning waste to the crusher Another example was the municipal garden that received and compost the waste of the University Restaurant.

Chapter conclusions

New aspects and dimensions were added in this post exploratory research version, for example, it was identified in the interviews that engagement and human resources availability are major keys for environmental programs continuity, directors and other decision-makers discontinuity may be a weakness factor that influence socioenvironmental programs. The interviews were deployed with end of the processes stakeholders that faced and overcame these obstacles, that were first identified through the literature review. The interviews raised the importance of bringing best practices examples regard waste management for a wide variety of realities and how management occur in each of them.

It is noticeable that several factors may influence the continuity of a program related to the socio-environmental theme in an HEI, however, some factors such as the engagement and availability of proactive human resources are of essential importance for the effectiveness and efficiency of the activities proposed for the program.

Chapter V - Sustainable Solid Waste Management Framework for Higher Education Institutions

Abstract

At Higher Education Institutions, sustainability must permeate research, teaching, outreach, management, operation, and behavior changes so they can become a role model for society. An important part of the discussion about sustainability in these spaces lies in solid waste management. This paper proposes a Framework for Sustainable Solid Waste Management at Higher Education Institutions. The framework presented in this paper aims to fill the gap on existing waste management systems due to lack of specificity for Higher Education Institutions peculiarities. Its implementation process considers community's culture of generation, reuse, disposal and recycling, aids HEIs' policy instruments development to pursue a sustainable path, and tools to diagnose and monitor management system's status. The framework was developed through systematic review of reports from leader Higher Education Institutions on sustainability and solid waste management, scientific articles reporting best practices on solid waste management, environmental policies and certification tools. The Framework for Sustainable Solid Waste Management at Higher Education Institutions brings some initiatives examples that will guide these institutions to pursuit sustainability with practical approaches. The System for Sustainable Solid Waste Management must be conducted in accordance with the Plan, Do, Check, Act cycle. Outputs of the presented framework seek to standardize waste management according to HEIs' teaching, research and outreach different profiles. By sharing experiences reports, campuses throughout the world can create a learning network. HEIs' community will be engaged in all phases of implementation, and culture regard solid waste aspects will be assessed using survey applications. Hence, this framework provides the Solid Waste Management Index's set of criteria to diagnose the system status. This behavioral and operational assessment allows to benchmark HEIs' buildings and departments, creates a qualitative and quantitative data baseline to compare with further years, and support decision makers by identifying campuses' physical and management aspects that need emergency interventions.

Overview

This article proposes a Framework for Sustainable Solid Waste Management at Higher Education Institutions (SWHEI), which engages community in decision-making in all implementation phases, and fosters a participative culture of sustainability throughout Higher Education Institution (HEI) and municipality actors.

HEIs are spaces for sustainable best practice and strategic planning development and application. This discussion must enroll research, teaching, outreach, management, operations, and behavior turning HEIs into role models for society (Palma et al, 2011; Bero et al, 2012; Lozano, Lukman, Lozano, Huisinigh, & Lambrechts, 2013), acting as pilot scale spaces to elaborate and implement strategies related to sustainability issues for reducing use of natural resources (Clarke & Kouri, 2009; Kaplowitz, Yeboah, Thorp, & Wilson, 2009; Barros et al., 2013; Spencer et al., 2013). In this way, community is capable to see changes at their environments, becoming culture of sustainability promoting agents, fostering a continuous learning process using multi, inter, and transdisciplinary actions (KARATZOGLOU, 2013). Solid Waste Management (SWM) is a key aspect of sustainable HEIs' campuses (FELDER; PETRELL; DUFF, 2001; FERRI; DINIZ CHAVES; RIBEIRO, 2015; HARRIS; PROBERT, 2009; MALAKAHMAD et al., 2010; SMYTH; FREDEEN; BOOTH, 2010).

A systematic review of lead sustainable HEIs' solid waste management policies, sustainability reports, and scientific articles, was deployed according to Beigl, Lebersorger, & Salhofer, 2008; Broadus, 1987; Burton, 1988; Hood & Wilson, 2001, 2003, presenting that HEIs waste quantities and hazardousness potential vary according to their didactic ends, research facilities, dining and residence halls (ALSHUWAIKHAT; ABUBAKAR, 2008), the main weakness is that HEIs solid waste management do not follow a standard protocol, this paper aims to fill this gap.

This article proposes a standardization framework for HEIs' solid waste management systems, considering HEIs' waste quantity, diversity, and peculiarities (BARNES; JERMAN, 2002), and community's generation, reuse, disposal and recycling culture (KAPLOWITZ et al., 2009).

Mostafa, Shazly, & Sherief, 2009 concludes that lack of environmental systems standardization cause negative impacts and trade-offs when considering environmental, social, behavioral/cultural and economic dimensions on decision-making. To consider community's

behavioral aspects and to foster sustainability awareness interventions aids HEIs' pursuit of sustainability (LOZANO, 2006).

Current Environmental Management Systems (EMS) does not consider all dimensions required for a sustainable waste management, hence, are not specific enough to HEIs peculiarities. HEI's waste management must consider seasonal change of its student community and third party employees, and waste quantity, diversity and hazardousness. Also, prevailing systems do not seek integration and transversally, do not pursue to build values regarding re-education for reduce, reuse, and recycling within community. Hence, existing EMSs ignore HEIs' diverse cultural aspects, and how they may influence consumption and disposal of solid waste patterns, that have major influence regarding social, environmental and economic waste management's effectiveness aspects (KELLY et al., 2006; SUTTIBAK; NITIVATTANANON, 2008; ZAIN et al., 2012b).

SWHEI is a framework divided in four phases – Plan, Do, Check, Act and each phase is subdivided in steps. *Plan* phase allows to prospect and to gather resources and permits project executioners to choose an implementation course of action. *Do* phase entails the framework by engaging community, and unveiling waste stream diagnosis. *Check* phase allows assessing previous phases' executional aspects, identifying opportunities for improvement, developing and applying monitoring indicators. *Act* phase elaborates and presents reports results to decision makers and community.

The expected outline of this Framework is to answer a “*How To?*” question that rises when HEIs campus seeks to start, update or enhance its waste management.

Sustainable Waste Management at Higher Education Institutions Framework

The Brazilian Group Núcleo de Pesquisa e Extensão em Sustentabilidade e Saneamento that deployed SWMHEIs Framework aimed to fulfill a solid waste management standardization gap reaching more sustainable HEIs. The researchers used as main references the International Standardization Organization (ISO) 14.001 Environmental Management System series, Global Reporting Initiative, and consultancy with several waste management specialists to accomplish frameworks final version.

The framework must be conducted in accordance with the Plan, Do, Check, Act (PDCA) (ISO 14000, 2015) cycle, these four phases of implementation are subdivided in a series of steps.

PDCA improvement cycle is a management tool that seeks prevention of mistakes in standardization systems (Moen & Norman, 2006).

The PDCA cycle phases are described as:

- Plan: Map of the human and financial resources, define objectives, project mission, goals and targets to monitor the processes required to achieve the expected results.
- Do: Sets up activities execution and operationalization.
- Check: Actions to assess the frameworks effectiveness and efficiency.
- Act: High management and stakeholder's system analysis to identify weaknesses and improvement opportunities, ensuring a continuous process improvement.

The framework proposed in this paper engages HEIs' community in solid waste management by turning them into sustainability promoters, community's sustainability behavioral and cultural assessments using surveys, considers cost-efficiency, presents a wide selection of best practices case studies, and enhances dialogue between HEIs, municipality, and recycling cooperatives, to promote consortia and integrated actions intra and extra campus's community, hence, compromises to publish, through self-reporting, successful experiences, acting local but with a global range of influence (ALNSOUR; MEATON, 2015; KELLY et al., 2006). Figure 11 shows the plan with more details.

Figure 11 - Description of solid waste management framework for universities according to the PDCA cycle.

The four PDCA phases are subdivided in steps that gather actions focused on solid waste management specifically for HEIs, presenting worldwide experiences that will help decision makers by creating an information exchanges network.

The item 2.2.2 presents specific actions selected by literature review over HEI sustainability reports and papers reporting solid waste management initiatives, and guidelines for implementing environmental systems models.

Plan

2.1.1 Working Groups Formation

This step aims to map students, teachers, researchers and staff who are interested in participating at implementing the Framework at campuses. This step is an effective way to map sustainability entrepreneurs, consolidating weekly meetings and task assignments to each

individual, not overloading any of the participants, combined with periodical presentation of results (Bero et al., 2012).

The literature review points that high management support is key for successful campuses pursuing sustainability. Without top-down and bottom-up consortium sustainability efforts are faded to fail due to lack of investments, infrastructure and engagement (Brinkhurst, Rose, & Maurice, 2011).

Hence, regarding staff engagement, even when participation is required by high administration, some individuals may give up participation due to overload assignments.

2.1.2 Goals Development

In this step, development of goals will enable decision-makers to schedule activities regarding framework implementation processes. It is important that each goal has specific deadlines.

Hence, to use progress as a motivational tool, at the end of each goal the products obtained must be presented to the group. It is of extreme importance that all individuals working in framework implementation to have a clear understanding of processes' objectives results and benefits (QUIROGA, 2009).

2.1.3 Technical / financial feasibility study

This step will describe projects' technical and financial feasibility and deployment potential. Human resources availability is key for further steps successful progress (LOZANO, 2016), assuring knowledge for project implementation. It is important to have people who understand solid waste management legislation and environmental impacts, and managers with leadership skills to coordinate and designate tasks to the team.

The framework initiative may come from high management (top - down approach), in this case, at most studied cases, financial resources were often available. An alternative path is pressure by student, faculty, and staff (bottom – up approach) community to high management. Acknowledging successful initiatives is key to overcome barriers faced by “faculty and staff's own reluctance to realize their potential as leaders of change” (Brinkhurst et al., 2011). If resources are not available inside the institution, the project can be submitted to funding agencies, using the strong argument of using the HEI campus as a living research lab.

2.1.4 Resources Availability

For a sound progress a Plan of Expenses must be developed showing sources and were operational, human and financial resources will be applied. Presenting these information in tables eases understanding. This step consolidates progress to go through a continuous and consistent path. This step will make sure that project implementation process will not overload the participants nor spend resources carelessly.

2.1.5 Selection of Specific actions

This step consists on selecting actions to be performed during framework deployment process, this selection must be carried in partnership with university's high administration, this is key for a successful project deployment as it foments faculty and staff entrepreneurs to move forward in investing their time into sustainable initiatives (Brinkhurst, 2011).

Actions must be selected in different levels, according to HEI's reality and educational characteristics, e.g. waste from an institution focusing on health sciences has greater environmental risk than an institution focusing on social sciences.

Actions selection must also respect human and financial resources availability, as well as decision makers' degree of commitment. Considering that if the framework becomes more mature, through years, more specific actions can be taken place.

Do

2.2.1 Community awareness

This step must be conducted so the project is developed with HEIs stakeholders' participation. This step will increase reliability of community on changes that are occurring on the solid waste management system, this way, they will increase their sense of identity as important actors and leaders that play a major role to a successful progress (Genus, 2014).

Through publicity and advertising campaigns, HEI's community must be informed of project's progress, this allows making the process open to suggestions and new members.

Additionally, the idea of this step is to aware the entire academic community by creating moral values of sustainability related to solid waste topic of discussion, so that all the community turn into multipliers of these actions.

2.2.2 To integrate educational dimension practices with other, engaging, operational and policy & management dimensions to improve campus sustainability

This is the key part of the framework, in this following session it will be presented strategies to integrate HEIs most important peculiarity, and what differs this framework from other frameworks already deployed. It is important to understand that the HEIs, different than other institutions, have the obligation to build knowledge and to train its community to serve society.

HEIs responsibility to prepare new leaders, based on sustainability principles, given the opportunity for raising awareness and sustainable culture by engaging its community in daily activities, by preparing them to see daily challenges and solve it through more sustainable approaches.

For example, this work is focused on building tools with a strong sustainability culture regard waste prevention, reuse and recycling, in this sense, there is no better way to accomplish this goal than using HEIs most important and strong element, its students. By integrating daily activities and operational challenges, or fomenting students to participate in management and decision making spaces it is possible to create strong sustainability leaderships. By exploring transversally HEIs' different research interfaces and using the campus as a living laboratory, HEIs are incentivizing students' engagement to solve campuses challenges by training them.

New educational methodologies must be deployed and applied for teaching, research and outreach. These methods must integrate educational activities in campus daily activities by engaging students to tackle campus challenges.

These actions must be applied according to HEI's campus educational and research profile, the actions are presented in the following section.

2.2.2.1 Teaching, research and outreach

Greening of the curriculum

This step is essential for project deployment due to classrooms being key discussion spaces to build critical thinking about sustainability and environmental issues. The greening of the curriculum in universities is a major discussion topic, and it has become a key tool for developing responses to crises, building critical and proactive human resources for prevention and solution of society problems. The greening process permeates HEIs' communities, therefore, it requires technicians, teachers and students, to be deeply engaged and committed to learning and disseminating knowledge related to sustainability aspects (CRAIG; ALLEN, 2015; MÜLLER-CHRIST et al., 2014).

The curriculum greening presented by this framework inserts the discussion of environmental issues, environmental protection and conservation, economics and optimization of natural resources in the teaching, research and outreach for undergraduate and graduate students (Capdevila; Bruno; Jofre, 2002; Koester; Eflin; Vann, 2006; Lukman; Tiwary; Azapagic, 2009; Yuan; Zuo; Huisingh, 2013). The curriculum greening within universities can occur in two paths, proactively, where teachers intend to initiate this process, or reactionary, where HEI policies, or students require this process to occur (LIDGREN; RODHE; HUISINGH, 2006).

The curriculum greening as a tool to foster sustainable management of solid waste in HEIs must address the following aspects:

1 - Awareness, through preparatory courses for teachers, focusing on legislation, best practices and innovation in the solid waste field of knowledge (CAPDEVILA; BRUNO; JOFRE, 2002);

2 - Institutionalization, where HEI decision makers must develop policies, plans, programs that consider the discussion of solid waste in teaching, research and outreach of main goals (Lozano, 2006; Zhang et al., 2011);

3 - Integration of social and environmental issues within programs of all courses (ALSHUWAIKHAT, 2008);

4 - Insertion of specific subjects, discussing the solid waste issues focusing on technological innovation, management processes, and socioeconomic dimensions (Lozano et al. 2011);

5 - Publication of specific textbooks, mandatory for disciplines, with environmental themes focusing on solid waste (Sterling, 2001);

6 - The curriculum greening process should pay attention to regional solid waste management needs, addressing practical challenges of communities where HEI is inserted (GAO et al., 2006);

7 – Feedback surveys for teacher's continuous improvement at the end of courses with social-environmental themes to enhance teaching and learning process (CRAIG; ALLEN, 2015);

8 - The curriculum greening should behave as an indicator of sustainable solid waste management performance at HEIs (STARS, 2015).

Outreach with focus in sustainability and environmental education

Outreach activities described in this step, whether in engineering, social sciences or health sciences, for example, is key tool to enhance discussions regarding solid waste management, incorporating technological innovation, optimization of operational processes and management and social integration and creating a sense of identity and belonging for collectors, cooperatives and other solid waste related activities at the base of the work pyramid (JAIN et al., 2013).

As one of HEI's main pillars, outreach must dialogue with teaching and research to overcome academia walls and tackle society's problems (PATTON, 1985). Outreach must also support society with innovative knowledge built into the classrooms and research laboratories, as a two-way path, where private sector provides directions, provoking HEI's purposes with its challenges, and the HEI, in return, provides benefits through qualified human resources and innovation technologies to prevent and solve such problems (NUNES; SILVA, 2011).

HEI outreach activities as a tool for practical application of knowledge acquired during courses has proven to be essential to a high quality education, preparing human resources through direct contact with needs of society. This process of dialogue allows academy to reformulate its organizational structure, curriculum to whatsoever regional needs (SAWYER, 2008).

1 – HEIs' outreach programs must be decentralized, covering all HEIs' courses (HORDIJK; BAUD, 2006);

2 - Outreach programs must communicate and assist the municipal solid waste management initiatives (ALNSOUR; MEATON, 2015);

3 - HEIs must facilitate bureaucratic procedures for integration between students and community (MÜLLER-CHRIST et al., 2014);

4 - HEIs must create short, medium and long-term programs that promote outreach activities supporting cooperatives and other solid waste collection activities in their operational and administrative processes to reduce influence of political discontinuity (HORDIJK; BAUD, 2006; MOHR; LEE, 2000);

5 - HEIs must designate a mandatory workload for teachers and students specifically for outreach activities (ITZEK-GREULICH et al., 2015);

6 - HEIs must promote an outreach activity that assists prevention and resolution of local communities' crises (Stokes; Coomes, 1998; Fantin, 2011).

Research using the campus as a living laboratory

As proposed in this step of the framework, research focused on sustainable solid waste management must cover physical aspects, training and raising awareness of solid waste collectors, innovative processes to solid waste prevention in and out campuses, enhance efficiency and effectiveness of treatment methods, moreover, the main strategy should focus on behavioral aspects in order to increase cultural values for the HEI's community regarding solid waste prevention, reuse, recycling and re-education (MAUSER et al., 2013).

This framework seeks to reinforce that research and outreach are one of HEIs' main pillars, applying knowledge produced within classrooms is responsible for preparing students to solve problems, using local needs, but with potential to global replications (HORDIJK; BAUD, 2006). HEIs' research must also maintain continuous dialogue with society in order to propose innovations that make their processes economically and ecologically feasible (GENUS; THEOBALD, 2014).

HEIs must be considered as peculiar communities where projects can effectively deploy, introduce and test innovative sustainability concepts. This new field of actions has catalyzed actions in campus infrastructure, opening of new research programs, leading investments and fostering a culture of sustainability throughout the campus (VEZZOLI; PENIN, 2006).

Problems related to reducing consumption of natural resources has fostered the use of HEI campuses as living laboratories of sustainability (MCMULLAN; LONG; GRAHAM, 1986). These

initiatives have been observed in areas related to solid waste prevention, reuse and recycling, building arrangements to reduce water and energy consumption, sustainable purchases (e.g. buy from certified environmentally friendly companies), furthermore efforts around transportation, use of renewable energy sources and outside community engagement with campuses facilities. Efforts joining physical and behavioral areas presents an excellent strategy to contemplate a sustainable campus (LEVY; MARANS, 2012).

To use the campus as a living laboratory encourages and strengthens commitment of students with applied challenges, and make campus environments dynamic to teaching and research activities. In addition, the Living Labs are a way to apply innovative strategies and management processes (EVANS et al., 2015).

Liedtke et al., (2012) presents a program of action to use campuses as living laboratories of sustainability, Figure 10.

Figure 9 - Program of actions to use campuses as living research laboratories. Where LLab means Living Lab.

Table 9, elaborated by the authors through literature revision, brings suggestions for the use of HEI campuses as living laboratories of waste management practices.

Table 9 - Suggestions for the use of HEI campuses as living laboratories of waste management practices.

Aspects	Suggestions
Educational	To map all teaching, research and outreach sustainability related initiatives using the campus as a research area

	To identify campus areas that requires actions of correction and focus on teaching, research and extension in these
	Teaching, research and outreach activities applied in micro and meso scales within the campus and work as a role model for municipality and industries
	Teaching, research and outreach must be multi and interdisciplinary, focusing on applying initiatives on campus in technological innovation, socio-cultural, organizational, economy and environment dimensions
Policy and management	To institutionalize policies that promote teaching, research and outreach, which use the campus facilities for their activities
	To create an experience exchange network with other universities (MACRIS; GEORGAKELLOS, 2006; VEZZOLI; PENIN, 2006)
	To disseminate results of research carried out using the campus property to the entire community that uses these dependencies (Mistura, Härter Vaniel, & Linck, 2010)

2.2.2.3 Management

HEIs campus management with a sustainable bias has shown, through creation of positions along academic and administrative hierarchy, an "strengthening strategy" that enhances institutions to achieve and consolidate environmental responsibility activities (EVANS et al., 2015).

Financial investments in solid waste management

Financial support is essential for project implementation, it is necessary that the commission responsible for this seeks resources, both within the HEI, by means of internal calls, and requests to decision-makers through annual expenses planning, as well as requests through public calls of funding agencies.

- Integrate project activities on half-yearly / annual financial planning;
- Submit proposals to funding agencies using the campus as a living research laboratory;
- Preparation of projects for institutions internal calls using the campus as a living research laboratory;

- Seek support of environmental agencies and sustainability institutions (BERO et al., 2012).

Political will

High management's support is key to begin, and to continuously improve HEIs' solid waste management, in many cases facilitates the implementation of environmental management systems, mostly because it comes with financial resources and specialized human resources (BRINKHURST; ROSE; MAURICE, 2011b).

Sustainability office

A specific space for discussion and for HEI community to address when they have questions or suggestions regarding sustainability or solid waste management system is essential. The creation of a specific office of sustainability within the institution will allow, through exclusive dedication of some professionals, like secretaries and leaders, to improve communication with community and deploy strategies to raise funds.

This step must follow these authors' suggestions in order to accomplish an dynamic, integrated and multidisciplinary office (BRINKHURST; ROSE; MAURICE, 2011b; VON BLOTTNITZ, 2006).

- To have professionals dedicated exclusively to perform administrative functions;
- To map individuals with an interest in participating;
- The office should contain representatives of students, faculty and staff;
- Provide trainees grants for various activities of the office to engage students.

Institutional policy

This step regarding institutional policies will provide legal support to actions and existing sustainability initiatives, as well as foster development and implementation of new initiatives, providing financial and human resources. Suggestions for how to proceed in these steps are:

- To develop an environmental/ solid waste policy a policy for the institution;

- To create an environmental committee divided in working groups;
- To elect a leader for each working group;
- To stipulate goals for each working group;
- To schedule regular meetings of working groups and to present working groups' results;
- To develop a policy that promotes actions to waste reduction, reuse, recycle.

