

The Value Sensitive Design of a Data Management System for Cooperative Waste Management in Brazil

How to reconcile the values of Historically Marginalised stakeholders with management concerns



***“Black waste picker,
driven by the telling of her story,
will survive on anything –
even if only nourished
by the dream of freedom.
And after so many
disappointments,
dissolutions
and denials
of what she longed for,
she saw that very little
had changed in those places,
where the shadow of exclusion
still lingers
but resistance
never falls silent.”***

- Prof. Dianne Vianna, University of Brasília
- Based on the poetic description of a persona created by a waste picker and on the life testimony of a former waste picker, Carmen, 27/01/2025.

Authors' Declaration

This declaration concerns the split-up of the thesis project group consisting of A S M Lutfor Rahman, Rabbi, and Frej Slot Arnfred, enrolled in the MSc in Techno-Anthropology, semester F25, at Campus CPH, year 2025.

As of 28 March 2025, the project group has been formally dissolved. From this date onwards, both students - Frej Slot Arnfred and A S M Lutfor Rahman Rabbi - will continue their project work independently.

We hereby give mutual consent to use the jointly produced material developed prior to the split. The jointly developed material includes text from the following sections:

Introduction, Background, Literature Review, Methods and Theory.

Data Collection Methods, References and parts of Qualitative Data are expected to remain the same.

The split has been agreed upon and signed by both parties. This declaration will be inserted at the beginning of each respective project report.



Frej Slot Arnfred
28th of March 2025



A S M Lutfor Rahman Rabbi
28th of March 2025

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Abstract

Waste pickers (catadores in Brazilian Portuguese) in Brazil play a vital role in urban waste management, but they remain socially and institutionally marginalised.

At the Cooperativa de Catadores Recicla Mais Brasil, waste pickers have largely been excluded from former initiatives aimed at designing digital solutions to support and enhance their daily work practices. Namely, their roles, needs, and values have received little to no consideration in design processes, while perceived deficits in transparency, together with ongoing power imbalances, have resulted in *mistrust* and hinder the development of inclusive and accountable digital solutions.

This thesis aims to adopt an ethical approach for designing a Data Management System (DMS) within the Erasmus+ Egalitarian project, ensuring the inclusion of waste pickers' values while addressing the operational needs of the cooperative management.

The research adopts a techno-anthropological perspective and employs Value Sensitive Design (VSD) as its main framework, and particularly, a participatory VSD to involve a wide range of stakeholders, including historically marginalised waste pickers in the design process. Here, participatory methods such as ethnographic fieldwork, interviews, and workshops were conducted in Brasília (Brazil) and Copenhagen (Denmark) to uncover stakeholder values and manage the value tensions that arose during the design process. This strategy delivers the value hierarchies that can be embodied technologically to identify design requirements and technical solutions for the Data Management System (also referred to as *EcoSistema*), integrating ethical design principles.

As a result, the stakeholders' values and norms have been balanced and prioritised to integrating them into concrete digital solutions for an ethically grounded DMS suitable for fairer waste management in Brazil. Indeed, functional features are not only supported by ethical principles, but also due to more inclusive and participatory design practices, digital products generated can be agents-/context-sensitive and enact more sustainable digital practices in the Brasília's waste management sector.

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1. Introduction

Digital solutions, such as data management systems, are now embedded in almost every facet of modern work life. Sometimes, these solutions not only shape work processes but also influence the lived experiences and rights of those who use them. Such technologies are introduced into workflows to enhance convenience, fairness, and efficiency; however, their implementation and integration—regardless of social context or user involvement—can instead perpetuate existing inequalities and generate a new form of social tension. Technologies often inherit latent biases and may reinforce power asymmetries and erode trust when their design is not critically scrutinised. During my fieldwork at one of the waste management cooperatives in Brasília, specifically *Cooperativa de Catadores Recicla Mais Brasil* (hereafter Recicla Mais or the Cooperative), I observed this firsthand. Here, digital systems and technologies were proposed and developed for the people who had never been involved in shaping them, resulting in impractical artefacts that offered neither a workable solution nor an ethically sound approach to technological design.