Discussion with municipality

One of most important innovations of this framework is constant dialogue between HEIs and municipality so decision-makers of both institutions can discuss similar problems and postulate joint solutions that will benefit both. There must be a constant dialogue between campus' and municipality's solid waste management, since HEIs cannot be taken as an island. This consortium is presented as a good strategy for strengthening this dialogue. Research HEIs' programs must be encouraged to address interactively municipal problems.

Monitoring and reports

Applying indicators and reporting assists monitoring the projects' implementation progress. This process must be open to public suggestions and observations (CEULEMANS; MOLDEREZ; VAN LIEDEKERKE, 2014).

- Reports should be available on digital platforms;
- Reports should be disclosed to the entire community, presenting successful actions and weaknesses;
- It must be discussed how improvements can be addressed individually and collectively;

This issue is discussed with more specificity in item 2.4.1 and 2.4.2.

2.2.2.4 Operational

A HEI campus committed to having its operations acting more sustainably is characterized by having some basic strategies, as described by Evans et al. (2015):

- Promoting engagement of teachers, students, and staff, all with different priorities, with supervisory powers of reporting activities at odds with HEIs' sustainability mission;
- Present awareness actions covering a wide range of activities and institutional facilities which allow campus functionality, including offices, laboratories, classrooms, dining rooms, bedrooms, and maintenance;
- Activities discussing wide distribution and diversity of buildings, diversity of waste, collection routs, and bins distribution.

Staff training/capacitation

It is important to raise employee's awareness and engagement. Hines et al. (1986) shows 17 studies that indicate that individuals are more likely to act in an environmentally responsible way when they understand environmental problems and / or its potential solutions, reinforcing the need for sustainable development to be inserted into the curricula discussions.

In this sense, it is possible to evaluate, both positive and negative aspects of environmental perception, engagement and awareness (Thomas, Perosa, & Martín, 2012; Tudor, Barr, & Gilg, 2007; Viebahn, 2002). Furthermore, consortia must be deployed for municipalities' staff training.

Producer Responsibility

A fundamental part of the framework is implementing producer responsibility strategies. They should dialogue with recycling collectors' organizations, as well as with companies that provide products for universities (Ferri et al., 2015).

- Insert producer responsibility strategies in buying processes;
- Require commitment to regular gathering of products suppliers, for example, pesticides, batteries, and light bulbs, to collect these products after its use. HEIs' campuses serve as collection points of these products, where the community could take them.

Storage and waste segregation

Storage containers must be clearly identified as its destination, thus avoiding that non-recyclable materials are sent to the wrong final disposal.

For domestic, health care services, hazardous, and construction waste management the local legal instruments must be applied.

This step must incorporate the following suggestions for teaching and research laboratories:

1- Foster calls for specific financial resources to deploy projects regarding technological innovation, optimization of operational processes and management with a focus on reuse, recycling and integration with cooperatives and other waste collection activities;

2- Aware researchers, so that they can be inspectors and internal mobilization agents to their work places, in areas such as reduction, reuse, recycling and re-education (MAUSER et al., 2013).

Based on some of United States Environmental Protection Agency's guidance (EPA, 2002) and Misura et al, (2010), it is presented some suggestions for teaching and research laboratories that generate chemical waste:

3- Identify and register chemical waste generators in the experimental activities in chemistry research and teaching laboratories;

4- Monitor the generation, quantitatively, of chemical waste according to each laboratory;

5- To identify, characterize and quantify the waste generated in laboratories, in an online database, then benchmark them;

6- Plan and test alternative procedures to decrease consumption of reagents for conducting experimental and laboratory activities;

7- Reuse waste laboratories by recovering solvents;

8- Develop a management system for the laboratories for its chemical residues;

9- Institutionalize the management system to ensure the continuity of the program;

10- Disseminate experiences with the waste management system between and to other laboratories;

11- Propose the ongoing evaluation of the program (update and optimize processes).

2.2.2.5 Culture

Awareness Programs

Intervention activities that encourage community to help the campus walk to a more sustainable path is essential where the students, faculty, researchers and staff become leaders in sustainability issues. These programs should reflect all internal and external community desires and identity (VIEBAHN, 2002).

In addition, disclosure of actions related to sustainability taken in campus, e.g. amount of recycled waste, and amount of waste recovered by producers responsibility shows community that projects actions are functional.

These awareness programs must:

- Have periodicity;
- Disseminate results of other sustainability initiatives taking place on campus;
- Act as a communication tool between community and decision makers;
- Be proactive and dynamic;
- Search support of decision-making committees through its institutionalization;
- Its activities should be included in institution's plans and programs;
- Its activities must have specific short, medium and long term goals.

The campus becomes an open sustainability model for community

The campuses must act as role models for society, working, for example as point for collection of hazardous waste such as light bulbs, batteries, etc.

The students, teachers, researchers and staff should be encouraged to disclose, by means of digital and oral routes, the various activities that take place on campus.

One must strengthen the community culture that the campus is a place where they can participate in activities related to solid waste and the community can learn by doing;

- Providing handcraft mini-courses for waste recycling community;
- Promote fairs where products made in short courses can be traded;
- Promote periodic fairs for marketing of handicrafts by collectors.

Community engagement

Initiatives that integrate and foster staff and faculty engagement in sustainability activities within institutions make these more efficient, effective and long-lasting (VIEBAHN, 2002).

The community should be sensitized that are essential factors in campus walk toward sustainability, such as:

- Have waste management sustainability representatives in decision making spaces;
- Part of your hours of participation in sustainability and solid waste management activities are considered as workload time;
- Engaging teachers and researchers in municipal decision-making;
- Strengthen and encourage dialogue between HEIs' and city's decision makers.

Check

2.3.1 Diagnosis of Input and Output Products and Waste

This part of the framework must be conducted to create a baseline of how is the waste management system working at HEIs, providing decision makers information to direct were most efforts should be inserted. Hence, this step of the framework will provide the decision-makers data by applying the Solid Waste Management Index for deploying diagnosis of key issues and what is being conducted in HEIs and how is the framework behaving, allowing to set goals and priorities.

This set of criteria aims to provide the right questions on how to pursue improvements of a HEIs solid waste management, such as: Are we discussing waste management in all our possible communication means? Are we concerning about engaging our community? What are we doing to minimize our impacts over natural resources? What can we do to enhance to pursue a more environmental friendly waste management?

The application of these criteria will allow subside the creation of baseline data on the environmental and sustainability performance, as well as advising information on how the institution pursues and manage these aspects.

The Dimension Indexes, I_{Di} , are calculated by the equation 1:

$$I_{Di} = \frac{1}{n} \sum_{j=1}^n P_j$$

Where: j = Dimension; P_{ji} = i -th individual criteria for each dimension j ($j=1,..., n$; $i=1,...,m$).

The I_{Di} will further be combined into a composite index through the Linear Aggregation Method (Nardo et al., 2008; Zhou et al., 2012). The SWaMI Index (*SWaMI*) can be calculated by applying the following formula:

$$I_{SWaMI} = \frac{1}{n} \sum_{j=1}^n \sum_{i=1}^m P_{ji} w_i,$$

Where:

$$\sum_{i=1}^m w(\text{educational}) = 2,6$$

$$\sum_{i=1}^m w(\text{engagement}) = 2,0$$

$$\sum_{i=1}^m w(\text{operational}) = 2,9$$

$$\sum_{i=1}^m w(\text{Policy\&management}) = 2,5$$

,

$$w_i \geq 0,$$

w_i = i -th practice indicators weight.

Similar to the Individual IWM Practice Index, I_{IWM} values may fall between 0 and 1, representing the worst and best possible result, respectively.

The Table 10, elaborated by the authors, shows a first set of criteria to collect the data.

Tabela 10 - Evaluation of Criteria to do the diagnosis of the Waste management, where if the HEI have the adequate management fill with 1; when HEI does not have the adequate management fill with 0; and when the HEI that does not have to deal with this kind of waste fill with -.

Area	Theme	Criteria	How to evaluate?
Educational (Teaching,	Sustainability insertion	1. Outreach projects focused on waste management	Does the HEI have any outreach projects that integrated with SWM

Research and Outreach)		2. Research projects focused in Waste Management	Does the HEI uses the campus as a living laboratory, Does the HEI use research to tackle solid waste prevention, reuse, and recycling operational and management challenges?
		3. Undergraduate courses that discuss Sustainable Waste Management in their curricula	Does the HEI insert solid waste prevention, reuse, and recycling subjects on courses curricula? Does the HEI
		4. Graduate courses that discuss Waste Management in their curricula	
		5. Publicity campaign of reducing, reuse and recycling practices	Does the HEI periodically insert subjects regard solid waste prevention, reuse and recycling in its official newsletter, or any other publicity media?
Engagement	Community (Students, Staff and Faculty)	6. Educational Programs for faculty and staff for Sustainable Waste Management	Does the HEI promotes short courses, or provides guides for its staff and faculty community that approaches solid waste prevention, reuse and recycling?
		7. Initiatives related to waste management promoted by faculty and staff	Does the HEI pursue, map or foment sustainability leaders inside its community by acknowledging their accomplishments over solid waste prevention, reuse and recycling initiatives results?
		8. Technical training, courses, lectures and cultural interventions in the sustainable solid waste management area	Does the HEI promotes any kind of training, short courses, lectures and cultural events that deals with solid waste prevention, reuse, or recycling?
Operational	Disposable Products (i.g.	9. Paper and card boxes consumption reduction	Does the HEI have any program to deal with this specific waste prevention, reuse or recycling?
		10. Plastic preventioon	

paper and
plastic)

Eletronics	11. Electronics reuse program	Does the HEI have any program to deal with this specific waste prevention, reuse or recycling?
	12. Collection and correct disposing of electronics program	
Sustainable Buildings	13. Proper disposal of lamps	Does the HEI dispose its lamps according to producers responsibility?
	14. Proper disposal or recycling of construction waste	Does the HEI have recycling programs for construction waste?
Food	15. Programs focused on food waste prevention	Does the HEI have programs, advertising, or other kinds of initiatives to tackle food waste?
Campus grounds	16. Composting of pruning waste	Does the HEI compost its pruning waste?
Biological and hazardous residues	17. Correct Biological and hazardous waste disposal	Does the HEI dispose its Biological and hazardous waste according to the specific legislation?
Water	18. Water conservation	Does the HEI have water conservation programs?
	19. Consortium with municipality to treat effluents generated on campus	In case of the HEI have to allocate its wastewater, does the HEI adequately allocate it, e.g. Does the HEI have wastewater stabilization lakes?
	20. Greywater reuse	Does the HEI have systems to reuse greywater in irrigation or cleaning purposes?
	21. Reuse of auto parts	Does the HEI promotes auto parts reuse, or recycling?
Transports	22. Adequate oil disposal	Does the HEI dispose oil according to the legislation.
	23. Adequate Tire Disposal	Does the HEI have programs for tires adequate disposal or tires reuse, and recycling?

Waste	24. SolidWaste Reduction, Reuse and Recycling Engagement Programs	Does the HEI have programs that engage its community, through teaching, research and outreach to tackle solid waste operational challenges?
	25. Space for community participation in waste management decision making	Does the HEI have an open space that promotes community engagement to participate, such as a committee, on solid waste decision making?
Governance	26. Policies, plans and programs for Waste Management	Does the HEI have institutionalization instruments to support, pursue or foment initiatives for solid waste prevention, reuse, or recycling?
	27. Sustainable planning with short, medium and long term goals	
	28. Existence of a specific office for Waste Management	Does the HEI have a space for the community
Policy and Management	29. Publication of reports regarding waste management	Does the HEIs have resolutions, programs, or initiatives that quantifies the amount of the specific items cited at the column on the right? The results can be presented through solid waste reports reports, in websites, or newsletter.
	30. Transparency in the allocation and return for subcontractors for the final disposal of hazardous waste	
	31. Participation of stakeholders in the elaboration of policies, plans and programs aimed at Waste Management	
Management for Sustainability		

2.3.2 To apply the Monitoring Indicators

The set of monitoring indicators must be elaborated and used to consolidate a baseline of important operational quantitative information, and assess efficacy and effectiveness of the Framework regarding campus daily activities. This set of indicators must be collected in a daily basis. The literature suggests that collection of data to be carry out on two different times of the year, during period of classes, and during the students breaks, to represent the discrepancies of waste production that occur during the school year. Thus, this set of indicators will allow decision-makers to have a baseline of data to compare with the before and after the implementation of the framework.

The Table 11, elaborated by authors, shows a set of indicators that will direct the first data collection. As the framework becomes more mature, other indicators must be added to specify and to make the monitoring more sensitive.

Table 11 - Set of Monitoring Indicators for the Waste Management Framework.

Waste Indicators	Indicators	Quantity
	W1. Total amount of waste that goes to landfill	Kg/year
	W2. Total amount of waste recycled	Kg/year
	W3. Total amount of hazardous waste generated	Kg/year
	W4. Total amount of waste from pruning services	Kg/year
	W5. Total amount of construction waste	Kg/year
	W6. Total amount of waste sent to composting	Kg/year
	W7. Quantity of bins for recyclable waste	# of recyclable bins
	W8. Quantity of bins for waste that goes to landfill	# of regular bins
	W9. Volume held per recycling bin	How much each bin holds (m ³)

2.3.3 Questionnaire application for Stakeholders Feedback

In this step, a feedback of the framework deployment process must be conducted so fragilities can be identified and corrected.

The framework deployment process should have as much dynamism and contribution of the academic community. So, after the implementation of actions, questionnaires that enable evaluation of the framework implementation must be prepared in accordance with specificities of each unit.

Questionnaires should cover aspects relating to the project implementation process, engagement, integration between units, satisfaction of participation, achievement of targets, etc.

2.3.4 Identification of Weaknesses and Improvement of Opportunities

From previous step, the application of feedback questionnaires to stakeholders must be identified weaknesses that must be worked on and opportunities for improvement, where focuses on the activities that make it possible to optimize the entire framework are carried. Weaknesses must be observed carefully and discussed with campus stakeholders.

The step of application of feedback questionnaires identifies key aspects of strengthening and weakening. This step will capture key data from persons that were engaged in frameworks deployment, allowing a specific discussion over paths to be pursued on the future (Shriberg, 2002).

Act

2.4.1 Reports Preparation

Reports developed in this step should be produced in an objectively and concisely, with accessible language to whole community, presenting data on *post factum* situation of implementation of sustainable solid waste management framework. This report must contain two mandatory parts, which are:

- Improvements occurred with implementation of the framework: the main results for the economy of financial resources should be provided, reduced environmental impact, reduce consumption, materials that have been reused, and recycled materials.

- Weaknesses found in current management system: It should be presented where the system has its weaknesses, to raise community's awareness and provides information to decision makers.

It is suggested that the report also contains an item explaining and describing experiences every of the process deployment, so that other universities, private businesses and the municipality can replicate and learn from the experiences of the HEI.

Reports can be developed following the Global Reporting Initiatives (GRI) guidelines, the International Standardization Organization (ISO) 14000 series, and Auditing Instrument for Sustainability in Higher Education developed at the Netherlands. These guidelines for reporting are widely used by the private sector.

2.4.2 Dissemination of results

Advertising and publicity actions to disseminate the project's results to the entire HEI's community, municipality and industries.

It is important that the entire community has access to reports, so they should be available in the official websites of the HEI, the HEI's newsletters must be sent at the e-mails of HEI's community.

This step is essential for the project's success due to the acknowledging students, faculty and staff engagement in activities that build a sustainable waste management system, confirming and reinforcing their identity as sustainability leaders. An example is University of Michigan's Planet Blue Ambassador Program where "ambassadors are encouraged to be sustainability champions in their residence, workplace, building, or school" (University of Michigan, 2016).

2.4.3 To assess the Monitoring Indicators sensibility and reliability

Indicators must provide information about the whole campus waste management system, helping decision-making and working as a support tool to improve HEI's policies and operational interventions. In this meaning, these indicators purpose and sensitivity must be periodically evaluated and continuously updated. As proposed by Quiroga (2009) once indicators were applied and data collected, it must be assessed by a specific commission regarding its sensibility and capability to provide the decision-makers with reliable data for further HEI's waste management system adequacy.

2.4.4 Decision Making Based on Database

This step is directly related to the previous three steps, because now, campus decision makers will use reports previously produced to analyze points where emergency actions are required.

Conclusions and framework outputs

The framework presented seeks to standardize waste management to different types of HEIs, turning these spaces in role models for municipality and private sector.

HEIs' community will be engaged in all phases of implementation, and culture regard waste aspects will be assessed using survey applications. Hence, this framework provides the Waste Management Index's set of criteria to diagnose the system status. This behavioral and operational assessment allows to benchmark HEIs' buildings and departments, creates a qualitative and quantitative data baseline to compare with further years, support decision makers by identifying campuses' physical and management aspects that need emergency interventions.

Different types of campuses will learn with each other through publication of reports of implementation processes experiences.

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Chapter VI - Assessing Sustainability Culture at the University of São Paulo – São Carlos

Abstract

Universities have the responsibility of promoting an awareness of sustainability among its students, faculty, and staff. They are also responsible for producing groundbreaking scientific knowledge, and sharing relevant experiences with the public. The University of São Paulo's Environmental Policies are in its final steps of development. Accordingly, the release of these Policies is an opportune moment to begin the process of assessing the culture of sustainability on the University's São Carlos Campus (USPSC). During the spring 2016 academic term, researchers at the University conducted a survey of its students, faculty, and staff to measure sustainability behaviors and levels of engagement and awareness of sustainability on campus. The survey was developed in collaboration with researchers at the University of Michigan (UofM) and was patterned after surveys conducted as part of UofM's Sustainability Cultural Indicators Program. The survey was deployed inside Sustainability Culture Indicators Program (SCIP) been applied at UofM since 2012, and replicated at USPSC in 2016. This paper uses data from 2016 application. Survey respondents were asked questions via an online platform about their sustainability-related behaviors and awareness including transportation, sustainable food purchases, conservation behaviors, waste prevention, and environmental management of green (natural) areas on campus. This paper presents and compares descriptive findings for students, faculty, and staff at USPSC, and presents findings from an examination of the links between sustainability behaviors, awareness, and engagement. The researchers will keep applying the survey in further years, so a comparative study can be deployed with the baseline data acquire *ex-ante* the USP's Waste Policy enactment, also, a comparative study will be deployed with data *ex-post* its enactment. Further papers will discuss a comparative study between USPSC's and UofM's application results, discussing different university's cultural, financial, and social realities.

Introduction

Universities have the responsibility of promoting sustainability awareness among students, faculty, and staff. They are also responsible for producing groundbreaking scientific knowledge, and sharing relevant experiences with the public (Levy & Marans, 2012). These spaces are key to implement practices and deploy strategies to engage communities in actions to raise culture of sustainability (Lukman & Glavič, 2006).

Universities throughout the world have combined efforts to lead its community's behaviors to a more sustainable path, this reflects on creation of sustainability offices and committees that engage campus members to build policies, plans and programs that set goals (Lozano, Lukman, Lozano, Huisinigh, & Lambrechts, 2013).

The University of Michigan (UofM), in 2012, started the Sustainability Culture Indicators Program (SCIP), and deployed a framework to assess the university's community culture and behaviors aspects. By applying surveys, researchers from the Institute for Social Research managed to gather behavioral aspects information concerning transportation, food, waste prevention, energy and water, being applied yearly since 2012 until 2015. The SCIP results are presented in indexes form and show, for example, how much the community is committed to recycling programs. Hence, the SCIP behavioral results are being crossed with operational data, for example, how much energy consumption was reduced. The University of São Paulo – São Carlos Campus, in 2014 started efforts to replicate this UofM's SCIP framework, by adapting the survey to its reality.

The University of São Paulo's (USP) Environmental Policies are in its final steps of development. One of these policies is directed specifically waste management, and it has its background support in Brazil's National Solid Waste Policy, setting prevention goals and predicting creation of plans and programs. Thus, this moment before the release of these Policies is an opportune moment to assess the culture of sustainability of the University of São Paulo - Campus of São Carlos Campus (USPSC), by creating a baseline data *ex-ante* the publication, allowing comparison in future years and how the policy impacted USP's reality.

Universities as a living research laboratory

Higher Education Institutions management should be presented as a good practices laboratory for innovation in diagnostic and monitoring systems for pressure on natural resources

and socioeconomic aspects (Genus & Theobald, 2014; Lozano et al., 2013; Velazquez, Munguia, & Zavala, 2008). This discussion relies on the university's role in being a model of best practices of sustainability for waste prevention, which should be inserted, for example, in its purchasing processes, focusing on products certified in social responsibility and choosing organic products and locally produced, reduce consumption of paper and disposable products; reduce consumption and prevent water and electricity losses; Buildings and facilities with thermal comfort, with green roofs and larger windows for lighting optimization; outreach programs focused on dialogue and training of students regard sustainability, so they also become agents of change and leadership committed to the theme; increase the number of courses and disciplines with teaching processes focused on sustainability; and to foster, through events, academic media and other vehicles, a culture sustainability based with actions throughout the campus and external community, among several other initiatives (Kelly, Mason, Leiss, & Ganesh, 2006).

In this sense, it is important to insert at university end activities the Sustainability Culture concept, understood as a reflection of values, behaviors and levels of understanding and commitment, degrees of integration and dispositions within a community, aligned with the concept of sustainable development. Universities are key spaces to raise sustainability awareness for current and future leaders, with innovative solutions to the greatest global challenges through research, teaching and outreach activities. In this sense, universities emerge as facilitators of best practices in strategic sustainable development (Shriberg, 2002).