The waste pickers, known locally as *catadores*—central to the Brasília’s waste management system—are historically racialised, marginalised, socio-culturally disadvantaged, and low-income individuals who play a significant environmental and economic role (Cruvinel et al., 2019; Borges et al., 2019). They remain largely excluded from decisions about the technologies that facilitate their work and face several tensions related to transparency, trust, control, and power deficits in their daily work practices. Several efforts were conducted to incorporate digital tools at Recicla Mais and other cooperatives as part of the Erasmus+ Egalitarian project. However, these initiatives were primarily designed by the engineering students with limited interaction with the cooperatives and the waste pickers. Consequently, the waste pickers—users who should ideally be more involved in designing digital solutions—had the opposite experience at the Cooperative. These digital solutions were developed with minimal ethnographic research and without a participatory design process or ethical considerations, failing to adequately account for their (waste pickers’) values, socio-cultural contexts, or varying levels of technological literacy (Bro et al., 2024). Excluding the primary users meant that most interventions did not address the Cooperative’s daily workflows, values, and needs of the waste pickers. Some prototypes were technically advanced but socially disconnected, while others remained unclear and unusable. Stakeholder participation in a system design clearly improves the alignment with user needs, promotes adoption, and supports more

sustainable, context-sensitive outcomes, which further underscores the importance of stakeholder engagement, community development, and institutional strengthening as pathways to sustainability (Simonsen & Robertson, 2012; Bødker et al., 2004). These shortcomings raise concerns about the ethicality of the previous technology design process and emphasise the need for an ethically designed digital system that is participatory, aligns with stakeholders' values, and addresses their concerns.

This thesis builds upon the *Erasmus+ Egalitarian SDG Challenge* (hereafter referred to as the Egalitarian project or the Project), an international collaboration involving universities from Brazil and Europe since 2024. The Project recognised the operational challenges faced by Recicla Mais in implementing accurate data collection and transparent handling. To address this issue, the Egalitarian project aims to strengthen Recicla Mais's operations through the development of an integrated software and hardware system, thereby digitalising components of its supply chain and supporting the sustainable development of technologies for waste pickers and the Cooperative (Egalitarian, 2024). Currently, this initiative is being conducted as part of one of the project tracks within the Egalitarian project, specifically the *Data Management System (DMS)*.¹ I participate in the ongoing *DMS* track, contributing to the design of a user-sensitive Data Management System (DMS), namely *EcoSistema*. This thesis aims to address issues of data accuracy, transparency, and inclusion, and proposes a set of functional features to achieve these objectives.

Since the initial scope of the Egalitarian project fell short in usability due to its explicit engineering-led focus, this thesis aims to address those shortcomings. The research adopts an original techno-anthropological perspective, seeking to integrate ethical and socio-cultural values into the DMS design process, ensuring that the values of marginalised waste pickers are acknowledged, prioritised, and integrated, while aligning with the Cooperative's operational concerns. This approach resonates with broader questions of how to design an ethical digital solution that is inclusive, participatory, and respectful of diverse stakeholder needs.

The thesis adopts Value Sensitive Design (VSD) as its primary theoretical framework to carry out an ethical DMS design, enabling the identification, prioritisation, and translation of stakeholder values (see Friedman et al., 2002; Cenci et al., 2023), while the participatory

¹ The Egalitarian project is organised around several thematic tracks, with participating students assigned to themes based on their academic background or research interests. In 2024, during the first cycle of the DMS thematic track, the Egalitarian project referred to it as the Integrated Supply Chain Management System (ISCMS) (see Egalitarian, 2024). As the project progressed, the theme was rebranded as Data Management System (DMS) from August 2024 onwards.

methods are incorporated to ensure active involvement of the waste pickers and the cooperative management throughout the process. Specifically, I propose a participatory VSD approach to develop the DMS, called EcoSistema. Unlike traditional frameworks, participatory VSD invites users to act as drivers, guiding the design process based on their values and norms, and translating these into functional features. However, in this thesis, the ethical stance is informed by relational egalitarianism—a perspective emphasising mutual respect, fair participation, and the dismantling of unjust hierarchies—which is linked to both the Egalitarian project’s vision and the thesis’s design approach. The research addresses social concerns identified during my earlier participation in the Egalitarian project, with a primary focus on integrating waste pickers into design phases to ensure the incorporation of a sustainable and effective system.

The contribution of this thesis is twofold. Firstly, it recognises and prioritises the values of historically marginalised stakeholders, especially waste pickers and the cooperative management, through ongoing participatory engagement in Brazil and Denmark. These empirically grounded values provide a reusable foundation for any future technological integration in similar cooperative settings. Secondly, it translates these values into related norms and concrete functional features of the DMS, demonstrating how stakeholder concerns can be inscribed in the DMS design following daily operations. Together, these contributions illustrate how an ethical co-design approach can both surface and operationalise values, ensuring that technical and organisational requirements are met while addressing the concerns of the stakeholders with conflicting interests. What emerges is EcoSistema: not just a tool for tracking data, but a DMS rooted in shared values, collective ownership, and mutual respect.

The thesis is organised as a journey that guides the reader from context to conclusions. Chapter 2 lays the groundwork, presenting the Brazilian waste-management landscape and outlining my earlier contributions to the Egalitarian project to frame the study. Chapter 3 introduces the research case, articulates the problem statement, and formulates the guiding research questions. Chapter 4 establishes the theoretical position of VSD, highlighting the participatory perspectives that underpin the analysis. Building on this, Chapter 5 details the methodological approach employed, while Chapter 6 proceeds to the design process, exploring stakeholders’ values and norms and demonstrating how these were translated into the DMS design, complemented by detailed functional-feature tables in the Appendix B. Finally, Chapter 7 synthesises the different strands, providing an integrated reflection on methodology and context, while Chapter 8 presents the conclusions of the thesis and offering recommendations for future research.