Hence, universities have the responsibility of encourage its community to develop a culture of sustainability within and outside university's facilities, by these means, actors, will consolidate as promoters of sustainability leaders (Marans & Shriberg, 2012).

In Brazil, universities have been mobilized to expand their research and human resources training in sustainability fields (Palma, Oliveira, & Viacava, 2011), as well to implement sustainable policies within their campuses transversally through teaching, research and outreach. This presents great opportunities to use campuses as laboratories to deploy and implement innovation in sustainability (Müller-Christ et al., 2014). Thus, aware current and future decision makers regarding sustainability, is key to consolidate sustainable development and social justice.

To measure sustainability culture, two components need to be integrated: The first deals with the behavioral aspects, which refers to monitoring how people are changing their attitudes (in the gym, in the company, in their homes, and daily activities) related to themes such as mobility,

shopping, food, etc., for a better alignment with the sustainability concept. The second component is eco-efficiency, which refers to the practice of producing more efficient and effective goods and services, while continuously reducing the consumption of natural resources and emitted pollution. That is, measuring eco-efficiency on the university campus is to calculate the academic impacts and services produced at the University in relation to the level of pressure it exerts on natural resources crossing this data with the communities behavioral and cultural aspects.

Solid Waste management at Universities

Recycling initiatives play an important role in a High Education Institution community behavioral changes regard solid waste management (Zain, Ezlin, Basri, Basri, & Zakaria, 2012). These kinds of initiatives must consider both operational/logistic and cultural aspects (Levy & Marans, 2012). In the USA, an increasing number of the universities are developing and implementing in their daily activities actions to reduce waste generation, reuse and recycling (Mason, Brooking, Oberender, Harford, & Horsley, 2003).

The Brown University, for example, has a continuous a successful waste management program working for the past 45 years. These initiatives usually begin with waste characterization, the Autonomous University of Baja California, the percentages of non-recyclables, potentially recyclables, and recyclables wastes were, respectively of 34%, 34% and 32% (Ramírez Barreto, 2008). In 2006 the Michigan State University launched the Be Spartan Green Environmental Stewardship Initiative, which part of it was the recycling program. All of this examples show that this is not a recent discussion, and yet, HEIs have a lot to improve in their waste management practices.

Inside a university it can be seen that recycling rates vary throughout the campus buildings depending on its size and category (Fox, 2011). This is due the diverse amount of efforts that are put inside each building.

In this mean, the researchers of this paper pursue the following research question, how efforts such as physical interventions regarding the number of bins, their distribution on-campus and number of collectors' influence in the recycling rates of a HEI.

Methods

University of São Paulo description

The State of São Paulo has the greatest universities in Brazil, researches of its universities are at frontier of scientific knowledge. Moreover, São Paulo universities act as cultural mosaics, attracting students from all over the world, adding different experiences, addressing different problems of society from different perspectives.

University of São Paulo has 11 campuses distributed throughout the state, four in São Paulo, one in Bauru, one in Piracicaba, one in Pirassununga, one in Lorena, one in Ribeirão Preto and two in São Carlos, summing a total of 92,792 students (Undergraduate and Graduate), 6,008 teachers, and 17,450 employees.

At USP - São Carlos, case study of this work, actions to raise awareness regarding culture of sustainability in its community would potentially reach 9,545 people (undergraduate 5,081, postgraduate 2,731, faculty 522, employees 1,211) (USP, 2012). These data illustrate the potential number of people affected by actions that lead to sustainability.

Thus, University of São Paulo's Environmental Policies are in its final steps of development. There are 11 policies, discussing Energy, Water, Green Areas and one specifically addressing Waste Management. Accordingly, the release of these Policies is an opportune moment to begin the process of assessing the culture of sustainability on the University of São Carlos School of Engineering (USPSC). Hence, one of main policy goals is waste prevention, which is the focus of this paper results description.

Data sources

Sample Description

The survey was deployed inside Sustainability Culture Indicators Program (SCIP) been applied at UofM since 2012, and replicated at USPSC in 2016. This paper uses data from 2016 application, Table 12 presents total population sample of students, teachers, and staff.

Table 12 - Overview of the Sustainability Culture Indicators Program population of students, faculty, and staff respondents samples at University of São Paulo – Campus of São Carlos.

Specifications	Total University of São Paulo – Campus of São Carlos sample	Total of University of São Paulo – Campus of São Carlos response rates in 2016 application	Total of University of São Paulo – Campus of São Carlos response rates in 2016 application (%)
Undergraduate students	2477	235	9
Faculty	206	61	30
Staff	353	100	27

As described by Callewart & Marans (2017), sample designs purpose is to obtain relatively significant amounts of responses from the entire university's community of students, staff and faculty.

The sample selection purposed to reach the largest number of respondents as possible, to do this, e-mails of all undergrad students, staff and faculty from São Carlos School of Engineering department were gathered.

E-mails contained a brief description of the survey objective, the estimated time of response, the link to the survey and the research group identification. The e-mails were scheduled to be sent weekly, in different days of the week, at different times of the day, this methodology aimed to reach respondents at different times, trying to adequate their different schedules.

Measures

Sustainability Issues covered by the survey were waste prevention, travel behavior, conservation behavior, and sustainability engagement. The survey was applied to students, staff and faculty through an online platform. Thus, the analysis reported in this paper focuses on waste prevention.

Examples of questions asked by the survey regarding waste prevention are: *Over the past 12 months, how often did you segregate recyclable garbage, you use reusable bags, compost in your current home? How often do you encourage your friends and family to save water, conserve electricity, reuse plastic bags, buy fewer things, buy environmental friendly products.; In general,*

how committed you are to the sustainability issue?; etc. Table 13 presents descriptive information regarding the number of responses for each studied item at the survey

Table 13 - Descriptive information regard the number of responses for survey items.

Waste Prevention descriptive table						
2016	University of São Paulo		University of São Paulo		University of São Paulo	
	Undergrad Students (%)	Undergrad Students	Staff (%)	Staff	Teachers (%)	Teachers
<i>Over the past 12 months, how often did you do the following things in your current home?</i>						
Segregate recyclable garbage						
Never	20%	48	3%	3	2%	1
Rarely	11%	27	9%	9	0%	0
Sometimes	13%	31	16%	15	8%	5
Always//Most of the time	55%	129	72%	69	90%	53
Not applicable						
Total	100%		100%		100%	
Number of respondents		235		96		59
Use reusable bags						
Never	24%	57	4%	4	2%	1
Rarely	22%	52	18%	18	14%	8
Sometimes	24%	57	31%	31	26%	15
Always//Most of the time	29%	69	47%	47	59%	34
Not applicable						
Total	100%		100%		100%	
Number of respondents		235		100		58
Compost						

Never	82%	191	61%	59	69%	40
Rarely	9%	21	17%	16	12%	7
Sometimes	4%	9	14%	13	7%	4
Always//Most of the time	6%	13	8%	8	12%	7
Not applicable						
Total	100%		100%		100%	
Number of respondents		234		96		58

How often do you encourage your friends and family to do the following things?

Reusing plastic bags

Never	13%	29	4%	4	5%	3
Rarely	22%	47	6%	6	16%	9
Sometimes	26%	57	25%	24	26%	15
Always/Most of the time	39%	84	65%	62	53%	30
Don't know						
Total	100%		100%		100%	
Number of respondents		217		96		57

Buy fewer things

Never	12%	27	11%	10	5%	3
Rarely	19%	41	8%	7	16%	9
Sometimes	31%	68	46%	42	32%	18
Always/Most of the time	37%	81	36%	33	47%	27
Don't know						
Total	100%		100%		100%	
Number of respondents		217		92		57

Buy environmental friendly products

Never	28%	59	16%	15	21%	12
Rarely	32%	68	20%	19	19%	11
Sometimes	29%	61	40%	38	40%	23
Always/Most of the time	12%	26	23%	22	19%	11
Don't know						

Total	100%		100%		100%	
Number of respondents		214		94		57
<hr/>						
<i>Do you support or not the following government policies, even if you had to pay for?</i>						
<hr/>						
Prohibit the distribution of plastic bags in supermarkets						
Strongly support	32%	69	33%	30	41%	25
Moderately support	30%	64	32%	29	26%	16
Neither support nor oppose	16%	35	12%	11	13%	8
Moderately oppose	13%	27	11%	10	7%	4
Strongly oppose	9%	19	12%	11	13%	8
Total	100%		100%		100%	
Number of respondents		214		91		61
<hr/>						
<i>In general, how committed you are to the sustainability issue?</i>						
<hr/>						
Very Committed	21%	45	11%	10	21%	11
Somewhat Committed	49%	106	45%	41	49%	26
Not very Committed	28%	62	0%	0	28%	19
Not at all Committed	2%	5	45%	41	2%	
Total	100%		100%		100%	
Number of respondents		218		92		56

Creating the indices

Items responses were grouped to create the University of São Paulo – Campus of São Carlos Waste Prevention Indexes. The indexes have the purpose of presenting the survey's findings in a more succinct way.

Applying the survey

During the 2016 first semester of the academic year, researchers at the University of São Paulo – Campus of São Carlos applied a survey to students, faculty, and staff at São Carlos School of Engineering, to measure sustainability behaviors and levels of engagement and awareness of sustainability.

The survey was developed in collaboration with researchers at the University of Michigan (UofM) and was patterned after surveys conducted as part of UofM's Sustainability Cultural Indicators Program.

Survey respondents were asked questions via an online platform about their sustainability-related behaviors and awareness including transportation, sustainable food purchases, conservation behaviors, waste prevention, and environmental management of green (natural) areas on campus.

Data analysis

Researchers used the Statistical Package for Social Sciences (SPSS) software and Bonferroni statistical test for statistical analysis.

Findings

Overview description

The table 14 summarizes the response data information regarding mean scores and statistical significance for Waste Prevention Awareness, Waste Prevention Engagement and Waste Prevention and Sustainability Commitment Indexes for University of São Paulo – Campus of São Carlos staff, faculty and undergrad respondents.

All the indexes presented statistical significance when compared between staff, faculty and undergrad groups.

Tabela 14 - Mean scores and statistical significance for Waste Prevention Awareness, Waste Prevention Engagement and Waste Prevention and Sustainability Commitment Indexes for University of São Paulo – Campus of São Carlos staff, faculty and undergrad respondents.

Index	Mean Scores			Significance
	Staff	Faculty	Undergrad	
Waste Prevention Awareness	3,22	3,07	2,93	***
Waste Prevention Engagement	3,34	2,98	2,55	***
Waste Prevention and Sustainability Commitment	2,99	2,93	1,99	***

Specific indexes statistical significance description

The questions regard waste prevention was grouped in three indexes to describe staff, faculty and undergraduate students engagement, awareness and sustainability commitment regard waste prevention.

The indexes are the following: Waste Prevention Awareness Index, containing the questions: Over the past 12 months, how often did you do the following things in your current home? 1. Segregated recyclable garbage; 2. Use reusable bags; 3. Compost.

For this index, statistical significance was noticed when compared the means between undergraduate students and staff, and undergraduate students and faculty. There is no significance between staff and faculty.

Staff respondents group presented more Waste Prevention Awareness then undergrads; the faculty respondents group presented more Waste Prevention Awareness then undergrads; And staff respondents group presented more Waste Prevention Awareness then faculty respondents group.

When asked over the past 12 months, how often did you do the following things in your current home? *Segregate recyclable garbage*, 129 (55%) undergraduates, staff 69 (72%), and faculty 53 (90%) answered *Always//Most of the time*. Regard the item *Use reusable bags* the main answers were for *Always//Most of the time*, which, 69 (29%) undergraduates, 47 (47%) staff, and 34 (59%) faculty, when

asked if they Compost waste, the main answers were *Never*, with 191 (82%) undergraduates, 59 (61%) staff, and 40 (69%) faculty.

The Waste Prevention Engagement Index contains the following questions: How often do you encourage your friends and family to do the following things? 1. Reusing recyclable bags; 2. Buy fewer things; 3. Buy environmental friendly products.

For this index, statistical significance was noticed when compared the means between undergraduate students and staff, and undergraduate students and faculty, and between staff and faculty.

Staff respondents group presented Waste Prevention Engagement than undergrads; the faculty respondents group presented more Waste Prevention Engagement than undergrads; And staff respondents group presented more Waste Prevention Engagement than faculty respondents group.

When undergraduate, staff and faculty were asked if how often do you encourage friends and family to reuse plastic bags? The main answers were *Always/Most of the time* with, 84 (39%) for undergraduates, 62 (65%) for staff, and 30 (53%) for faculty. When asked about how often do you encourage friends and family buy fewer things, the main answers for undergraduate and faculty respondents group were *Always/Most of the time* 81 (37%), and 27 (47%), respectively. And for staff respondent group the main answer was *Sometimes* with 42 (46%). For the item *Buy environmental friendly products* the main answer for the undergrad group was *Rarely*, with 68 (32%) of responses, for staff and faculty, respectively, the mains answer was *Sometime*, with 38 (40%), and 23 (40%), of responses.

The Waste Prevention and Sustainability Commitment contain the following questions: Do you support or not the following government policies, even if you had to pay for? 1. Prohibit the distribution of plastic bags in supermarkets; 2. In general, how committed you are to the sustainability issue?

For this index, statistical significance was noticed when compared the means between undergraduate students and staff, and undergraduate students and faculty. There is no significance between staff and faculty.

Staff respondents group presented more Waste Prevention and Sustainability Commitment then undergrads; the faculty respondents group presented more Waste Prevention and

Sustainability Commitment then undergrads; and staff respondents group presented more Waste Prevention and Sustainability Commitment then faculty respondents group.

For the item 2. In general, how committed you are to the sustainability issue? Most of respondents answered that they are *somewhat committed* to the sustainability issue, with 106 (49%) undergraduate, 41 (45%) staff, and 26 (49%) faculty.

What USPSC learned and perspective for future applications

Challenges faced by USPSC researchers

The main challenge faced by USPSC researchers encouraged people to participate the questionnaire.

A way found to overlap this situation was to schedule e-mails, once a week, sent in always in different times of the day. Also, the responsible teacher used filling the questionnaire as a task for the courses he was teaching. Other publicity strategies used were:

- Creating a video with the research purpose and description, with the link to the survey, the link for the video was embedded at the invitation e-mail sent to the respondents. This strategy presented good results.
- Asking the schools' official journal to release two articles about the research, the first containing a brief description of the project and the second containing an interview with the responsible teacher and the Environmental Management Superintendent, also with the link to the survey.

Future: Comparative study with next years' application results

The SCIP-USP is a multi-year research project that aims to measure the culture of sustainability at University of São Paulo, in this sense the researchers will keep applying the survey in further years, so a comparative study can be deployed with the baseline data acquire *ex-ante* the USP's Waste Policy enactment, also, a comparative study will be deployed with data *ex-post* its enactment.

Thus, the SCIP applied at USPSC was just a pilot scale effort, researchers now have the university's Environmental Management Superintendent support, and now the survey will be applied to the whole University of São Paulo, at all campuses.

By systematically and periodically presenting key signals to assist in the processes of management of the university campuses daily activities will provide subsidy for decision making.

SCIP Survey is a key tool to support high management and is relevant to several sectors of the university. The current indicator systems used at the university do not yet have a structure that integrates these two key components - Eco efficiency and behavior. This is one of the main innovations proposed by this research project. Future works will present and compare descriptive findings for students, faculty, and staff, also, data regard natural resources consumption at USP, and present findings from an examination of the links between sustainability behaviors, awareness, and engagement.

The Eco-efficiency versus behavior project at University of São Paulo – Campus of São Carlos

The structure of indicators under construction will put in the same basket two important components, technology and the internalization of sustainable actions and culture (in the part of management, maintenance and in the individual activities of the day to day). By developing different strategies from one building to other, it will favor analyzing the best strategies through a synergistic process. That is, the questionnaire will work to show how physical changes are strengthening the culture of the university community and how technological innovations influences behavior changes.

This study will provide researchers with an insight into the sustainability behavior of the USP community, thus informing management process where sustainability awareness interventions are needed, in a building scale.

The results from the Sustainability Culture Surveys and Eco Efficiency indicators will be cross-checked. This, due to the behavior and values of individuals have a direct influence on resource consumption, and waste generation. The consumption of these resources, in addition to being influenced by technology and equipment conservation, is influenced by the way individuals use them. That is, understanding these relationships - innovation, capacity building, awareness -

are key to improving management for sustainability. If innovation is not internalized by potential users, there is a decrease in performance and waste of resources.

The cross-referencing of performance and behavior indicators allows to accurately capture these relationships and to feed back the management, research and teaching processes. Extrapolating this scenario to other institutions, such as Banks or industries, which have thousands of branches spread across the country, one can observe the potential impact that this analysis can provide to managers.

If these agencies, for example, implement innovations in energy saving systems, what will be the social-environmental impact? How significant will be the engagement of employees and users?

a. Future: Comparative study between USPSC's and UofM's results

Further papers will discuss a comparative study between USPSC's and UofM's application results, discussing different university's cultural, financial, and social realities and how they may influence undergraduate, staff and faculty culture of sustainability.

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Chapter VII - Solid Waste Management Index for Brazilian Higher Education Institutions

Abstract

This paper presents Solid Waste Management Index (SWaMI) for Higher Education Institutions, which fills a gap regarding a specific waste management tool for HEIs decision makers, considering the responsibility of educating and training future leaders and the need to insert the sustainable waste management discussion in its end activities. The SWaMI is sensitive to educational (teaching, research and outreach), engagement, operations and policy & management dimensions, expressing graphically dimension behavior and tendencies, if applied throughout years, and where decision makers should focus efforts. For the criteria selection, articles regard sustainable waste management were selected and studied. The selected criteria were divided in dimensions, further weighted according to their significance in waste management. These weights were discussed and stipulated based on expert opinion using the Budget Allocation Process (BAP) weighting method. The individual indexes for each dimension will further be combined into a composite index through the Linear Aggregation Method. When comparisons were deployed between HEIs, no statistical significance was noticed when the means were compared between universities using ANOVA with Tukey test. Nevertheless, when comparing each dimension within each HEI, there was significant difference between the Policy and Management dimension and the other three dimensions of the evaluation criteria at USP. The SWaMI provides decision makers with graphic results regard HEIs solid waste management situation, hence, it allows the creation of a baseline of data on how the current system works, pointing out the dimensions that present the greatest fragility allowing to perform benchmarking between buildings, institutes, and even between HEIs.

Introduction

Higher Education Institutions (HEIs) decision makers have tackled to turn these spaces in to sustainable best practices role models, inserting social-environmental premises in management

and operations through a transversal and integrated way. In this context, solid waste management, one of society's main problems, has been discussed in HEIs' research, teaching and outreach end activities.

Hence, strategies as creation of committees have been adopted by HEIs to insert social-environmental aspects in their daily management and operational processes, have proven effective in this transition process towards sustainability. However, these decision spaces need decision support tools, deploying diagnosis and monitoring, presenting results in a concise form. According to Nashimura (2015), compose indicators is one of major environmental assessment tools, for example, supporting self-reporting and further analysis regarding HEIs' sustainable aspects.

This paper presents Solid Waste Management Index (SWaMI) for Higher Education Institutions, which fills a gap regarding a specific waste management tool for HEIs decision makers, considering the responsibility of educating and training future leaders and the need to insert the sustainable waste management discussion in its end activities. The SWaMI is able to identify weaknesses in educational (teaching, research and outreach), management and operations, graphically showing dimension behavior and tendencies, if applied throughout years, and where decision makers should focus efforts.

The SWaMI can be calculated through a criteria framework that addresses a HEIs Educational, Engagement, Operational, and Policy and Management major aspects. The criteria of the compose index were selected through an extensive literature review regard solid waste management, containing data from scientific articles, sustainability reports, certification standards, Brazilian laws and norms, and other HEIs' best practices experiences throughout the world.

Cheng; Chan & Huang (2003) discuss how the use of indexes, as information support tool, enhance decision-making regard solid waste management, concluding that the use of this type of tool contributes to a systemic and temporal view, allowing to perform benchmark comparisons between HEIs and by creating a baseline that can be compared over the years.

The objective of this work's researchers is to present the Solid Waste Management Index for Higher Education Institutions. Also, a comparative study applying the proposed index between the University of São Paulo (Brazil), Federal University of Santa Maria (Brazil), State University of Santa Maria (Brazil), and University of Michigan (USA) will be presented.

Waste Management at Higher Education Institutions

The implementation of sustainability at HEIs decision-making and operational processes has gained strength in the last decades as a response to the pressure over the environment, one of the main problems that have been tackled is the exponential growth of waste generation and inadequate disposal negative impacts (BALDWIN; DRIPPS, 2012; FELDER; PETRELL; DUFF, 2001; LIM; HAMILTON; JIANG, 2015; MALAKAHMAD et al., 2010; MASON et al., 2003; ROUSE, 2006; THOMAS; PEROSA; MARTÍN, 2012).

HEIs have the potential to generate large quantity and diversity of waste accordingly to its research and teaching profiles (FURIAM and GÜNTHER, 2006), hence, in some cases may not have an environmentally adequate disposal. The study deployed by Oliveira Júnior (2012, page 49) at the Federal University of Lavras, presents a total generation of 2479 liters of chemical residues, Veiga (2013) presents that at the University of São Paulo – Campus of Ribeirão Preto, of the 199 laboratories studied by the researchers, 67% generated chemical waste. At the Federal University of São Carlos, a study by Saqueto (2010, p.71) shows that the campus generates a total of 670 liters per month of chemical waste, and 218 liters per month are incorrectly disposed, and only 9 liters per month are treated. A study depoloyed by the University of Brasília has identified that from 278 university laboratories, 144 use chemical products, 61% throw their waste "down the sink" or in trash cans. Araujo and Viana show in their study, in the University of São Paulo's School of Arts, Sciences and Humanities (EACH - USP), that in one day, 233 kg of waste were generated in the restaurant located in the unit, of which 84% corresponded to organic matter, the authors highlight how these values remarks the need to implement awareness programs regard how waste must be managed by students, researchers, faculty and staff, and how important it is the role that they execute in this process.

These studies show the potential environmental risk of waste generation within HEIs (ARMEJO DE VEGA; OJEDA BENÍTEZ; RAMÍREZ BARRETO, 2008; BALDWIN; DRIPPS, 2012; MASON et al., 2003; SMYTH; FREDEEN; BOOTH, 2010a). Additionally, these data show the lack of standardization of waste management processes in HEIs. It is worth mentioning that the waste management varies according to HEIs financial, social, cultural, population, size, and teaching, research and extension profiles (CORRÊA et al., 2010). Cruz et al., (2009) point out that

the waste management in the HEI is badly done, which can lead to the deterioration of public health.

HEIs are tackling social-environmental issues by adopting Environmental Management Systems (SGA) (TAUCHEN, 2006; ALSHUWAIKHAT; ABUBAKAR, 2008), and Sustainability Certification (BOLAANE, 2006). In Brazil, the University of Passo Fundo, implemented an EMS based on the International Organization for Standardization (ISO 14000) set of standards, significantly reducing its negative impacts on the environment (TAUCHEN; BRANDI, 2006). The University of Monterrey adopted a sustainability reporting system, based on the Global Reporting Initiative (LOZANO, 2004), postulating goals to encourage the entire university community to reduce the natural resources consumption. Sustainability certifications for HEIs are also successful strategies to pursue sustainability, e.g. Sustainability Tracking, Assessment & Rating System (STARS) and Green Metrics, however, these tools do not specifically address waste management, hence they are not sensitive enough to support decision making regard waste prevention, and recycling.

Solid Waste Management Index for Brazilian Higher Education Institutions

Within the field research and literature review, several criteria were selected and must be considered when discussing waste management at HEIs. These criteria are divided into items that can positively foster and that can strengthen the university's transition towards sustainability.

This set of criteria aims to provide the right questions on how to proceed to enhance of the waste management system of HEIs, such as: Are we discussing waste management in all our possible means of communication? Are we concerned about engaging our community? What are we doing to minimize our impacts on natural resources? What can we do to tailor waste management to a more environmentally friendly bias?

Applying these criteria will allow for a type of diagnostic view. It will replace the creation of basic data on the performance of the environmental and sustainability aspects of the HEI before the implementation of the framework, as well as advising on how the institution pursues and manages these aspects.

For the criteria selection, articles regard sustainable waste management were selected and studied according to literature review methodology, proposed by HIBBS et al. (1984), Broadus

(1987), Burton (1988), Hood; Wilson (2001), Hood; Wilson (2003), adapted for social sciences and sustainability by Newig et al. (2008), Newig (2009) and Brandt et al. (2013). The following research, waste, sustainability, university campuses and higher education research terms were used in the following databases: Science Direct, Scopus and Web of Knowledge were used, 11,093 were obtained. Brazilian scientific platforms were also used, however, for Periódicos Capes the articles had already been found on the previous platforms, the Scielo platform did not presented any results. Data from ISO 14000 EMS series, Global Reporting Initiative self-reporting framework, and Green Metrics and STARS HEIs sustainability certification.

The composite index was deployed following the framework postulated by Nardo et al. (2008). The first step was to select the assessment criteria, based on waste management best practices, which the index was further build. Each criteria is answered with a Boolean response, where 1 means Yes, the HEI has adequate management, and 0 means No, the HEI do not have adequate management. Then, these criteria were aggregated in Education, Engagement, Operations and Management & Policy dimensions.

The second step was the dimensions weighting process. The selected criteria were divided in dimensions, further weighted according to their significance in waste management. These weights were discussed and stipulated based on expert opinion using the Budget Allocation Process (BAP) weighting method (Nardo et al., 2008; Zhou et al., 2012). Surveys with dimensions description and criteria were sent to a total of 40 experts from universities in Brazil, 18 of them answered, they estimated an importance factor for each dimension by following a five points Likert scale, from unimportant to highly important. The weights were then calculated as normalized median importance factors.

The overall value of the index ranges from 0 to 10, where the closer to 10, more adequate the HEI waste management system is.

The Dimension Indexes, I_{Di} , are calculated by the equation:

$$I_{Di} = \frac{1}{n} \sum_{j=1}^n P_j$$

Where: j = Dimension; P_{ji} = i -th individual criteria for each dimension j ($j = 1, \dots, n$; $i = 1, \dots, m$).

The I_{Di} , will further be combined into a composite index through the Linear Aggregation Method (Nardo et al., 2008; Zhou et al., 2012). The SWaMI Index (I_{SWaMI}) can be calculated by applying the following formula:

$$I_{SWaMI} = \frac{1}{n} \sum_{j=1}^n \sum_{i=1}^m P_{ji} w_i,$$

$$\sum_{i=1}^m w(\text{educational}) = 2,6$$

$$\sum_{i=1}^m w(\text{engagement}) = 2,0$$

$$\sum_{i=1}^m w(\text{operational}) = 2,9$$

$$\sum_{i=1}^m w(\text{Policy\&management}) = 2,5$$

$$,$$

$$w_i \geq 0,$$

where: $w_i = i\text{-th}$ practice indicators weight.

Similar to the SWaMI Individual Management Practice Index, I_{IWMP} values may vary between 0 and 1, representing the worst and best possible result, respectively.

Where:

A = area (ED, EN, OP, PM)

ACA_n = Adequate criteria (1) by area n

CAn = Total number of criteria for the dimension P

W_n = Criteria weight for P

The index is calculated and expressed annually, where universities will annually report on the application of this index with a descriptive analysis of each dimension explaining the main projects executed, highlighting their results, potentialities and weaknesses.

Data analysis

Researchers used the Statistical Package for Social Sciences (SPSS) software and Bonferroni statistical test for statistical analysis.

Results and Discussion

Solid Waste Management Index Evaluation applied to four different universities for the year of 2016

This set of criteria will provide decision-makers data by applying the Solid Waste Management Index for deploying diagnosis of solid waste management and operation key issues. The application of these criteria creates baseline data on the environmental and sustainability performance, as well as advising information on how the institution pursues and manage solid waste.

The following table 15 presents the evaluation results for four different universities with data from 2016.

Table 15 – Evaluation of Criteria for SWaMI of four universities with data from the year 2016, where if the HEI have the adequate management fill with 1; when HEI does not have the adequate management fill with 0; and when the HEI that does not have to deal with this kind of waste fill with -.

Category	Theme	Criteria	Evaluation			
			USP- BR	UofM - US	UNIOESTE - BR	UFSM - BR
Educational (Teaching, Research and Outreach)	Sustainability implementation	1. Outreach projects focusing on waste management	1	1	1	1
		2. Research projects focusing on waste management	1	1	1	1
		3. Undergraduate courses that discuss waste management in their curricula	1	1	1	1
		4. Graduate courses that discuss waste management in their curricular	1	1	1	1
Engajement	Community (Students, Researchers	5. Advertising campaigns promoting waste reduction, reuse and recycling initiatives	1	1	0	1

	Faculty and Staff)	6. Educational programs for faculty and staff focusing on sustainable waste management	1	1	1	1
		7. Activities promoted by faculty and staff related to solid waste management	1	1	1	1
		8. Technical training, lectures, courses and cultural interventions focused on sustainable solid waste management	1	1	0	1
Operational	Disposable products (e.g. paper and plastic)	9. Initiatives of paper and paperboard waste prevention	1	1	1	1
		10. Initiatives of plastic waste prevention	1	1	1	1
	Electronics	11. Programs for electronic waste reuse	1	1	0	0
		12. Programs for electronic waste adequate disposal	1	1	1	1
	Sustainable buildings	13. Adequate lamp disposal	1	1	0	1
		14. Construction waste adequate disposal	1	1	0	1
	Food	15. Programs of cafeterias food waste prevention	1	1	0	1
	Campus	16. Programs of organic waste composting	1	1	0	0
	Biological and Healthcare Services Waste	17. Biological Waste and Health Services adequate disposal	1	1	1	1
		18. Program to reduce water consumption	1	1	0	1
	Water	19. Consortium with municipality to treat effluents generated on campus	1	1	0	0
		20. Greywater reuse	0	0	0	0
	Transports	21. Reuse of auto parts	1	0	0	0

		22. Adequate oil disposal	1	1	0	1
		23. Adequate Tire Disposal	1	1	0	1
		24. Waste Reduction, Reuse and Recycling Engagement Programs	1	1	1	1
	Waste	25. Space for community participation in waste management decision making	0	1	1	1
		26. Waste management policies, plans and programs	0	1	1	1
	Sustainable Policy	27. Sustainable planning with short, medium and long term goals	0	1	0	1
		28. Committee for waste management	0	1	0	1
	Management and Policy	29. Publication of waste management and operational data reports	0	1	0	1
	Sustainable Management	30. Transparency in the storage and final disposal of hazardous waste	0	0	1	1
		31. Participation of stakeholders in of waste management Policies, Plans and Programs elaboration	1	0	0	1

Table 15 presents the summarized results for the Index application:

Table 15 - Summarized results for the Index application for University of São Paulo - Brazil (USP), University of Michigan - US (UofM), Federal University of Santa Maria - Brazil (UFSM), and Western Parana State University - Brazil (UNIOESTE).

Dimension	USP		UofM		UFSM		UNIOESTE	
	<i>I_{Di}</i>	<i>I_{IWMP}</i>	<i>I_{Di}</i>	<i>I_{IWMP}</i>	<i>I_{Di}</i>	<i>I_{IWMP}</i>	<i>I_{Di}</i>	<i>I_{IWMP}</i>
Education	2,60		2,60		2,60		2,6	
Engagement	2,00		2,00		2,00		1,00	
Operational	1,87	6,88	2,55	8,80	2,04	9,10	1,02	5,44
Management & Policy	0,41		1,64		2,46		0,82	

According to table 15, no statistical significance was noticed when the means were compared between universities using ANOVA with Tukey test ($p < 0,05$).

Table 16 shows statistical tests dimensions interactions for each university. Means were compared crossing dimensions of each university, but not between universities.

Table 16 - Statistical tests for dimensions interactions for each university. Means were compared crossing dimensions of each university, but not between universities.

Dimension		University			
		USP	UofM	UFSM	UNIOESTE
(I)	(J)	Sig.	Sig.	Sig.	Sig.
Educational	Engagement	1,000	1,000	,913	1,000
	Operational	1,000	1,000	,133	,929
	Policy & Management	,000*	,834	,243	1,000
Engagement	Educational	1,000	1,000	,913	1,000
	Operational	1,000	1,000	1,000	,929
	Policy & Management	,001*	,834	1,000	1,000
Operational	Educational	1,000	1,000	,133	,929
	Engagement	1,000	1,000	1,000	,929
	Policy & Management	,000*	1,000	1,000	,589
Policy & Management	Educational	,000*	,834	,243	1,000
	Engagement	,001*	,834	1,000	1,000
	Operational	,000*	1,000	1,000	,589

*Significance with ($p < 0,05$).

Table 16 shows that there was significant difference between the Policy and Management dimension and the other three dimensions of the evaluation criteria at USP. Which means, in general terms, that the set of evaluation criteria is sensitive enough to assess if the dimensions have influence over other dimensions' performance. For example, if you change Policy and Management at USP, changes will probably be noticed inside other dimensions.

A graph presentation regard the summarized results is shown below:

Figure 10 - Graph presentation for the Index application summarized results.

The descriptive analysis is presented within each of the five dimensions in the following section:

Before starting the discussion of analysis, it is worth mentioning that USP has developed its Environmental Policy, which aims to give the character, identity and describe the mission of the university regarding its position to socio-environmental aspects, where each unit, institute and museum should elaborate their Environmental management plans, unfolding them within specific themes such as waste management, environmental education, energy, water, etc.

According to the general score of each of the universities, in general, UofM presents the best performance of the three universities, it must be emphasized that the university stands out in the dimension of Management and Politics.

The descriptive analysis is presented within each of the five dimensions in the following section:

Education (Teaching, Research and Extension)

It must be reinforced how the Educational dimension is transversal to all other dimensions. The SWaMI differs from other performance assessment tools because it is part of a greater framework which aids HEIs transition to a more sustainable path. A key element, or peculiarity, that HEIs must use in its favor is the academic community potential, that by engaging in teaching, research and outreach that uses the campus as a living laboratory will build a culture of sustainability.

The SWaMI assessment flow goes from educational dimension, through engagement, and aims to assess the integration of these first two with operational, and policy and management dimensions, by teaching using practical examples within the campus for solid waste prevention, reuse and recycling, to use research to tackle campus daily challenges, and build innovation to deal with solid waste, to insert research on management processes and deploy strategies to support decision making.

According to Ometto et al. (2014) there is a project in progress, since 2013, financed by the National Council of Scientific and Technological Development in partnership with the University of the Rio dos Sinos Valley - Rio Grande do Sul and the University of the Vale do Itajaí - Santa Catarina, to analyze curricular documents of undergraduate courses, identify approaches and methodologies related to sustainability, define criteria, indicators, strategies and actions applicable to HEI ".

The example of the Production Engineering course at the School of Engineering of São Carlos (EESC), which is implementing sustainability aspects within its disciplines, according to Ometto et al. (2014), has 13% of its environmental subjects, 12 out of a total of 91 subjects offered in the course.

As for extension programs, several can be cited in this dimension, such as USP Recicla and the Participative Learning Program, which are focused on activities for students and staff seeking training in environmental issues. The Science and Technology Park of USP-Capital, which receives schools that aims to "present the cultural heritage of USP, through the articulation between society, culture, science and technology, guaranteeing accessibility and environmental sustainability" (PRCEU, 2016).

The University of Michigan has 639 sustainability-focused courses, and in its fiscal year 2015 invested \$2 million in the Third Century Initiative, which subsidizes two long-term projects designed to foster its students' educational experience with related topics Sustainability.

When waste management, the university recycled 30% of all its waste in the year 2015, in addition to composting more than 460 tons of waste. These compounds are intended for gardens, both university gardens and community initiatives in Ann Arbor.

Engagement

Jacobi; Tristão; Franco (2009) and Marcelino (2016) report their experiences at USP with the insertion of the socio-environmental theme in the universities and support the importance of the engagement of actors from the different spheres of these institutions to contemplate the expected advances. Through exploratory research within USP - São Carlos, the researchers realized that the commitment and sense of belonging in activities are of fundamental character for the efficiency, effectiveness and continuity of actions within the universities.

Regard to waste management, most of the activities that direct their actions to this theme were initiated by the initiative of teachers, employees and teachers, and only materialized and consolidated by their commitment and commitment. USP has a long and proactive walk towards waste management that adopts the concepts that are friendly, many of the actions being promoted and continued due to the participation of its community. Under the recommendations of the Superintendence of Environmental Management, in 2014 started discussions on the postulation of the Solid Waste Policy, which aims to propose goals with the preparation of Plans and Programs for Solid Waste Management, where each unit must, Requirements. This Policy is based on the Federal Law that institutes the National Policy on Solid Waste, and should act in harmony with it.

At the University of Michigan, several student volunteers participate in the Food Recovery Network, which in partnership with UofM restaurants, make efforts to withdraw food from the waste stream by donating it to the Food Harvesters and serving the city's low-income population. Until December 2015, the initiative donated more than 6 thousand kilos of food, equivalent to supply 10 thousand families. In April 2015, the E-Waste event was held, coordinated by teachers and employees, where 220 kilos of electronic waste were collected for recycling.

Operational

Waste Management

The São Carlos Campus respects all the criteria proposed in the table.

Since the middle of 1990, the University of São Paulo has had several initiatives to manage its waste.

All health and laboratory wastes are taken to the campus's Chemical Waste Laboratory. The laboratories, in addition to taking the necessary measures, provide management and final disposal, also performs the recovery of several solvents and returns them to the didactic laboratories. However, according to exploratory research and interview data, some laboratories do not accept these recovered solvents, so the LRQ team assigns them to laboratories that accept them, if there is an excess, the laboratories responsible for the waste must bear the costs of disposal through incineration.

These activities of recovery of these chemical residues are an initiative of the LRQ itself, lacking institutional support, which weakens the whole initiative. In addition, the LRQ team provides lectures to undergraduate and graduate students to inform them of good practices related to chemical residues, according to interview data, these lectures should be requested by the course coordinators, however, these Invitations are not being made, and when they are, it is not widely publicized and few people come.

Batteries are collected at the São Carlos School of Engineering, São Carlos Institute of Chemistry and the Institute of Mathematical and Computer Sciences, the latter still collecting CDs and DVDs and then destined for the LRQ, where they are stored and destined to companies that carry out the appropriate final disposal.

All laboratories follow a routine of work, always acting in accordance with the legal instruments of federal, state and municipal scopes. Aiming at standardizing the laboratory activities, the USP Solid Waste Policy was prepared, an action coordinated by the SGA and that composes the major initiative that is the elaboration of USP's Environmental Policy. This policy is in final process of processing, and until 2017 will be published. All units should prepare their Solid Waste Management Plans and present it to the SGA, the plan includes reuse, reduction, recycling, and re-education initiatives, respecting the peculiarities of each unit.

The University of Michigan Recycling Program (UofM) currently operates under the supervision of the Custodial and Grounds department, which are responsible for the buildings and open spaces that make the Ann Arbor campus unique. This department is responsible for more than 26 million square meters of property.

The department's agreement mission is as follows:

"Our mission is to serve, with excellence, offering maintenance services, pest management, waste management and recycling, land maintenance and landscaping services in support of making the campus a safe, functional and attractive environment. "

The activities of the University of Michigan Recycling Program are carried out by the Waste Reduciton & Recycling Office (WRRO), which strives to provide operational and educational waste reduction and recycling programs that reduce the University's environmental footprint within the community Local, state and global. WRRO also encourages students, faculty, staff, and visitors to apply the skills learned through these programs on and off campus, now and in the future.

Unlike the University of São Paulo, the University of Michigan has an integrated program to recycle its waste with the city of Ann Arbor's waste recycling program. The programs work together to improve the quality of recycling services provided in the spaces Academics and civilians. It should be noted that the reality of UofM's university campus is completely different from the realities of the campuses of Brazilian universities. The UofM buildings are distributed throughout the city, there are no delimitations of where the campus begins and ends. Recyclable waste baskets identified with the university symbol can be found distributed throughout the city.

Policy and Management

The University of São Paulo counts on the initiative that made all bureaucratic processes environmentally friendly by reducing the use of paper, as well as the University of Michigan. The initiative operates in the same way in both universities, through digital channels, where through a page within the intranet system it is possible to make requests and requests for goods and services without the use of paper.

On the campus of São Carlos, the activities of the Sustainable EESC Program began in 2014, which, divided into several commissions, stimulated the discussion of sustainability within the campus of São Carlos in 2016, with the change of the board of the EESC. Called the

Sustainability Commission, among its activities may be cited as a mini-course of Sustainable Events, which assists organizational committees in designing and executing projects of events that use the least natural resources. We can also present the ICMC Program of Socio-Environmental Management of the Office of Planning and Management, created in 2013 which is a strong supporter of socio-environmental initiatives within the unit of the Institute of Mathematical Sciences and Computing. Promote, in articulation with the other ICMC agents, the encouragement of the incorporation of values, attitudes and behaviors that are environmentally adequate the encouragement of minimization of waste generation. At the Institute of Chemistry of São Carlos, the Environmental Ethics Commission was created (IQSC Ordinance 1.034 / 2008, dated 05/21/2008). With the bias of contemplating sustainability-oriented and environmentally friendly management, USP institutes São Carlos has proactively taken initiative, through the initiative of its employees, teachers to students.

In 2010, the University of Michigan created its sustainable university identity in governance, with the support of the President of the University where the University's goals and objectives were defined to ensure that sustainability aspects are an integral part of decision-making, as to foster the integration of staff and students into educational and practical activities to build a culture of sustainability across the campus.

The university was supported by the Graham Institute for Sustainability and the Campus Sustainability Office to integrate academic activities with campus operational activities. Thus, the Integrated Sustainability Assessment project, which engages employees, teachers and students, aims to monitor and act as a decision-making tool in the areas of Buildings, Sources of Energy, Transportation, Water, Food, Purchasing and Recycling, and Culture.

Chapter conclusion

The SWaMI also provides an assessment of how the frameworks is behaving, regard education dimension. Once the commission implemented the framework, this Index must be periodically updated, in this sense it will be possible to present the community the framework implementation results regard how HEIs' sustainability initiatives on solid waste management are being efficient.

The SWaMI provides decision makers with graphic results regard HEIs solid waste management situation, hence, it allows the creation of a baseline of data on how the current system

works, pointing out the dimensions that present the greatest fragility allowing to perform benchmarking between buildings, institutes, and even between HEIs.

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Chapter VIII - Agent-Based Modeling as a decision-making tool for recycling initiatives

Abstract

Agent-Based Modeling is presented as a useful tool for waste management in High Education Institutions (HEIs) since its recycling initiatives are weakened by lack of strategical planning, and consequently lack of engagement and financial and human resources. Experiments were conducted using five factors for collectors and five factors for bins, both using the same number of users, with ten repetitions. The statistical tests conducted used Tukey and Duncan tests, both with 5% of confidence, using ANOVA to identify if there was significance difference between the means of recyclable waste collected when model parameters changed, and Linear Regression with a Growth Curve model, due waste collected increase tendency behavior. Researchers used SPSS software. By using this modeling methodology, the researchers concluded that the number of bins have more influence than the number of collectors. In addition, this shows that investing in increasing the number of bins is less expensive than investing in the increasing the number of collectors. The ABM methodology translates in a resourceful tool for environmental management modeling in High Education Institutions.