2. Research Background

In order to comprehend the background of the issue, I emphasise building the reader's foundational knowledge, focusing on waste management practices within cooperatives in Brasília. It also outlines the Egalitarian project and its context, my previous contributions, and describes the complying SDGs, which are essential to underline the urgency of an ethically-sensitive system design.

2.1 Waste Pickers and Cooperatives in Brasília

Brasília, the capital of Brazil, can be seen both as a symbol of ideology and a place ridden by socio-infrastructure issues. Originally designed to decentralise power and promote development, Brasília has been criticised for neglecting human-scale infrastructure and for systematically excluding the workers who built it. Many of these workers now reside in its peripheral zones, where they often live under unstable conditions ([Gehl, 2010](#); [Beal, 2010](#); [Stierli, 2013](#); [Kelly, 2020](#)). A significant result of these inequalities is the city's inadequate waste management. Historically, Lixão de Estrutural, the largest open landfill² in Latin America, it served as Brasília's primary disposal site, leading to serious environmental issues. Since its closure in 2018, waste management has shifted to recycling facilities, and many former landfill workers have transitioned into organised cooperatives, such as Recicla Mais, which now play a vital role in the city's recycling system ([WEIGO, 2023](#); [2025](#)).

A cooperative is an autonomous association of waste pickers who earn by recycling waste and unite to meet their mutual socio-economic needs through a collectively owned and democratically managed enterprise ([International Alliance of Wastepickers, n.d.](#); [Bouvier & Dias, 2021](#)). In the Brazilian context, recycling cooperatives like Recicla Mais are instrumental for unionising waste pickers into formal groups, allowing access to social protections, legal recognition, more secure working conditions, increased bargaining power, and training. This results in higher income and greater social recognition compared to working as independent waste pickers. For the wider community, cooperatives lead to higher recycling rates, lower environmental impact, and job creation ([BVRio, n.d.](#)). Overall, these cooperatives support more sustainable and inclusive waste management practices than those associated with open landfills.

² Open landfills are sites where waste is disposed of irresponsibly, often openly, without environmental safeguards. ([Nathanson and A., 2025](#))

The profession of *scavenging*, known as ‘waste picking,’ has been officially recognised by the Brazilian Ministry of Labour and Employment since 2002 as ‘Catadores de material reciclável,’ commonly referred to as *Catadores* or waste pickers, which means collectors of recyclable materials. However, many catadores still work under precarious conditions, often without proper equipment, safety measures, or access to formal employment benefits such as medical leave or retirement plans ([Ministério do Meio Ambiente, n.d.](#); [Dias, 2018](#)). Waste pickers in Brasilia are predominantly women of African or mixed-race backgrounds, typically come from low-income backgrounds with lower literacy and very often live in poor housing conditions, which reflect the intertwined gender, race, and class inequalities ([Medina, 2008](#); [Borges et al., 2019](#)). A survey conducted with a sample of 1,025 waste picker participants from Lixão de Estrutural demonstrated that 17% of them resided in slums, while around 27% lacked access to local sewage connections, and 64% used untreated water in their daily lives. Around 69% of them lived with health risks and job-related injuries ([Cruvinel et al., 2019](#)). These findings clearly point to widespread and entrenched vulnerabilities among waste pickers, with a hint that the broader picture may be even more severe. While waste picking offers significant environmental benefits, it is important to recognise that the primary motivation for individuals engaging in waste picking is solely economic. From an economic standpoint, these environmental advantages are merely positive externalities. This perspective is crucial for understanding the dynamics of waste-picking activities, as it underscores the economic necessity that drives individuals to engage in this practice, despite its broader ecological benefits.

The following section outlines the workflow and organisational structure of the Egalitarian project.

2.2 The Erasmus+ Egalitarian Sustainable Development Goals Challenge

The Erasmus+ Egalitarian SDG Challenge builds on the earlier Global Students SDG Challenge, launched in 2018 to connect universities in Brazil and Europe, and develop solutions aimed at empowering Brazilian waste pickers in line with the United Nations’ Sustainable Development Goals ([see Section 2.5](#)). With Erasmus+ ([see European Commission, n.d.](#)) funding from January 2024, the project enabled broader interdisciplinary collaboration and connected students from four different countries: Brazil (Universidade de Brasília),

Portugal (University of Minho), Denmark (Aalborg University), and the Netherlands (Saxion University of Applied Sciences) ([Global Students SDG Challenge, n.d.](#)).