Introduction

Development of strategic planning tools to support decision making increased in the past decades due the necessity for organizational structures enhancement (Enger, Rauter, & Baumgartner, 2016). Agent-Based Modeling (ABM) is a computational tool that can be deployed in ecology, social sciences and engineering to simulate decision making process (Courdier et al., 2002; Grimm et al., 2006). ABM allows creation of artificial worlds that represent complex systems and collective or individual behaviors at different scales, enabling researchers control communities and organizational structures' qualitative and quantitative parameters. (Bonabeau, 2002; Courdier, 2002; He et al., 2017).

Solid Waste management is a complex subject (Lenzen & Reynolds, 2014) due to involving diverse dimensions, actors and complex problems, aiming to prevent solid waste generation, and to foster initiatives regard reuse and recycle (Zen et al. 2016). The model here presented explores with an explanatory approach the relationship between bins and collector quantity may influence HEIs' waste recycling performance.

After an immersive research about recycling initiatives inside two universities, regarding management and operational levels, and by studying other initiatives throughout the world the researchers identified that recycling initiatives required a modeling tool capable of deploying scenarios and helping strategical planning. In this sense, the main purpose of this research is to fill the gap regarding a modeling tool addressed to decision makers concerning the growing field of recycling at universities that seek to enhance strategically their existing, or implement new, initiatives. Fagnani; Guimarães (2017), Gallardo et al. (2016), Tangwanichagapong et al. (2017), Berchin, (2017), Lara (2017) reinforces that waste management is key for a Higher Education Institution path tackling sustainability

This research innovates by filling a gap regard tools to support HEIs decision-making, that is the lack of a specific tools that exhausting study and works inside the waste management dimension. This work considers individual and communities behaviors.) To tackle waste management plans efficiency and efficacy, actions beyond operational prevention, reuse and recycling, such as awareness instruments and interventions are needed (Araujo; Viana, 2012; Meng; Wen; & Qian, 2016).

In this sense, ABM is presented as a useful tool for waste management in High Education Institutions (HEIs) since its recycling initiatives are weakened by lack of strategical planning, and consequently lack of engagement and financial and human resources (Bero et al., 2012; Alnsour and Meaton, 2015). Several studies in HEIs found that recycling bins distribution, presented direct impact over a university community's recycling behavior (Luyben et al. 1979, Goldenhar and Connell, 1992; Katzvel and Mishima, 1992; McCarty and Shrum, 1994). Lack of storage also negatively influences recycling (Williams, 1991). Therefore, ABM is a key tool to understand and strategically plan HEIs recycling systems.

This works innovation is to use Agent-Based Modeling methodology to deploy an investigative model, from an institutional perspective, regard recycling initiatives, moving towards sustainable management and a strategical use of resources. Researchers compared the influence of

increasing number of bins or collectors over waste recycling. Results have shown that, theoretically, increasing the number of bins, instead of hiring new collectors staff, is a low-cost solution to enhance waste recycling.

This paper creates an ABM that explores collecting resources (bins, man-power, and storage) influence on a recycling program and how it can support decision makers to plan recycling programs.

Agent-Based Modeling as a decision-making support tool

According to Wilensky (2015), ABM can be described as “a computational modeling paradigm that enables us to describe how any agent will behave. The methodology of ABM encodes the behavior of individual agents in simple rules so that we can observe the results of these agents’ interactions”.

Using the Agent-Based Modeling permits to create artificial worlds representing complex systems, representing the collective or individual community’s behavior, in different scales where researchers can control different, qualitative and quantitative, parameters in different levels inside communities and organizational structures (Bonabeau, 2002; Courdier, 2002).

As other computational models, ABM can be used for prediction purposes where results reliability will depend on data accuracy. ABM allows to study processes of real world phenomena in a more tractable and efficient way, and raises approaches to observe through explanatory perspectives essential mechanisms underlying such phenomena (Wilensky, 2015).

Researchers used Agent Based-Modeling methodology due to its capability to represent real events in a virtual and controlled world, and permitting decision makers to build scenarios. Bonabeau (2002) describes the benefits of using ABM as: sensitivity to emergent phenomena, providing real interpretation of a system and flexibility.

ABM is a key resourceful tool to understand and strategically plan waste management (Shi; Thanos; and Celik, 2014; Meng; Wen; & Qian, 2016; Nguyen-Trong et al., 2017) such as HEIs recycling systems, due the possibility to observe in some explanatory approach agents’ behaviors and to present results in a communicative and educating way.

Methodology

The primary research question addressed in this paper is “How does quantity of bins, number of collectors, and availability of storage space influence HEIs’ quantity of recyclable waste (RW) collected?”

The tool used for deploying the computational scenarios was NetLogo software (Wilensky, 1999).

Experiments were conducted using five factors for collectors and five factors for bins, both using the same number of users, with ten repetitions. The statistical tests conducted used Tukey and Duncan tests, both with 5% of confidence, using ANOVA to identify if there was significance difference between the means of recyclable waste collected when model parameters changed, and Linear Regression with a Growth Curve model, due waste collected increase tendency behavior. Researchers used SPSS software.

Model details are described following Grimm et al. (2010) recommendations.

Purpose of the model

This model’s purpose is to present a tool for HEIs recycling initiatives strategical planning. Current recycling initiatives are developed by sustainability entrepreneurs (teachers, staff, and students) lacking institutional and financial support, and often implemented and enhanced through trial and error. By using the ABM tool presented in this paper, these entrepreneurs can explore scenarios and implement a concise, effective and efficient scheme, selecting the one that most fits their resources availability.

This model is addressed to decision makers for strategical planning scenarios deployment regarding interaction between recyclable bins distribution, waste collection routes, and relation between number of bins, number of collectors, and waste generated. The model has the campus as spatial scale, and weekly as temporal scale.

Model components

Model components are agents that play the roles in the given virtual environment. In this work the agents will be the users, collectors and bins.

Users agents

Users are described as the individuals that will generate waste, they will move randomly. They will reset their amount of waste every new day.

Users within a certain radius of the bin will check if the bin has available space for receiving the amount of waste that they hold, if yes, they will dispose the waste inside the bin, if the bin is full or if its availability is lower than the amount generated by the user, the user will search for another bin.

Collectors agents

Collectors are individuals responsible for collecting the garbage from the bins and taking it to the warehouse where will be stored. The collectors will move directly to the bin at a certain time of the day and check if a bin has waste in it, if yes, it will collect the amount, if not they will search for another bin. They will reset the amount of waste they can carry every new day.

It is noteworthy that collectors also have a limited capacity for carrying waste, so if one collector go to a bin and the amount of waste inside the bin is higher than the amount that he has available to carry, they will not collect only the amount of waste they can carry out of that bin.

Bins agents

Bins receive the waste generated by users. To receive this waste, they available space must be lower than the amount of waste that the nearby user holds.

Warehouse agent

The warehouse is where the collectors will take the waste at the end of each day.

The next section describes with more details each agent function and rules inside the system.

Extent of the model system

Process overview and scheduling

The model presents relationship between some HEIs' key operational aspects that influence recycling initiatives success, inputting number of users, number of collectors, route of collection, number and disposition of bins.

For this model, it is assumed that every bin is a recycling bin, all waste generated is recyclable and that once collectors take the waste to the warehouse it will be recycled.

Collectors play a key role in this model, they are responsible for daily waste collection from bins, if the bins are full the users will throw recyclable waste in different bins, and this will be directly affected by the quantity and allocation of the bins.

The users (students, staff, and faculty) also play a key role in this model, they are responsible for throwing the waste in the right bins, dispersion, identification, and capacity of bins (Luyben et al. 1979, Williams, 1991; Goldenhar and Connell, 1992; Katzvel and Mishima, 1992; McCarty and Shrum, 1994), are described as of major impact on recycling. Figure 12 shows a sketch of interactions between the agents.

Figure 11 - Interactions between users, bins and collectors on the model.

State Variables and Scales

Table 16 shows details of the model's control variables, constraints, and temporal resolution.

Table 16 - Model's control variables, constraints, and temporal resolution.

State Variables and Scales		Initial Inputs
Control Variables	Number of bins	Set by observer
	Number of collectors	Set by observer
	Location of the bins	Random
Constrains	Amount of waste that bins can receive	The amount of waste that each bin holds is 38 Kg/day

	Amount of waste that collectors can carry	The amount of waste that each collector collects per day is 25 Kg/day
	Number of users	Will vary
Temporal resolution	Time	<p>The model will consider every tick as one hour, with a total of 24 hours/ticks to count one day.</p> <p>The model will be reset at tick 23, starting a new day. The amount of waste carried by users, the availability to carry waste by collectors will be reset. The amount of waste in warehouse will not be reset.</p>
	Collection of waste from the bins will be done daily	At tick 16 the collectors will go out to collect the waste
	Collectors get their capacity of carrying waste reset every start of the day	Every day they will be able to carry 25 Kg
	User's waste is increased at every tick	<p>At every 3 ticks the users will produce 0,03kg of waste;</p> <p>The max amount of waste produced per user per day is 0,9 Kg/inhab./day².</p>
	User's waste is reset at every start of the day	At tick 0 users waste is reset to zero
	The waste inside the bins is accumulative	If one bin was not visited by a collector on one day, the next day the amount of waste in the bin will be add with the amount of waste of a new day.

Model simulations

Experiments were conducted by running the model with different sets of bins and collectors, to evaluate which variable had more influence over the recyclable waste amount in the warehouse at the end of seven days.

The simulations were deployed using a matrix of 5, 10, 15 and 20 bins; 5, 10, 15 and 20 collectors; and a total of 500 users.

Figure 12 - Screen shot of model GUI. The NetLogo software interface aids Agent-Based Modeling methodology by graphically presenting changes on the set of the control module. The control module allows to change model parameters and to deploy different scenarios. The output module shows user, collectors, bins, and warehouse agentsets.

Results and Discussion

The first experiment shows the influence that increasing the number of bins has on the recyclable waste generated at the end of seven days.

The results present the interaction between changes in the number of bins and changes in the number of collectors and how those affect the amount of recyclable waste generated. The tests were conducted according to the following matrix presented in Table 17.

Table 17 - Matrix of quantity of recyclable waste generated, the values are presented in Kg.

		Quantity of collectors				
		1	5	10	15	20
Quantity of bins	1	345 Kg	540 Kg	540 Kg	540 Kg	540 Kg
	5	345 Kg	1290 Kg	1485 Kg	1492.5 Kg	1537.5 Kg
	10	345 Kg	1342.5 Kg	2032.5 Kg	2340 Kg	2430 Kg
	5	330 Kg	1350 Kg	2145 Kg	2572.5 Kg	2812.5 Kg
	20	345 Kg	1365 Kg	2137.5 Kg	2632.5 Kg	2910 Kg

Influence of bins in total amount of waste collection

Figure 15 presents a plot which shows that the mean of RW behavior increases in conjunction with the increase in the number of bins. Even an increase in just one bin corresponds to an increase in the median of RW generated.

Figure 15. Interactions between users, bins and collectors on the model.

Figure 13 - Growth curve for influence of bins quantity over recyclable waste collected.

Table 18 presents the ANOVA results of the Linear Regression test, where it can be seen a high F value, confirming that the Linear Regression using a Growth Curve model is suitable to describe the results.

Table 18 - ANOVA results of linear regression using growth curve model for bins influence over the recyclable waste collection.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	83920193.470	1	83920193.47	193.52	0.00
Residual	107546314.100	248	433654.49		
Total	191466507.600	249			

Table 19 shows the difference between the factors, in this case the number of bins. Significance can be noticed in all subsets. in all subsets, the values for σ are higher than 0.05,

accepting the null hypothesis inside the subset, which shows that the means inside the subsets are all in the same range.

The Tukey and Duncan statistical tests divide the influence of the bins over the waste generated in four subsets. All factors have significant influence over the amount of waste generated, except for subset 3, that aggregate the third and fourth factors, meaning that these factors do not present significance when compared with each other, the same happens for the fourth and fifth factors, that are aggregated in the fourth subset. It can be read that the fourth factor does not present significance when compared with both third and fifth factors.

Table 19 - ANOVA presenting difference between factors inside results of linear regression using growth curve model for bins influence over the recyclable waste collection.

	Quant_of_bins	Subset for alpha = 0.05			
		1	2	3	4
Tukey HSD ^{a,b}	1	0	328.5000		
	5	0	1180.2000		
	10	0		1679.1000	
	15	0		1907.4000	1907.4000
	20	0			2043.0000
	Sig.	1.0000	1.0000	0.354	0.810
Duncan ^{a,b}	1	0	328.5000		
	5	0	1180.2000		
	10	0		1679.1000	
	5	0		1907.4000	1907.4000
	20	0			2043.0000
	Sig.	1.0000	1.0000	0.067	0.276

Influence of collectors in total amount of recyclable waste collection

Figure 14 presents a plot that shows the means, as the number of bins increases, RW behavior also correspondingly increases. With the quantity of one bin, the median of RW generated increases as well until the third factor, where one can be observed a reduction on the increase of RW generated.

Figure 14 - Growth curve for influence of collectors quantity over recyclable waste collected.

Table 20 presents the ANOVA results of the Linear Regression test, where it can be seen a high F value, confirming that the Linear Regression using the a Growth Curve model is suitable to describe the results.

Table 20 - ANOVA results of linear regression using growth curve model for collectors influence over the recyclable waste collection.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	29.507	1	29.507	57.728	0.000
Residual	126.760	248	0.511		
Total	156.267	249			

Table 21 shows the difference between the factors, in this case the number of collectors. Significance is noted in all subsets, the values for σ are higher than 0.05, accepting the null hypothesis inside the subset, which shows that the means inside the subsets are all in the same range.

The Tukey and Duncan statistical test divide the influence of the bins over the waste generated in four subsets. The first and second factors have significant influence over the amount of waste generated. The third subset aggregate the third, fourth and fifth factors, meaning that these factors do not present significance when compared with each other.

Table 21 - ANOVA presenting difference between factors inside results of linear regression using growth curve model for collectors influence over the recyclable waste collection.

		Subset for alpha = 0.05			
	Numb_of_collectors	N	1	2	3
Tukey HSD ^{a,b}	1	50	512.1000		
	5	50		1223.4000	
	10	50			1696.2000
	5	50			1837.3000
	20	50			1869.3000
	Sig.		1.0000	1.0000	0.747
Duncan ^{a,b}	1	50	512.1000		
	5	50		1223.4000	
	10	50			1696.2000
	5	50			1837.3000

	20	50		1869.3000
	Sig.	1.0000	1.0000	0.258

To allow a more understandable interpretation of how the subsets change, the values of the following plot presents the values are arranged according to significance between subsets. In addition, Figure 4 provides evidence to explain that there is a diminishing returns situation happening. As you increase the number of bins or collectors, the increase (delta recovered) of waste collected becomes smaller and smaller. This is important because it points to a limit in the ability of collecting more recyclable waste.

Figure 15 - Growth curve for influence of bins and collectors quantity over recyclable waste collected.

The influence of bins is bigger than collectors over the amount of recyclable waste. This translates into a smaller cost to the institution, since it is cheaper to invest in bins than to invest in contracting new collectors. Each unit of the bins with 50 liters cost around US\$ 30.00, with a life span of five years. Each collector will cost, in the case of USP – São Carlos, US\$ 600.00 per month, this is US\$ 39,000.00 in the end of the same five years.

Conclusions

During this research deployment, it was identified lack of standardization of waste management at Higher Education Institutions that may cause negative environmental impacts. In this sense, this work presents an Agent-Based Modeling tool, with behavioral and operational approaches, to aid decision making regard recycling initiatives (Grimm et al., 2010).

This model presents itself as a tool to assist decision-making and planning, a key aspect is that it allows to perceive where investments will be more successful and have the most efficient cost/benefit relation, it aids, also, to develop and test potential solutions and contribute for the continuous learning of all involved parties.

The researchers conclude with this study that physical interventions have direct influence on the amount of recyclable waste collected (Meng; Wen; & Qian, 2016). By using this modeling methodology, the researchers concluded that the number of bins have more influence than the number of collectors. In addition, this shows that investing in increasing the number of bins is less expensive than investing in the increasing the number of collectors.

The ABM methodology translates in a resourceful tool for environmental management and waste management modeling (Shi; Thanos; and Celik, 2014; Nguyen-Trong et al., 2017). The researcher also concluded that physical interventions have a direct influence on the amount of recyclable waste collected. By using this modeling methodology, the researchers concluded that the number of bins have more influence than the number of collectors. In addition, this shows that investing in increasing the number of bins is less expensive than investing in the increasing the number of collectors.

The main learning that was added to the researcher who developed this work was the ability to explore a wide field that is waste management, the ability to identify gaps within the full spectrum of what that management is focused on HEIs.

Also in this work deployment, the researcher also developed and improved several skills, such as using SPSS and NetLogo statistical software to develop the ABM model, as well as adding experience in identifying and articulating with various waste management actors, adding learning in design and application of questionnaires, as analysis of Its results.

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Chapter IX - General conclusions

During this research deployment, it was identified lack of standardization of waste management at Higher Education Institutions that may cause negative environmental impacts. In this sense, this thesis presents a waste management system to HEIs with tools with behavioral and operational approaches to aid decision making towards a sustainable path.

The tools presented in this work were built through literature reviews, exploratory research, and interviews, applied in case studies.

The main products of this thesis are: 1. Framework of a Waste Management System for Higher Education Institutions; 2. A descriptive chapter regard the recycling programs at the University of São Paulo and University of Michigan; 3. The Waste Prevention Culture Assessment for Higher Education Institutions; 4. The Waste Management Index for Higher Education Institutions; and 5. The Agent-Based Model to aid decision-making for recycling initiatives.

When deploying the exploratory research regard waste management and recycling programs at USP and UofM, it was noticed that several factors may influence the continuity of a program related to the socio-environmental themes in a HEI, however, some factors such as the engagement and availability of proactive human resources are of essential importance for the effectiveness and efficiency of the activities proposed for the program.

This thesis presented the Solid Waste Management System Framework for Higher Education Institutions, a management tool that presents several actions to align the existing management system, also counting on a Waste Management Index for HEI that captures the Peculiarities of each campus, providing managers with a baseline of data on how the current system works, pointing out the dimensions that present the greatest fragility.

In addition, from the systematic literature review on waste management, and the case studies conducted at the University of São Paulo - São Carlos and University of Michigan, many variables influence solid waste management, as Political Will, Human Resource Availability, Financial Resource Availability, Community Engagement, and Infrastructure. Another important point is the existence of HEIs Directives and Resolutions, however, although both groups of actors interviewed mentioned this importance, when applied the Waste Management Index, both institutions presented good performance in their waste management, but none of them has

legislation to legally support initiatives, this suggests that the existence of an internal university policy can increase the strength of the initiatives, however, the success or fragility of management processes will depend more on factors related to human resources and Engagement.

This framework presents itself as a tool to assist decision-making and planning, a key aspect is to bring together stakeholders interested in the project to implement the Waste Management System from the beginning of the deployment, to develop and test potential solutions and contribute for the continuous learning of all involved parties.

This framework's validation, regarding education dimension, several papers confirm that curriculum change is a key tool campuses transition to sustainability. We put this in the discussion of the application results of the index; the exploratory part, the discussion of the interviews with the USP and UofM recycling programs bring strong supporting discourses that fed this part of the framework, mainly regarding the importance of sustainability leaderships within the IES community; As for the policy and management dimension, in addition to being reinforced in the interviews, due to my participation in EESC Sustentável (a policy making committee inside the São Carlos School of Engineering), and in the USP's Environmental Policy elaboration and discussion groups, it was clear that the institutionalization of actions aimed at sustainability within policies and resolutions, support these existing practices and encourage the creation of new practices.

The ABM methodology translates in a resourceful tool for environmental management modeling in High Education Institutions. The researcher also concluded that physical interventions have a direct influence on the amount of recyclable waste collected. By using this modeling methodology, the researchers concluded that the number of bins have more influence than the number of collectors. In addition, this shows that investing in increasing the number of bins is less expensive than investing in the increasing the number of collectors.

The main learning that was added to the researcher who developed this thesis was the ability to explore a wide field that is waste management, the ability to identify gaps within the full spectrum of what that management is focused on HEIs and deploy tools to minimize their problematic, and the ability to search for relevant data and interpret them critically.

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Anexes

Annex 1 - Published Paper - MOREIRA, R.M.; CETRULO, T. B.; CORTES, A. D. M.; CETRULO, N. M.; MALHEIROS, T. F. Sustainability Assessment of Policies: Brazilian National Solid Waste Policy Case Study. Revista Gestão e Sustentabilidade Ambiental, v. 6, n. 2, p. 79 -96,2017. DOI: 10.19177/rgsa.v6e220177996

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AValiação DE SUSTENTABILIDADE DE POLÍTICAS: ESTUDO DE CASO DA POLÍTICA NACIONAL DE RESÍDUOS SÓLIDOS BRASILEIRA

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RESUMO

A inserção da sustentabilidade na elaboração e execução de políticas visa trazer um enfoque transversal e integrador à políticas, planos e programas. Assim, a proposta deste trabalho foi realizar uma avaliação de sustentabilidade da PNRS. O trabalho foi dividido em duas etapas, a primeira, a elaboração de um marco teórico sobre avaliação de sustentabilidade, e elaboração dos critérios para avaliar a política sob a perspectiva da sustentabilidade; a segunda foi realizar a uma análise *ex-post* da PNRS com base nos critérios utilizados anteriormente. Foram obtidas um total de 30 critérios. A PNRS possui um texto com enfoque em sustentabilidade, no entanto, a política não se enquadra no conceito de sustentabilidade, visto que de acordo com as experiências encontradas a partir de artigos científicos mostra o cenário atual das organizações públicas e privadas, Estados e Municípios com baixa eficiência na execução das exigências da Lei.

Palavras-chave: Avaliação de sustentabilidade; Gestão ambiental; Meio ambiente e sociedade.

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1 INTRODUÇÃO

Em níveis globais percebe-se a constante busca em gerir resíduos sólidos de modo sustentável. Neste sentido, academia, poder público e iniciativa privada têm cooperado para que a sociedade contemple meios de produção, hábitos de consumo e disposição que minimizem os impactos negativos aos recursos naturais. Esta cooperação tem obtido resultados como inovações tecnológicas, culturais, e de gestão.

A principal ferramenta de gestão é a elaboração de políticas focadas em resíduos sólidos, nos diversos âmbitos federais, estaduais e municipais, com a postulação de objetivos, missão e metas que visam a redução da geração, reuso, reciclagem e reeducação de maneira integrada (MORRISSEY; BROWNE, 2004; BERTICELLI; PANDOLFO e KORF, 2016). Neste sentido o Brasil propôs em 2010 sua Política Nacional de Resíduos Sólidos, que será o objeto de estudo deste artigo onde realizar-se-á uma avaliação de sustentabilidade de seu conteúdo e como esta política afeta a sociedade de acordo com os critérios propostos.

Como proposto por Morrison-Saunders; Therivel (2006), realizar a avaliação da inserção da sustentabilidade dentro do conteúdo de políticas é um método essencial para que a sociedade contemple um desenvolvimento sustentável amparado por seus tomadores de decisão e com metas de curto, médio, e longo prazo. A avaliação de sustentabilidade (AS) de políticas é um novo campo de conhecimento, que proporciona a identificação de fragilidades, possibilitando a elaboração e aplicação de instrumentos que auxiliem em estratégias de gestão mais integradoras, duradouras e que respondam de forma mais efetiva em contextos de crise (POPE; ANNANDALE; MORRISON-SAUNDERS, 2004; GIBSON, 2006; NESS et al., 2007; DOS SANTOS; DIAS; e VAZ, 2016).

Esse artigo apresenta a Avaliação de Sustentabilidade da Política Nacional de Resíduos Sólidos Brasileira (PNRS) utilizando como critérios os Princípios de

Sustentabilidade propostos por Gibson (2006) discutindo aspectos *ex-post* a sua publicação.

2 METODOLOGIA

Avaliação de Sustentabilidade aplicada a políticas

As políticas públicas apresentam-se de maneira complexa devido à diversidade de atores participantes, diferentes níveis hierárquicos, necessidade de discussão com outras políticas, horizontes de tempo e incentivos (DE FREITAS RODRIGUES, 2011). Assim, instrumentos têm sido utilizados a fim de avaliar sua eficiência e eficácia, e possibilitando o monitoramento de seus resultados. Apresenta-se, neste sentido, a avaliação da sustentabilidade (AS), definida pela observação, avaliação e análise das decorrências de uma política, plano, programa, projeto, ou empreendimento, quanto a seus aspectos relacionados a sustentabilidade (POPE; ANNANDALE; MORRISON-SAUNDERS, 2007).

Ainda, a AS quando o processo de avaliação de sustentabilidade é aplicado ao contexto de políticas, devem ser observados aspectos como a sua aplicabilidade, monitoramento de sua eficiência e eficácia, continuidade e diversidade de atores inseridos. Devido à necessidade de realizar AS em políticas elaboradas em lugares com realidades, econômicas, e/ou sociais, e/ou ambientais, e/ou culturais diferentes, exige-se que estes instrumentos de avaliação se adequem a diferentes situações, a fim de serem sensíveis a todas e quaisquer lacunas existentes no objeto de avaliação (POPE; GRACE, 2006).

O método de AS utilizado nesse artigo utiliza os princípios de sustentabilidade de Gibson, com análise qualitativa, que trazem uma abordagem interdisciplinar e multitemporal, considerando transversalidade e focando na minimização dos efeitos de *trade-off*, diferente do conceito convencional do tripé da sustentabilidade baseado nos pilares social, econômico e ambiental, que são estudados separadamente, e apresentam dificuldade em integrar os resultados, negligenciando a interdependência desses fatores (GIBSON, 2006).

A avaliação de sustentabilidade utilizando os princípios de Gibson (2006), descritos na Quadro 1, apresenta um modelo de processo de avaliação integrador que visa:

1. Ter uma visão sistêmica da tomada de decisão, respeitando inter-conecções entre objetivos, ações e efeitos, com monitoramento dos resultados;
2. Elaborar uma avaliação adaptativa com a implementação das opções mais desejáveis em todos os níveis estratégicos e processuais;
3. Redefinir os objetivos motivadores e consequentes critérios de avaliação e decisão evitando as convencionais categorias social, econômica e ambiental, de modo a garantir atenção a requisitos geralmente negligenciáveis e focando em atingir ganhos múltiplos, e de reforço mútuo;
4. Postular regras básicas para minimizar *trade-offs* enquanto a tomada de decisão é direcionada aqueles que são inevitáveis;
5. Facilitar os processos de tomada de decisão a fim de garantir a participação e engajamento público.

Quadro 1: Descrição dos princípios de sustentabilidade de Gibson (2006).

<p>1. Integridade do sistema socioecológico</p> <p>Construir relações entre sociedade e meio-ambiente que estabeleçam e mantenham a integridade dos sistemas em longo prazo, protegendo suas funções ecológicas.</p>
<p>2. Recursos suficientes para subsistência e acesso às oportunidades</p> <p>Garantir que indivíduos tenham condições suficiente para uma sustentar uma vida digna não comprometendo a capacidade de sustento das gerações futuras.</p>
<p>3. Equidade intrageracional</p> <p>Garantir que oportunidades suficientes para todo o espectro da sociedade, seja de no âmbito econômico, ou no âmbito de idade.</p>
<p>4. Equidade intergeracional</p>

Garantir que as atividades das gerações atuais não comprometam a qualidade de vida das gerações futuras, possibilitando que ambos cidadãos jovens ou idosos tenham as mesmas oportunidades.
5. Manutenção de recursos naturais e eficiência Minimizar os impactos sobre os recursos naturais através de inovação tecnológica e estratégias de gestão para mitigar impactos negativos.
6. Civilidade socioambiental e governança democrática Engajar o público na tomada de decisão, bem como, fomentar lideranças na sociedade que discutam as necessidades e que promova a conscientização de responsabilidade coletiva da comunidade.
7. Precaução e adaptação Contemplar incertezas, e evitar ações com potenciais riscos que comprometam a sustentabilidade da comunidade. Deve ser realizada uma gestão adaptativa e preventiva, fomentando o aprendizado contínuo.
8. Integração entre situação atual e de longo prazo Aplicar os princípios de sustentabilidade de modo integrado e transversalmente, sempre buscando benefícios múltiplos.

Fonte: Gibson (2006).

Estudo de caso: Avaliação da Sustentabilidade da PNRS

Todo o conteúdo da PNRS foi analisado, suas diretrizes, princípios, planos estaduais, regionais e municipais, isso devido a necessidade de realizar a avaliação de todas as etapas de deliberação e ação do objeto de estudo (GIBSON, 2006). Ressalta-se que esta é uma lei de âmbito nacional, logo, vários temas não são de sua responsabilidade direta, ficando a cargo de outros instrumentos legais e respeitando diferentes hierarquias.

Os dados utilizados para responder as questões são provenientes de uma pesquisa exploratória de artigos científicos e experiências dos pesquisadores com o objeto de estudo. Ainda, foram utilizadas experiências e descrições de estudo de caso

ex-post a publicação da PNRS descrevendo atividades nas diversas áreas do conhecimento como direito, economia, sociologia e ecologia.

Neste artigo foram elaboradas questões chave para cada um dos princípios, o objetivo desta etapa da pesquisa foi elaborar uma série de questões que possibilitassem a avaliação da sustentabilidade. A elaboração das questões chave para a avaliação de sustentabilidade, foi realizada através de oficinas realizadas pelo Núcleo de Pesquisa e Extensão em Sustentabilidade (NUPS), no mês de agosto de 2016. As questões são apresentadas na Quadro 2.

Quadro 2: Questões postuladas de acordo com os critérios de Gibson (2005) para avaliação de sustentabilidade da PNRS.

<p>1. Integridade do sistema socioecológico (A PNRS prevê...)</p> <p>a. A mitigação de impactos socioambientais negativos gerados por resíduos sólidos?</p> <p>b. Avaliação e análise do fator de resiliência do domínio morfoclimático e das condições físicoquímicas de solo e água?</p> <p>c. Ações de avaliação, análise e monitoramento dos impactos aos recursos naturais e sociedade, requeridos e afetados por atividades relacionadas a gestão e gerenciamento de resíduos? (ex: Estudo de Impactos Ambientais [EIA], Avaliação Ambiental Estratégica [AAE])</p>
<p>2. Recursos suficientes para subsistência e acesso a oportunidades (A PNRS prevê...)</p> <p>a. Incentivos financeiros para catadores para catadores?</p> <p>b. Treinamento para os catadores?</p> <p>c. Condições adequadas de trabalho para os catadores?</p> <p>d. Geração de novos, e fomento dos já existentes, mercados geradores de renda?</p> <p>e. Avaliação do impacto da política na dinâmica econômica do município?</p> <p>f. Linhas de financiamento para atividades relacionadas a gestão e gerenciamento de resíduos?</p> <p>g. Seria interessante um critério de inserção de pessoas de baixa renda nos mercados de reciclagem?</p>

<p>3. Equidade intrageracional (A PNRS prevê...)</p> <p>a. Ferramentas para mitigar a marginalização dos trabalhadores (habitação/educação/exposição/saúde/etc...)?</p> <p>b. Políticas assistencialistas?</p>
<p>4. Equidade intergeracional (A PNRS prevê...)</p> <p>a. Condições adequadas de vida para os descendentes?</p> <p>b. Instrumentos para minimizar a desigualdade social dos descendentes perante os demais (desigualdade social herdada)?</p> <p>c. Cenários futuros?</p> <p>d. Análises, monitoramento e inclusão de estudos de impacto cumulativo e sinérgico das áreas após vida útil do aterro?</p>
<p>5. Manutenção de recursos naturais e eficiência</p> <p>a. Inclui princípios de Ecoeficiência?</p> <p>b. Considera metas, programas ou planos referentes à geração de energia a partir dos resíduos?</p> <p>c. Estipula análise de ciclo de vida de produtos?</p>

Continua.

Quadro 2: Questões postuladas de acordo com os critérios de Gibson (2005) para avaliação de sustentabilidade da PNRS.

Continuação.

<p>6. Civilidade socioambiental e governança democrática (A PNRS prevê...)</p> <p>a. A participação de ONGs, comitês de bacias, e outros agentes de representação da sociedade civil na planos e programas?</p> <p>b. A discussão sobre inovação entre indústrias geradoras de resíduos e universidade? (Conceitos de inovação tecnológica; produção mais limpa)?</p> <p>c. A criação e existência de algum órgão para mediar a relação entre cooperativas e outros setores do mercado?</p> <p>d. Consórcios entre municípios?</p> <p>e. Mecanismos de transparência no processo de governança?</p> <p>f. O diálogo entre diferentes planos (Política de Educ. Amb.; Plano de Recursos hídricos; Política de Saneamento; Plano de mudanças climáticas) na elaboração de programas?</p> <p>g. Documentos comprobatórios da efetividade da atividade de terceiros contratados para destinação final?</p>
<p>7. Precaução e adaptação (A PNRS prevê...)</p> <p>a. Planos emergenciais contra impactos ambientais?</p> <p>b. Adaptação às mudanças climáticas</p> <p>c. Zoneamento para previsão de impactos</p>
<p>8. Integração entre situação atual e de longo prazo</p> <p>a. A PNRS prevê a revisão periódica de seus planos e programas?</p>

3 RESULTADOS E DISCUSSÃO

Foram obtidas um total de 30 questões, sendo estas dispostas dentro das oito dimensões propostas por Gibson (2006). No Quadro 3, apresenta-se a avaliação e

análise da PNRS de acordo com os Princípios de Sustentabilidade propostos por Gibson et al. (2005):

Quadro 3: *Check-list* de avaliação do cumprimento dos critérios e exigências propostas pela PNRS de acordo com o diagnóstico da gestão de resíduos sólidos da USPSC. Adequado ao critério ●; Não Adequado ○.

Critério	Avaliação	Marco legal específico
Integridade do sistema sócio ecológico		
1.a	●	Art. 6º - §: 5.º; 7.º; Art. 7º - §: 1.º, 2.º, 3.º, 4.º, 5.º; Art. 8º - §: 1.º, 3.º, 4.º, 17.º; Art. 9º - I, II; Art.14º - §: 1.º, 2.º, 3.º, 4.º, 5.º, 6.º; Art. 29º; Art. 30º; Art. 31º; Art. 32º; Art. 33º; Art. 37º; Art. 39º - §: 2.º, 3.º, 4.º; Art. 41º; Art. 42º - §: 1.º, 2.º, 4.º, 7.º, 8.º; Art. 47º; Art. 48º; Art. 49º; Art. 17, XI b)
1.b	○	Não trata de resiliência
1.c	●	Art. 8º, XVII d) e f); Art. 17º,I
Recursos suficientes para subsistência e acesso a oportunidades		
2.a	●	Art. 18º - §: 2.º, 11.º; Art. 36º - I; Art. 42º - §: 2.º, 3.º, 5.º
2.b	●	Art. 7º - IX .º
2.c	●	Art. 42º - III; Art. 15º - V
2.d	●	Art. 8º - IV Art. 18º - II ; Art. 19º XI e XII
2.e	○	Instrumentos propostos pela PNRS são insuficientes para serem considerados no âmbito municipal
2.f	●	Art. 43º; Art 44º
Equidade intrageracional		
3.a e 3.b	○	--
Equidade intergeracional		
4.a e 4.b	○	--
4.c	●	Art. 15º - II; Art. 17º - II
4.d	○	--
Manutenção de recursos naturais e eficiência		
5.a	●	Art. 6º - V
5.b	●	Art. 9º - § 1; Art. 15º - IV
5.c	●	Art. 6º - VII; Art. 7º - VII e VIII; Art. 8º - III; Art. 19º - XV; Art. 21º -VII; Art. 30º; Art 36º; Art. 42º -II; Art. 44º - II
Civilidade socioambiental e governança democrática		
6.a	●	Art. 19º - §: 11Art. 15º parágrafo único
6.b	●	Art. 6º - § 6; Art. 8º - : VI;
6.c	○	--
6.d	●	Art. 8º, XIX e Art. 45º
6.e	●	Art. 6º, X; Art. 8º, XI e XII; Art. 12º
6.f	●	Art. 5
6.g	○	--

Precaução e adaptação		
7.a e 7.b	○	--
7.c	●	Art. 17, XI a)
Integração entre situação atual e de longo prazo		
8.a	●	Art. 15º; Art. 17º; Art. 19, XIX; Art. 21º, IX

3.1 Integridade do sistema sócio ecológico

Partindo do princípio de que a lei foi formulada para minimizar os impactos negativos, a mesma, permeia as diversas dimensões de temas socioambientais. Desde seu modo de estruturação, a lei permite que seus executores tenham uma orientação detalhada para a interpretação e de sua regulamentação.

Nos Planos e Programas deverão ser consideradas as peculiaridades de cada microrregião onde atividades, de responsabilidade pública ou privada, referentes à gestão e gerenciamento de resíduos forem instaladas.

A PNRS prevê Estudo de Impactos Ambientais e licenciamento para qualquer tipo de empreendimento que trabalhe com resíduos, em qualquer etapa das atividades.

Quanto a responsabilidade compartilhada, embora a lei preveja esta ação, não existe efetividade neste aspecto, pois como as empresas não realizam a gestão do ciclo de vida, que deveria ser de quem produz, a responsabilidade compartilhada faz com que nenhum dos atores deste ciclo assume a responsabilidade (CARDOSO GOMES et al., 2014).

3.2 Recursos suficientes para subsistência e acesso a oportunidades

A PNRS traz uma discussão de caráter de integração social em relação aos catadores, além disso, reforça a qualidade de trabalho na prestação de serviço relacionada ao gerenciamento dos resíduos. A PNRS, também, fomenta a criação, e provém incentivos fiscais, a cooperativas e outras formas de associação de catadores de materiais reutilizáveis e recicláveis, em especial aquelas formadas por indivíduos de baixa renda (NETO, 2011).

3.4 Equidade intrageracional

A PNRS não traz a discussão para uso futuro das áreas dos aterros sanitários. No entanto, a Norma Brasileira (NBR) 8419: Apresentação de projetos de aterros sanitários de resíduos sólidos urbanos: procedimento. Rio de Janeiro, 1992 em seu item 5.1.8 discorre sobre o “Uso futuro da área do aterro sanitário”.

A PNRS não traz políticas assistencialistas focadas para catadores de materiais reutilizáveis e recicláveis, no entanto, prevê prioridades ao provimento de incentivos fiscais a cooperativas e outras formas de associação de catadores de materiais reutilizáveis e recicláveis formadas por indivíduos de baixa renda.

3.5 Equidade intergeracional

A PNRS visa melhorar a qualidade de vida dos catadores (GOUVEIA, 2012), através da integração do sistema social, econômico, ambiental e cultural, no entanto, não prevê metas a longo prazo para a perpetuação desta qualidade de vida dos descendentes dos indivíduos relacionados a gestão e gerenciamento de resíduos sólidos.

A PNRS exige que os planos e programas sejam reavaliados quanto sua eficácia periodicamente, considerando em seus textos e ações as tendências socioeconômicas nacionais e internacionais.

A PNRS não traz a discussão para uso futuro das áreas dos aterros sanitários. No entanto, a “Norma Brasileira (NBR) 8419: Apresentação de projetos de aterros sanitários de resíduos sólidos urbanos: procedimento”, em seu item 5.1.8 discorre sobre o “Uso futuro da área do aterro sanitário”.

3.6 Manutenção de recursos naturais e eficiência

Se embasando nos princípios de sustentabilidade, a PNRS se debruça sobre aspectos que exigem iniciativas de otimização de todos os processos inseridos na cadeia de gestão e gerenciamento dos resíduos, de modo que o consumo de recursos naturais seja o menor possível. Podemos observar os diversos incentivos a aterros que utilizam os gases gerados pela decomposição dos resíduos para produção de energia. Como o

caso apresentados por De Abreu et al. (2014), Franco; Castilho Junior; De Souza (2014), De Souza e Valdés (2015), Pinãs et al. (2016).

As principais fontes de geração de resíduos são os aterros sanitários, no entanto, estes, para gerarem energia, desde que certifiquem sua viabilidade técnica e ambiental e com a implantação de programa de monitoramento de emissão de gases tóxicos aprovado pelo órgão ambiental. No entanto, não existe legislação específica para o projeto de implantação deste sistema de aproveitamento de gases para geração de energia.

A PNRS traz o conceito de ciclo de vida como: “série de etapas que envolvem o desenvolvimento do produto, a obtenção de matérias-primas e insumos, o processo produtivo, o consumo e a disposição final.”

3.7 Civilidade socioambiental e governança democrática

A PNRS prevê a criação de programas e ações para participação de grupos interessados no Plano Municipal de Gestão Integrada de Resíduos Sólidos, no entanto, não especifica se esta participação ocorrerá na discussão de elaboração dos Planos.

A articulação entre poder público, iniciativa privada e centros de pesquisa, como universidades, fortalecem o cenário da gestão e gerenciamento de resíduos sólidos, exemplos disso são países como Suíça, Estados Unidos e China (SANT'ANNA; MACHADO; DE BRITO, 2015).

A PNRS não prevê a criação de nenhum órgão de mediação entre cooperativas e catadores de materiais reutilizáveis e recicláveis. O cenário de articulação do mercado de logística reversa, por exemplo, encontra-se fragilizado por falta desta articulação. O que se observa é a criação de Fóruns do movimento de cooperativas e catação para que ocorra este espaço de discussão política.

A criação de Consórcios Intermunicipais é fomentada pela PNRS, de modo a possibilitar que municípios menores, que possam não conseguir implantar aterros sanitários, ou equipamentos de incineração devido a limites orçamentários, por exemplo, possam ter uma destinação adequada de seus resíduos. No entanto, os mecanismos

legislativos para regulamentar o funcionamento destes instrumentos não são claros e bem definidos, possibilitando uma fragilização deste tipo de ação (NETO; MOREIRA 2012).

A PNRS exige a divulgação de informações à órgãos de fiscalização, porém, não prevê a divulgação a comunidade sobre as informações relacionadas ao sistema de gestão e gerenciamento de resíduos sólidos por parte das empresas e organizações públicas e privadas.

A PNRS implementa um sistema declaratório com periodicidade, no mínimo, anual. A pessoa jurídica que operam com resíduos perigosos devem se cadastrar no Cadastro Nacional de Operadores de Resíduos Perigosos. Este cadastro exige periodicamente informações gerenciais por meio de Relatórios de Atividades e formulários específicos.

3.8 Precaução e adaptação

A PNRS não exige dentro de nenhum de seus instrumentos medidas de prevenção para áreas propícias a desastres naturais.

3.9 Integração entre situação atual e de longo prazo

Política Nacional de Resíduos Sólidos, que se desdobra nas diversas instancias federais, estaduais e municipais para a elaboração de planos e programas, contendo metas de curto, médio e longo prazo para padronizar a gestão de resíduos e de modo que estes resíduos cause o mínimo possível de impacto a saúde pública.

O Plano Nacional, e o Plano Estadual de Resíduos Sólidos, tem prazo indeterminado de vigência e horizonte de 20 (vinte) anos, a ser atualizado a cada 4 (quatro) anos. No entanto, não existe periodicidade de revisão para os Planos Municipais de Gestão Integrada de Resíduos Sólidos.

3.10 A PNRS é sustentável? O que é exigido pela PNRS *versus* O que vem sendo realizado na ponta dos processos

Em um panorama sistêmico, a perspectiva de gestão de resíduos sólidos da PNRS é inovadora trazendo em seu texto ações de integração, como pode ser interpretado no artigo 3º da Lei, que define a Gestão Integrada de Resíduos Sólidos como o “conjunto de ações voltadas para a busca de soluções para os resíduos sólidos, de forma a considerar as dimensões política, econômica, ambiental, cultural e social, com controle social e sob a premissa do desenvolvimento sustentável” (BRASIL, Lei 12.305 de 02 de agosto de 2010).

Com base nos resultados da avaliação de sustentabilidade da PNRS, observa-se que a política aborda conceitos, possui diretrizes e em seus princípios e objetivos prioriza questões relacionadas a sustentabilidade. No entanto, diversos trabalhos divulgados após a publicação desta lei confirmam que a sustentabilidade não acontece na ponta do processo de execução dos planos e programas exigidos por esta política (DE FREITAS RODRIGUES, 2011; CHAVES; SANTOS JR; ROCHA, 2015).

A PNRS foi publicada há cinco anos, portanto, os prazos para os municípios se adequarem já foi contemplado. Porém, problemas com a inoperância da lei como: falta de fiscalização; de articulação entre setores e hierarquias do governo brasileiro; e falta de transversalidade, são vistos continuamente. A execução desta lei em âmbito municipal é uma situação de alta complexidade e de baixa probabilidade de cumprimento das exigências propostas nos prazos determinados.

Por exemplo, municípios e estados tinham dois anos para publicar seus Planos de Gestão de Resíduos, após três anos da data limite deste prazo, 33,5% dos municípios brasileiros declararam possuir PMGIRS, deste total, 8,63% situam-se na região sudeste, 2,71% encontram-se na região Norte, 7,68% na região Nordeste, 11,49% na região Sul e 2,89% na região Centro-Oeste (IBGE, 2014).

Machado (2012) aponta como fragilidades da PNRS:

1. os conflitos políticos, onde o problema encontra-se nos indivíduos eleitos, estes, devem compreender que a política deve ser feita pelo povo e para o povo, não deixando conflitos de interesses partidários exercerem influência;

2. o déficit de recursos humanos preparados, pois há uma lacuna na gestão municipal que deve ser preenchida com incentivo à educação técnica e específica para os funcionários;

3. a falta de recursos financeiros, não existe prioridade para a área ambiental no orçamento do município, a gestão trabalha com medidas de correção e não de prevenção.

Estes são alguns dos fatores que impedem a eficácia e eficiência de políticas voltadas a responder a problemas socioambientais.

Estes instrumentos de gestão pública devem almejar a equidade entre todos os setores, agindo a partir da inter-relação dos mesmos, não sobrepondo as peculiaridades de um setor sobre os outros. O seu trabalho, por exemplo, como o Estado enxerga os cidadãos e organizações da sociedade civil que trabalham com catação, como um entrave ao sistema de gestão de resíduos, segregando-os e não promovendo políticas públicas para geração de trabalho a esses indivíduos.

Assim, a maneira que instrumentos voltados a temas da socioambientais e sustentabilidade irão se comportar também devem ser estudados, isso, devido à variabilidade das realidades locais, regionais e nacionais. A avaliação de políticas refere-se à averiguação da situação posterior à publicação destas, e a elaboração e execução de seus planos de gestão locais, a fim de garantir que os mesmos sejam funcionais e auxiliem de maneira concreta e continuada aos atores que o utilizarão, analisando a efetividade e eficiência no cumprindo de seus propósitos (CRABB; LEROY, 2012).

O reconhecimento da sociedade como ator fiscalizador da execução destas políticas, é um ponto chave para o cumprimento e alcance dos objetivos propostos por políticas, planos e programas públicos. Isso é possível através da transição do modelo de gestão atual para um modelo que conte com os princípios da transparência, integração e engajamento social, de maneira contínua, nos processos de elaboração e aplicação destas políticas.

A PNRS como uma política de âmbito federal, e com desdobramentos nos âmbitos estaduais e municipais carece de aspectos de fiscalização e monitoramento, a sustentabilidade não é seu objetivo final, no entanto, como uma política de influencia em aspectos sociais, econômicos e ambientais carece de instrumentos que garantam um desenvolvimento sustentável, por exemplo, suas metas planos e programas não fomentam questões intrageracionais e intergeracionais, o que é traduzido em uma gestão de resíduos que não garante estabilidade econômica e ambiental para as gerações atuais e futuras. Seus prazos para reavaliações dos Planos que devem ser elaborados pelos municípios apresentam um *gap* de tempo, não considerando a taxa de crescimento populacional e expansão dos municípios, bem como, não exige uma discussão integrada com outros instrumentos básicos relacionados a zoneamento estratégico.

4 CONCLUSÕES

A PNRS possui um texto com enfoque em sustentabilidade, no entanto, o resultado final da avaliação e análise do atual cenário das organizações públicas e privadas, Estados e Municípios apresentam baixa eficiência na execução tanto em concordância das exigências e prazo estipulados pela Lei na ponta dos processos, como podem ser vistos nos diversos artigos e documentos apresentados pelos autores deste artigo. Estes resultados apontam que a PNRS não contempla sustentabilidade, tanto nos seus aspectos de planejamento, como de operacionalização e execução. A PNRS, ainda, não garante explicitamente aspectos relacionados ao desenvolvimento sustentável no que tange a gestão de resíduos no país.

A PNRS foca seus esforços em medidas corretivas, quando devem ser fomentadas iniciativas preventivas, observa-se isso devido ao seu texto apresentar diversas diretrizes para reciclagem, no entanto, pouco se exige de instrumentos que viabilizem a redução de geração, e os instrumentos que preveem o reuso, como a logística reversa, não funcionam de acordo com o esperado, sem diretrizes claras ou fiscalização para que tais exigências sejam cumpridas.

No entanto, algumas iniciativas têm sido fomentadas e com o respaldo da Lei têm se fortalecido, principalmente nos aspectos referentes as associações e cooperativas de catção e reciclagem.

Como principais perspectivas futuras, recomenda-se que planos e programas que mitiguem a problemática do gerenciamento de resíduos devem ser elaborados e executados de maneira transversal e integrada, com participação social, com uma visão de conjunto e de atuação dinâmica e proativa, considerando aspectos regionais e conjunturas socioeconômicas locais e levando a discussão a todas as classes comunidade. Além disso, os instrumentos derivados da lei deveriam ter uma construção mais participativa para que possam ser adequados às diferentes realidades estaduais, regionais e municipais. Nesse sentido, ressalta-se a necessidade de serem estabelecidas instancias de participação que permitam uma atuação mais dinâmica e proativa da sociedade civil.

SUSTAINABILITY ASSESSMENT OF POLICIES: CASE STUDY OF THE BRAZILIAN SOLID WASTE NATIONAL POLICY

ABSTRACT

The inclusion of sustainability in elaboration and execution of policies aims to bring a transversal and integrative approach to policies, plans and programs. Thus, the proposal of this work was to carry out a sustainability assessment of the PNRS. The work was divided in two stages, the first one, elaboration of a theoretical framework on sustainability assessment, and elaboration of criteria to assess the policy from a sustainable perspective; The second was to conduct an *ex-post* analysis of PNRS' text based on the criteria deployed previously. A total of 30 criteria were obtained. The PNRS' text has focus on sustainability, however the policy does not fulfill the concepts of sustainability, as presented by the experiences reported by scientific articles that shows the current scenario of public and private organizations, States and Municipalities presents low efficiency in the execution of the requirements of the Law.

Keywords: Sustainability assessment; Environmental management; Environment and society.

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Annex 2 – Published Paper - MOREIRA, R.M.; CETRULO, T. B.; CORTES, A. D. M.; CETRULO, N. M.; MALHEIROS, T. F. Brazilian National Solid Waste Policy applied as a tool to enhance an university campus waste management. Journal of Management and Sustainability, v. 7, p. 101-111, 2017. DOI: <https://doi.org/10.5539/jms.v7n3p101>.

Brazilian National Solid Waste Policy applied as a tool to enhance an university campus waste management

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Abstract

The aim of this work is to discuss the Brazilian National Solid Waste Policy potential to enhance Brazilian universities waste management by analyzing the University of São Paulo, Campus of São context in accordance with the national policy requirements. Universities in Brazil lack a legal instrument to strengthen its waste management, which brings this paper innovation by applying the Brazilian waste policy as a standardization instrument to adapt waste management at Brazilian higher education institutions. The research used a descriptive and qualitative approach, data were collected from literature review, university documents and semi structured interviews, a case study approach is used to analyze the campus solid waste management activities, procedures and operations inherent the. The main findings conclude that University of São Paulo waste policy is being deployed, based on Brazilian Solid Waste National Policy requirements, confirming it translation into a potential framework tool to support decision making for adequacy of environmentally sound management of Brazilian. Further studies are required *ex-post* the policy enactment to assess the impacts of the waste policy at the university impacts.

Keywords: sustainability culture, waste policy, environmental management.

1. Introduction

Discussions regard sustainability is a key criterion for policies elaboration and execution, inserting goals for equity and social justice promotion, efficiency in the use of natural resources and economic prosperity, giving priority to society's present well-being, without compromising future generations (Belkhir, 2015; Broman & Robert, 2017). Furthermore, private companies, public institutions and organized society have tackled to insert sustainability on daily

activities and decision making over last decades in response to negative pressure on the environment where anthropic actions occur, such as exponential solid waste generation growth and inadequate disposal (Mallak et al., 2014; Mesjasz-Lech, 2014; Stark, & Lindow, 2017).

University campuses can be faced as small cities (Alshuwaikhat & Abubakar, 2008), due to their size, number of people, diversity of activities and consumption of natural resources. Nevertheless, universities, responsible for producing human resources, assume the role of facilitators of sustainability actions within society, through their teaching pillars, research, and outreach, where students, teachers, and staff are considered as urban agents with potential towards sustainability leadership (Mauser et al., 2013; Tom et al., 2012; Yuan & Zuo, 2013).

In this perspective, in 2005, solid household waste generation in South America was 1.1 kg. inhab⁻¹.day⁻¹ (Hoorweg, Bhada-Tata, & Perinaz, 2012, page 09). Of 1.04 Kg.inhab⁻¹.day⁻¹, in the Southeast region, this value was 0.88 kg.inhab⁻¹.day⁻¹ (Abrelpe, 2013, page 28), and the University of São Paulo, Campus of São Carlos (USPSC) generates 1.46 kg.person⁻¹.day⁻¹ of waste (Schalch, 2014). Following this tendency, universities waste generation is large and diversified, resulting from its end activities (Armijo de Vega, Ojeda Benítez, & Ramírez Barreto, 2008; Baldwin & Dripps, 2012; Smyth, Fredeen, & Booth, 2010).

The Brazilian National Solid Waste Policy (PNRS) enactment in 2010, create a legal conceptual basis for new tools and establish goals for the country waste management systematization (Brazil, 2010). This policy requires city halls to elaborate the Municipal Plans of Integrated Management of Solid Waste (PMGIRS). Thus, universities in Brazil do not have a specific policy to standardize waste management.

This paper innovates by bringing the Brazilian National Solid Waste Policy requirements and applying them as a standardization instrument to adapt waste management at Brazilian higher education institutions, disseminating through their practices a culture that walks from the perspective of sustainability lenses.

The objective of this work is to discuss the PNRS' potential to enhance Brazilian universities waste management by analyzing the University of São Paulo, Campus of São context in accordance with the PNRS' requirements.

2. Method

The research used a descriptive-qualitative approach proposed by (Thomas & Magilvy, 2011), which considers data aspects regarding credibility, applicability, consistency and neutrality. The research used data from documents and interviews to describe activities, procedures and interactions inherent to Solid Waste Management of the University of São Paulo, São Carlos campus (USPSC) as well as a systematic literature research to construct the analysis basis.

Analyses were conducted accordingly to the PNRS requirements, describing what needed to be addressed by a university's solid waste management.

The initial stages of work analyzed the Solid Waste Inventory prepared by Schalch et.al. (2014). This inventory has a diagnosis of the generation, and description of the waste management of USP - SC.

A case study was conducted (Baxter & Jack, 2008), using semi structured interviews (Drever, 1995) conducted with key management process actors from within the USP São Carlos campus, these actors were questioned

regarding management and operational aspects of campus processes, questions addressed issues regard How much waste is produced daily? Who deals with the disposal of urban waste? What is the standard procedure to deal with hazardous waste? What are the main challenges faced by the waste management inside this university? Etc. The interview stage was a key factor for observation and verification of the practice and application of documented processes found.

In addition, several papers developed at USPSC campus by undergraduate students were used as information grants, from disciplines and scientific initiation projects, which provided data and discussed the sustainability theme within USPSC.

3. Results

University campuses have food, housing, and transportation services, many have school hospitals and clinics, generating healthcare waste, as well as research laboratories that generates hazardous waste that needs specific disposal. Furthermore, in addition to teaching and research activities, campuses host various social and scientific events (Tangwanichagapong et al., 2017). These factors show the waste generation variety and consumption of natural resources (Baldwin & Dripps, 2012). Thus, with enormous potential of socio-environmental impacts, the heterogeneity of university campuses, different land uses and activities, aggregated with the fact that universities have social responsibilities for society training and education, environmental management and sustainability in universities requires an approach different from cities.

In this context, universities need a high input of natural resources, with a very wide range of diversity, Figure 1 brings the example of USPSC waste inputs and outputs.

Figure 1. Waste inputs and outputs at USP-SC.

Brazilian universities have daily complex operations that generate potentially polluting environmental impacts, and have been neglected in terms of a legislation tool that brings specific requirement regarding social and environmental responsibility (Adeniran et al., 2017).

In its management framework, universities have city halls, councils, committees, and various stakeholders included in their decision making. Thus, within its waste management, practices aimed at reduction, reuse, and recycling, as well as community re-education are of extreme importance, and within universities, actions that promote recycling practices are the most commonly applied (Armijo de Vega, Ojeda-Benítez, & Ramírez-Barreto, 2003; Zain et al., 2012). Thus, it is necessary to reinforce the relationship between university and municipality, discussing innovative methodologies and planning strategies that contemplate equal civil benefit, with healthy environmental conditions, to the whole spectrum of society (Duarte, Gaudreau, Gibson, & Malheiros, 2013).

3.1 University of São Paulo waste management

Solid waste management within university campuses, discussing and applying awareness-raising actions that deal with reduction, reuse and recycling have a direct influence of a university community consumption patterns and waste generation (Callewart & Marans, 2013)

Since USP-SC has different profiles of teaching, research and outreach activities, being Institute of Chemistry, Institute of Physics, Institute of Computational Sciences and Mathematics, School of Engineering and Institute of Architecture and Urbanism, with different research and teaching profiles, translated in specific characteristics of generation and waste management, the PNRS requirement for the preparation of Solid Waste Management Plans for each unit of the university, such as for each dimension of a city, is applicable.

The University of São Paulo's Environmental Policies are in its final steps of development. One of these policies tackles waste management specifically, and it has its background support in Brazil's National Solid Waste Policy, setting prevention goals and predicting creation of plans and programs.

The USP Solid Waste Policy is a proposal of the University's Environmental Management Superintendence (SGA), an initiative of the USP dean's office. One of SGA's first actions was the elaboration of the USP Solid Waste Policy, by creating a committee with several teachers, staff, technicians and lawyers from within and outside the university. The meetings occurred periodically, mainly in the campus of USP - Piracicaba. The USP-SWP assumes the PNRS's premises, adapting itself to the university realities of each campus. One of the initiatives proposed by the USP-SWP is the decentralization of waste management, where all units, museums, departments, and campuses City Halls should prepare their Waste Management Plans.

The USP Solid Waste Policy (USP-SWP) requirements for Management plans are compared, in table 1, with PNRS' requirements.

Table 1. Parallel between the PNRS's and the USP-SWP's Waste Management Plans. Evaluation of the adequacy of actions performed by USP based on the investigator's observations and interview data (PNRS, 2010): ● Adequate; ◎ Non adequate; ○ Needs Revision.

PGRS items required by PNRS (2010)	Draft PGRS proposed by USP	Ev aluation
"I - Description of the enterprise or activity"	Description of the solid waste generator (Units, Museums, Integration Bodies, Complementary Bodies and Campuses City Halls) as to: a) location, b) population, c) activities developed, d) physical space, e) administrative structure and f) Environmental aspects	●
"II - Diagnosis of solid waste generated or managed, containing the source, volume and characterization of the waste, including related environmental liabilities"	Diagnosis of the generation of solid waste following a methodology for collecting information and tabulating the data related to the waste listed in this policy;	●
"III - Observed the norms established by the organs of the the National Environmental System(Sisnama), National	Definition of the operational procedures related to solid waste management stages under the responsibility of the generator, indicating those responsible for solid waste management and collaborators;	●

Sanitary Vigilance System (SNVS) and Unified System of Attention for Agricultural Sanitation (Suasa) and, if there is one, the municipal solid waste management plan”	Identification of the Technician duly qualified for the elaboration, implementation, operationalization and monitoring of all the steps of the solid waste management plan, including the control of tailings environmentally adequate disposal	●
“IV - Identification of solutions shared or shared with other generators”	Identification of solutions shared or shared with other solid waste generators	●
“V - Preventive and corrective actions to be taken in situations of incorrect management or accidents”	Description of preventive and corrective actions to be performed in situations of incorrect management or accidents (Contingency Plan);	●
“VI - Goals and procedures related to solid waste reduction, in accordance with the standards established by the organs of Sisnama, SNVS and Suasa, reuse and recycling”	Elaboration of goals and procedures related to the solid waste reduction;	●
“VII - If applicable, actions related to shared responsibility for the product life cycle, in the form of art. 31”	Presentation of proposals and actions regarding shared responsibility for the processes, products and services developed and consumed at the University;	○
“VIII - Sanitary measures for environmental liabilities related to solid waste management”	Carried out by the USP-São Carlos Residues Inventory	●
“IX - Review period, observing, if applicable, the term of validity of the respective license of operation by the organs of Sisnama”	The Solid Waste Management Plan shall be reviewed one year before the end of the term of office of the Units, Museums, Integration Bodies, Bodies Complementary and City Halls	●
	Elaboration of indicators to waste management performance monitoration.	●

It is observed that the text proposed by the USP-SWP waste management plans requirements is very similar to the PNRS. This is due to the committee that drew up this draft to have studied under the PNRS, which has a significant support, for the development of the policy for the university.

However, it is necessary to observe that the realities of university campuses are quite peculiar and may vary among the Higher Education Institution class, for example, many have laboratories with equipment that carry toxic and radioactive elements that demand special management, others, have researches with animals, generating residues such as carcasses, anatomical pieces, viscera, and corpses of animals suspected of infection. This emphasizes the need to translate this federal policy into a decision-making tool to specific cases of university campuses, although, the peculiarities of the plan and programs must be carefully studied and mentioned in policies text, of each campus, minimizing the possibility of gaps in their executions.

Many universities, as well as municipalities already have a waste management system, however, the elaboration and execution of a Waste Policy rise as a tool (Amasuomo and Baird, 2016) to guide and support universities to institutionalize more environmentally friendly waste management. As shown by Zurbrügg, (2012) institutions that institutionalize environmental practices had this dimension strengthened.

3.2 Case study

3.2.1 Description of the USP São Carlos Case Study

The University of São Paulo (USP) is the largest university in Brazil, with great relevance within the international academic scene. The campus of USP located in the city of São Carlos, counted in 2015, with 5,199 undergraduates, 2,579 postgraduates, 1,179 employees and 531 teachers, which adds a character of return and socio-environmental responsibility. Also, it consumes $161,541 \text{ m}^3 \cdot \text{year}^{-1}$ of water, and $11.3 \text{ GWh} \cdot \text{year}^{-1}$, being $1191.22 \text{ KWh} \cdot \text{person}^{-1}$ of electricity (Paulo et al., 2010), in addition to CO_2 emissions, waste generation, Natural resources and consumption of public monetary resources. In 2011/2013 a total of 36 kg of recyclable paper were collected on the São Carlos campus (USP- Recicla, 2013).

USP - São Carlos has the following units: Institute of Physics (IFSC), Institute of Chemistry (IQSC), Institute of Mathematical Sciences and Computation (ICMC), School of Engineering of São Carlos (EESC) and Institute of Architecture and Urbanism (IAU). As an example of the diversity of waste generation, according to Schalch (2014)

Table 1, specifically shows the amount of each residue produced. Table 1 describes quantitatively the waste generation of the campus.

Table 1. Qualitative and quantitative description of residues generated in USP-SC (Schalch et al., 2014)

Type of Waste	Amount
Urban waste generated within the São Carlos Campus	6325 Kg.d ⁻¹
Waste from the third party restaurants generated within the São Carlos Campus	95 Kg.d ⁻¹
Pruning waste generated within the São Carlos Campus	16 dumpster.month ⁻¹ 1.trucks ⁻¹

Commercial Establishments and Service Providers waste generated within the São Carlos Campus	0.74 m ³ .week ⁻¹
Chemicals waste generated within the São Carlos Campus of USP	645 Kg.month ⁻¹
Workshop waste generated within the São Carlos Campus	30 Kg.month ⁻¹
Healthcare Waste generated within the São Carlos Campus	0.65 m ³ .week ⁻¹
Civil Construction Waste generated within the São Carlos Campus	162 m ³ .month ⁻¹
Geology Research Waste	250 Kg.month ⁻¹

Since USP has different units, and these have specific characteristics of generation and management of their residues, this reinforces the PNRS requirement for the elaboration of Solid Waste Management Plans for each unit of the university.

3.1.2 USP São Carlos Case study - Waste Management analysis in accordance to the PNRS' requirements

Table 2, elaborated with PNRS and field research data, shows the relationship between what is proposed by the PNRS, through the Criteria proposed to elaborate the Integrated Municipal Plans for Solid Waste Management (PMIGRS) and the management actions that occur within USP-São Carlos.

Table 2. PNRS requirements checklist, and description of activities according to the USP-SC solid waste management diagnosis. Evaluation of the effectiveness of actions: Complies with the requirements ●; will be adapted wit USP-SWP publication ◎; does not meet the requirements ○.

Responsibility Agent	PNRS Item	Evaluation
São Carlos municipality	Art. 19, Paragraph II; Art. 19, Paragraph III	○
	Art. 19, Paragraph V; Art. 19, Paragraph XIII	●
	Art. 19, Paragraph VII	◎
USP-SC	Art. 19, Paragraph I; Art. 19, Paragraph V; Art. 19, Paragraph IX; Art. 19, Paragraph X	●
	Art. 19, Paragraph IV; Art. 19, Paragraph XI; Art. 19, Paragraph XIV; Art. 19, Paragraph XV; Art. 19, Paragraph XVI; Art. 19, Paragraph XVII; Art. 19, Paragraph XVIII; Art. 19, Paragraph XIX	○
	Art. 19, Paragraph VIII; Art. 19, Paragraph XII	◎

Third party	Art. 19, Paragraph XIII	•
Incineration Companies	Art. 19, Paragraph VII	©

4. Discussion

The case study's qualitative-descriptive analysis is presented below for each PNRS requirement.

"Diagnosis of solid waste situation ", Arct. 19, Paragraph I: USP-SC has a generation, disposal and final disposal of waste inventory. However, this diagnosis is not periodic. The PNRS requires the preparation of Municipal Plans for the Integrated Management of Solid Waste (PMGIRS), which contains the steps of diagnosis, and adequacy, and where odds can be noticed, decision-makers must apply corrective actions. Regarding the diagnostic stage in USP-SC, it was already performed by Schalch et al. (2014), which was a punctual and proactive action of a teacher/researcher, with no obligation.

"Identification of satisfactory areas for environmentally adequate final disposal of waste", Art. 19, Paragraph II and "Identification of the possibilities for the implementation of shared solutions with other Municipalities, considering, in the economies of scale criteria, proximity to established sites and ways of preventing environmental risks, "Arct. 19, Paragraph III. Responsibility of the Municipal Master Plan.

"Identification of solid waste generators and subjects to management plans and actions of Reverse Logistics", Arct. 19, Paragraph IV: Carried out by the São Carlos Waste Inventory. Today USP has a battery collection program, where special bins are spread across several locations at the campus, once these containers are full, an agent collects and takes them to supermarkets, for reverse logistics process purpose. There is no institutional policy for reverse logistics of lamps.

"Operational Procedures and Minimum Specifications for Environmentally Appropriate Waste Disposal (Chemical and Biological Waste)", Arct. 19, Paragraph V: The chemical and biological waste treatment at USP-SC is responsibility of the Chemical Waste Laboratory (LRQ), there are actions to recover solvents, as well as adequate waste storage for disposal through incineration, the companies that perform this process return to the laboratory a legal document proving the proper disposal of the waste. Some laboratories do not trust the solvents recovered by the Laboratory of Chemical Waste, these laboratories prefer to buy new ones, which is a fragility of the public financing system. The LRQ gives recovery preference to large laboratories, forcing small laboratories to have their own recovery system.

"Indicators of operational and environmental performance of public services of urban cleaning and solid waste management", Arct. 19, Paragraph VI: The cleaning of the three areas of USP-SC campus is performed by third party companies and do not have performance Indicators.

"Rules for transportation and other stages of solid waste management", Arct. 19, Paragraph VII: Transportation of part of the waste is carried out by the city of São Carlos, all the collected volume is sent to the sanitary landfill of the city; Hazardous waste is transported by specialized companies and recyclables are destined to cooperatives. Batteries and lamps are collected by specific companies. However, the final destination of these wastes is not transparent.

"Definition of responsibilities for its implementation and operationalization", Arct. 19, Paragraph VIII: The USP Solid Waste Policy indicates that each Institute should compose a Council to manage its waste, decentralizing decision-making by city halls and the dean's office.

"Technical training programs and actions aimed at their implementation and operation", Arct. 19, Paragraph IX and "Environmental education programs and actions to promote the non-generation, reduction, reuse and recycling of solid waste", Arct. 19, Paragraph X: There are programs such as USP-Recicla, which has been operating in São Carlos since 1995 in Environmental Education to waste reduction, one of the products of this program is the Practical Guide for minimization and management of waste - USP São Carlos. In addition, it also has the PAP (Participating Learners) Program, which aims to incorporate sustainable principles and practices among university's staff, serving as an example for students and for society in general.

"Programs and actions for the participation of interested groups, especially cooperatives or other forms of recyclable materials collectors' association formed by low-income individuals", Arct. 19, Paragraph XI: At USP-SC, there are outreach programs dealing with Solid Waste: The CDCC program, whose focus of activities developed by the Center for Scientific and Cultural Disclosure are students and teachers of secondary and fundamental education. And, implanted in the Campus in 1997, the Small Citizen Project that serves 220 children from low-income families of São Carlos, with various cultural and educational activities.

"Mechanisms for the creation of sources of business, employment and income, through the valuation of solid waste", Arct. 19, Paragraph XII: It already appears in draft, which will be instituted by the USP Waste Management Policy.

"System for calculating the costs of rendering public services for urban cleaning and solid waste management", Arct. 19, Paragraph XIII: Residues produced at USP-SC that are sent directly to the landfill do not generate any cost to the university. However, for the treatment of chemical and biological waste that needs to be incinerated in a third-party company, the cost is covered by the laboratory itself, which obtains funding from sources of research and private initiative.

"Waste reduction, reuse, segregation and recycling goals, among others, with a view to reduce waste quantity sent to environmentally appropriate final disposal", Arct. 19, Paragraph XIV: It will be instituted by the USP Waste Management policy.

"Description of the forms and limits of the participation of local public authorities in the selective collection and reverse logistics, and other actions related to shared responsibility for the product life cycle", Arct. 19, Paragraph XV: Will be instituted by the USP Waste Management Policy.

"Means to be used for the control and supervision, at a local level, of the implementation and operationalization of solid waste management plans", Arct. 19, Paragraph XVI: Will be instituted by the USP Waste Management Policy.

"Preventive and corrective actions to be practiced, including monitoration program", Arct. 19, Paragraph XVII: Will be instituted by the USP Waste Management Policy.

"Identification of environmental liabilities related to solid waste, including contaminated areas, and respective sanitation measures", Arct. 19, Paragraph XVIII: Carried out by the Inventory of Residues of USP-São Carlos.

"Periodicity of its review, with priority being given to the period of validity of the municipal multiannual plan", Arct. 19, Paragraph XIX: Will be instituted by the USP Waste Management Policy.

The table 3 presents a description of what are the PNRS item and how the USP-SC complies with it.

Table 3. Evaluation description for each PNRS item.

PNRS		Evaluation description
Item		
Art. 19, Paragraph I		The waste diagnosis must be deployed yearly, according to PNRS' requirements. The USP-SC produces a yearly based diagnosis within a course conducted by a teacher, although, this is a proactive initiative and is not institutionalized to strengthen the initiative.
Art. 19, Paragraph II		The disposal must accomplish specific Brazilian Regulation Norms (NBR), with a set of operational criteria to prevent socioenvironmental risks.
Art. 19, Paragraph III		
Art. 19, Paragraph IV		The university complies with the requirements proposed by the PNRS, e.g. is the adequate disposal of light bulbs, where the university directs them to the producer for recycling.
Arct. 19, Paragraph V		The PNRS sets that each laboratory is responsible for its hazardous waste management according to the waste classification within the NBR criteria, respective to the waste level of hazardousness.
Art. 19, Paragraph VI		The PNRS sets that bruming and urban cleaning waste must be adequate disposed and if applicable composting must be carried.
Art. 19, Paragraph VII		The PNRS requires an official response by the companies that handle the waste final disposal, this document must be stored and presented to Brazilian public health agencies in a regular basis.
Arct. 19, Paragraph VIII		The PNRS suggests that each unit, department, campus, parks and museum that compose the university must elect a council that will handle the planning and implementation of waste policies and goals. The USP deployed its own waste policy following the PNRS's directives.
Art. 19, Paragraph IX		The USP-SC already promotes awareness interventions with the USP Recicla recycling program and fulfills the PNRS's requirements, plus, this program presents as a role model for other institutions due to its successfull initiatives. This program has a strong relationship with the city recycling cooperative.
Art. 19, Paragraph X		

Arct.	19,	
Paragraph XI		
Art.	19,	The PNRS strongly requires this item and the USP-SC fullfils it with the long-
Paragraph XII		lasting relationship between the university' recycling program and the city recycling cooperative.
Art.	19,	The PNRS sets criteria for anual assessment of the costs generated by waste
Paragraph XIII		disposal. This is a public service, although, e.g. is the campus of São Paulo, that due to its size must pay for this service to the municipality.
Art.	19,	
Paragraph XIV		The USP-SC is in its final processes for the university's Waste Policy
Art.	19,	implementation, this policy brings the election of committees to plan the mission and
Paragraph XV		pursuit for unit, department, and museum to tackle a sound waste management, with goal
Art.	19,	that best suits each reality.
Paragraph XVI		
Art.	19,	The PNRS requires the periodic policy review, with elaboration of new goals and
Paragraph XVII		assessing its waste management weakenessess and strengths.
Arct.	19,	The USP waste policy predicts to implement strong programs that tackle
Paragraph XVIII		environemmental risks control by acquiring new technologies. The USP Environmental Management Superintence handles these issues.
Art.	19,	The PNRS requires plans and programs to be assesssd and reviwed, with
Paragraph IXX		possibility to adequation. The PNRS sets the periodicity for its review, but this periodicity is flexible according to the institution size, for example.

5. Final considerations and future perspectives

Many of the requirements proposed by the PNRS are the municipality's responsibility, this highlights the discussion that the university cannot be taken as an island, and its actions must transpose the limits of the academy and influence the society and the other way around. It also has a pivotal role in the discussion of sustainability, bearing the responsibility of increasing individuals' cultural awareness and knowledge, as well as proposing technological innovations and tools to direct society towards sustainable development. They have a responsibility to act in education and research, proposing technological innovation to improve and direct effective solutions for waste management, policy development, and dissemination of information and integration of the external community to create a sustainable future (de Souza et al., 2016).

USP-São Carlos does not have a waste management plan, however, as shown in Table 2, its management already occurs in a systematic way. This shows that the adequacy requirements proposed by the PNRS come to add an effective management. The publication of the PGRS-USP under the hierarchical umbrella of the PNRS comes to give institutional strength, providing political and legislative support for activities that already occur.

In addition, the university must be a management model for municipalities (Tu et al., 2015), by adapting to the PNRS requirements, through a dynamic and participative process, with continuous improvement and learning.

An institution can have an effective solid waste management, however, without an institutional legal framework, this management becomes fragile and its efficiency and effectiveness is vulnerable to the change of decision makers, thus, the of an Environmental Policy elaboration and a Policy with Focus on waste management, with well-defined plans and goals are a strong support tool.

This work's purpose was to analyze the University of São Paulo – São Carlos campus solid waste management according to the Brazilian National Solid Waste Policy requirements, to certify the capability of this policy to turn in to a support tool to enhance a university's waste management, since Brazilian universities do not have any legal specific framework to conduct this adequacy. This paper concludes that the Brazilian Solid Waste National Policy translates into a strong framework tool to support decision making for adequacy of environmentally sound management of Brazilian university campuses.

In this context, it is important to emphasize the similarity between university campuses and small cities in terms of waste generation diversity and the impacts on natural resources resulting from its variate activities of teaching, research, extension, laboratories, administrative processes, food, housing, transport and maintenance. However, regard to the application of the PNRS's requirements, it must be noted that municipalities are obligated to do it, although, universities that have the same potential pollutant profile, do not have this obligation. This means a lack of legal support for a university to direct its waste management activities into a more environmentally sound path.

Innovative strategies and technologies must be deployed and applied within universities to tackle a sound and optimized waste management and daily operational activities. Assessments regard the opportunities can be divided in universities' main operational dimensions, as it follows:

Primary and secondary wastewater reuse: The university uses a high amount of water per day to fulfill a diverse range of activities, in this context, wastewater with different physical and chemical characteristics is generated, and other to send it to disposal, this wastewater has potential, with previous adequate treatment, to be used in campus irrigation, greywater generated can be used within buildings and distributed to campus surroundings for cleaning purposes.

Recycling physical interventions: Studies regard bins amount and allocation, collectors' best routes and community cultural aspects must be conducted to guarantee an effective recycling program. The campus must be a place for the surrounding community waste collection, as specific bins for glass, plastic, paper, aluminum, batteries, wastes of hardware and domestic appliance. In this context, the campus will serve as a hub and mediator for recyclables adequate disposal by the community and further collection by third party companies.

Energy consumption reduction: Initiatives and innovation regard electricity generation must take place within the university facilities, these initiatives must also be presented to the community as tools to decrease natural resources consumption and awareness initiatives will allow them to integrate the program, reinforcing their importante role in energy consumption decrease.

Organic waste composting: A large amount of organic waste is generated daily, with high potential for composting, the USP São Carlos campus has a program where all the composted waste turned in fertilizer are used in

the municipal garden that produces vegetables for surrounding schools. Authors suggest the institutionalization through a policy implementation so this program is not discontinued due to decision makers change.

Community awareness: The USP Recicla recycling program has a history of successful awareness interventions within the university that translates in amount of waste recycled increase. In this sense, financial and human resources must be directed to improve the USP Recicla recycling program to strengthen and to support its awareness and environmental education interventions.

USP's waste policy is being deployed, based on PNRS' requirements, this confirms the PNRS' potential as a framework for universities waste management policies elaboration, although, a key factor for success of its enactment and functionality is the diverse university stakeholders' engagement on its elaboration. The policy has a strong potential, tackling to foster the insertion of sustainability, institutionally transversal, and functional structure, integrating processes and objectives that introduce culture and values related to sustainability for its community, and capable of reflecting paradigm shifts, from the rector's office and university's city hall to classrooms and throughout university walls.

Finally, USP - São Carlos, even though it does not have an institutionalized management plan, the system is functioning, however, with some adjustments that must be corrected, being foreseen to be adapted after USP-SWP enactment, further studies are required *ex-post* its enactment to assess the waste policy impacts at the university.

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Annex 3 - Questionário USP Recicla - ontem e hoje

USP Recicla - ontem e hoje

Os pesquisadores buscam por meio deste formulário descrever a trajetória do Programa USP Recicla, a partir da visão de seus participantes. Traçando uma linha do tempo, de desafios e perspectivas, até o panorama atual.

Termo de concordância

Todas as informações coletadas nos questionários serão mantidas em sigilo e serão utilizadas apenas no âmbito da pesquisa. O tempo de preenchimento deste questionário é de cerca de 10 minutos. Termo de consentimento esclarecido Aceito participar da pesquisa para a qual fui convidado (a), contribuindo com o preenchimento deste formulário, parte da pesquisa intitulada “Programa USP Recicla - ontem e hoje”. Trata-se de parte da tese de doutorado do discente Rodrigo Martins Moreira - PPGSEA – EESC- USP, orientado pelo Prof. Dr. Tadeu Malheiros do Departamento de Hidráulica e Saneamento da EESC-USP. Sei que minha participação é livre, não é obrigatória, podendo ser interrompida por minha decisão a qualquer momento, sem qualquer prejuízo. *

☐ Li, e aceito os termos

☐ Li, e não concordo com os termos

1. Primeiramente, há quanto tempo você participa do Programa USP Recicla?

☐ Há 1 ano

☐ Entre 1 e 5 anos

☐ Entre 5 e 10 anos

☐ Entre 10 e 15 anos

☐ Mais de 15 anos

2. Você ainda participa do USP Recicla?

☐ sim

☐ não

Se não, descreva brevemente o motivo de não participar mais.

3. Você poderia fazer uma breve descrição do histórico do Programa USP Recicla durante o seu período de participação? Ressaltando suas principais motivações de participação.

4. O programa USP Recicla está ativo em sua unidade?

☐ sim

☐ não

5. Quantas pessoas estão envolvidas nas atividades do USP Recicla em seu campus

☐ menos de 5

☐ entre 5 e 10

☐ entre 10 e 15

☐ entre 15 e 20

6. O programa apresenta relatórios periódicos, acessíveis a comunidade interna e externa à USP, com seus resultados?

☐ sim

☐ não

Se sim, via quais meios?

☐ via *newsletter* USP

☐ website

☐ palestras

☐ livros, guias e cartilhas (digitais ou impressos)

7. É perceptível a influência das ações do programa no cotidiano do campus (ex. redução da geração de resíduos; aumento de resíduos enviados a reciclagem)

☐ sim

☐ não

8. Onde as ações do Programa estão inseridas?

☐ Alojamento

☐ Restaurante Universitários

☐ Prédios administrativos

☐ Laboratórios

☐ Outros espaços

9. O programa da sua unidade tem parcerias com a prefeitura municipal?

☐ sim

☐ não

10. Quais fatores influenciaram o sucesso do programa em sua unidade

☐ Vontade política

- ☐ Recursos financeiros
- ☐ Recursos humanos
- ☐ Infraestrutura
- ☐ Engajamento
- ☐ Respaldo através de Portarias e Resoluções da Universidade

Por gentileza, faça um breve comentário sobre quais fatores influenciaram o sucesso do programa em seu campus

11. Quais fatores pode influenciar a fragilização do programa em seu campus

- ☐ Falta de vontade política
- ☐ Falta de recursos financeiros
- ☐ Falta de recursos humanos
- ☐ Falta de infraestrutura
- ☐ Falta de engajamento
- ☐ Falta de respaldo através de Portarias e Resoluções da Universidade
- ☐ Conflito de interesses

Por gentileza, faça um breve comentário sobre quais fatores influenciaram a descontinuidade do programa em seu campus.

Annex 4 – USP Recicla publications

Produtos e Projetos	Endereço para acesso
Mini apostila prática: Composteiras para espaços mínimos	http://www.projetosustentabilidade.sc.usp.br/index.php/content/download/1323/12868/file/MINI%20APOSTILA%20PR%C3%81TICA%20c%C3%B3pia.pdf
Guia prático para minimização de e gerenciamento de resíduos – USP São Carlos	http://www.projetosustentabilidade.sc.usp.br/index.php/content/download/2060/20930/file/Guia_Pr%C3%A1tico_Minimiza%C3%A7%C3%A3o_Res%C3%ADuos_2012.pdf
Projeto educativo para minimização de resíduos sólidos no restaurante universitário da USP / São Carlos: a importância da continuidade	http://www.projetosustentabilidade.sc.usp.br/index.php/content/download/2244/23753/file/2007simpep_fernanda_pazut_alita_taiwo.pdf
Diagnósticos dos resíduos alimentares como ferramenta educativa no restaurante universitário da USP São Carlos: Uma abordagem metodológica	http://www.projetosustentabilidade.sc.usp.br/index.php/content/download/2245/23759/file/XVIII_SIMPEP_Art_645.pdf
Guia para aprender a realizar a gestão de resíduos da Comunidade de Madrid, Espanha	< http://www.madrid.es/UnidadWeb/Contenidos/Publicaciones/TemaMedioAmbiente/SeparacionResiduos/Campa%C3%B1aseparacionresiduos.pdf >
Olhando os resíduos e repensando as práticas - página eletrônica do USP Recicla do Campus da USP em Ribeirão Preto, SP	http://www.cirp.usp.br/residuoscampusrp

Política Nacional de Resíduos Sólidos	http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/112305.htm
Avaliação da Geração de Resíduos Sólidos em Eventos Acadêmicos Vinculados à EESC – USP a Partir da Utilização do “GUIA PRÁTICO PARA...	http://www.projetosustentabilidade.sc.usp.br/index.php/content/download/2476/26767/file/Pivotto%20Oliveira,%20Benjamin.pdf
Manual Básico de Compostagem	http://www.projetosustentabilidade.sc.usp.br/index.php/content/download/3253/35409/file/Apostila%20Compostagem%20AMPLIADA_d2012.pdf
Guia para gerenciamento de resíduos - Campus “Luiz de Queiroz”: saiba o que fazer para reduzir, reutilizar e encaminhar resíduos	http://www.esalq.usp.br/usprecicla/docs/gresiduos.pdf
Projetos do USP Recicla de Ribeirão Preto	http://rodocrosita.cirp.usp.br/residuoscampusrp/public/index.html

- Aperfeiçoamento da Coleta Seletiva [<https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/coleta-seletiva-sao-carlos/>](https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/coleta-seletiva-sao-carlos/)
- Compostagem [<https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/compostagem/>](https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/compostagem/)
- Eventos Sustentáveis [<https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/eventos-sustentaveis/>](https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/eventos-sustentaveis/)
- Mobilidade [<https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/mobilidade/>](https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/mobilidade/)
- Moradia Sustentável [<https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/moradia-sustentavel/>](https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/moradia-sustentavel/)
- Resíduos no RU [<https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/residuos-no-ru/>](https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/residuos-no-ru/)
- Indicadores <https://usprecicla.wordpress.com/projetos-educativos/campus-usp-sao-carlos/indicadores/>