The Egalitarian project is organised into two cycles per year—Spring and Autumn—each spanning half a year to facilitate student collaboration. The cycles begin with a week-long event, the Waste Summit, hosted either by UnB (in January) or by partner universities (in August). During the summit, professors and project staff present results from the previous semester and introduce updated or new project tracks. Students then conduct site visits, brainstorm solutions, and present their proposals before starting their semester-long studies in collaboration with multiple groups and sub-groups within the tracks. After the summit, students return to their home institutions and work on their selected project track, either individually or in sub-groups, to research and develop solutions. Their outcomes are then fed back into the broader project track and consolidated into final outputs, which are incorporated into the next cycle for ongoing improvement ([Egalitarian, 2025b](#)). Each project track comprises student groups from diverse academic backgrounds and institutions, working towards a common goal through specialised subprojects. Group compositions and focus areas vary each semester based on student expertise, project needs, and evolving project-track objectives, enabling the project to adapt dynamically with complex challenges.

2.3 Egalitarian Project in Relation to Egalitarianism and Author's Standpoint as a System Designer

The Erasmus+ project, Egalitarian, officially titled “Education, diGitALIsaTion and collAboRatIon for sustAiNability,” abbreviated as EGALITARIAN to reflect its core mission of fostering a more egalitarian world by addressing critical issues in waste management, supporting and empowering waste pickers of Brazil. The project aims to improve the lives of the waste pickers by providing access to digital and engineering solutions, which can enhance operational efficiency and potentially increase their income, thereby contributing to a fairer society where no individual is left behind. It emphasises the development of the waste management system in Brazil by drawing on more mature and developed systems in Europe. The project also seeks to reduce global inequalities, promote sustainability, and create a more balanced and fairer world through knowledge exchange ([Appendix C](#)). However, the project officials might name it Egalitarian, reflecting a normative aspiration to promote a fairer world by empowering waste pickers through digital solutions in Brasília. Compounding this, the rationale for the project’s title remained officially unexplained; the *Good Practices Guide*

(Egalitarian, 2025a) merely recorded the full title without clarifying why it was chosen. This lack of clarity left participants unsure whether to approach the problem primarily with an engineering mindset—delivering efficient technical solutions—or from a techno-anthropological perspective aimed at interrogating the broader socio-cultural context.

The term “*egalitarian*” or “*egalitarianism*” can be interpreted within various philosophical traditions. In this thesis, I adopt *relational egalitarianism* as my normative standpoint to conduct an ethical design for the DMS. The view of relational egalitarianism is that justice involves not merely the equal distribution of goods but also the removal of social hierarchies so that individuals can relate to one another as more equals (Anderson, 1999; Arneson, 2013; Scheffler, 2003; Lippert-Rasmussen, 2018). It aims to create conditions where the stakeholders interact on the basis of mutual respect and where socio-economic disadvantages rooted in arbitrary factors, such as class or race, are actively mitigated (see Arneson, 2013; Temkin, 1993, pp. 27-32). Classical egalitarian theories focus on how much of some goods each person receives, while relational egalitarians emphasise non-numerical aspects, for example, respect, standing, and power, in ethical decision-making (Anderson, 1999; Lippert-Rasmussen, 2018, ch.2). Relational theorists contend that what truly matters is how individuals relate to one another, whether any group wields arbitrary power, exerts unearned authority, or is consistently treated as epistemically inferior (Nath, 2020), which is evident in Brasília’s waste management sector, particularly at Recicla Mais.

For waste pickers who have faced intersecting disadvantages of race, class, and several social conditions for years, the primary injustice is not merely unequal income but their systematic exclusion from decision-making as well as fair and transparent communication with accurate data transmission tools that govern their labour. Relational egalitarianism considers such exclusion as a moral failure because it denies waste pickers’ standing as decision-makers in matters that directly affect their work and livelihoods. It also reinscribes the hierarchies where designers have full authorship of solutions, and waste pickers are positioned as passive recipients (Lippert-Rasmussen, 2018, ch.2). Adopting this view, therefore: (a) frames inclusion as a justice requirement, not a courtesy, (b) demands a design process that counters power asymmetries within the cooperative management and frontline waste pickers, and (c) links methodological choices to the conduct of ethical system design.

Table 1: Egalitarian project trajectory: Earlier cycles vs Present thesis

Dimension	Earlier cycles	Present thesis
Ethical frame	Implicit utilitarian focus on efficiency through engineering solution	Explicit <i>relational egalitarianism</i> with participatory VSD for waste pickers value preservation in system.
Primary actors	Egalitarian project officials, participants with engineering mindset	Waste pickers, cooperative staff, careful software designers, social workers.
Design driver	Technical feasibility	Stakeholder values and power symmetry
Expected Success metric	Prototype completion	Sustained use, perceived fairness, enhance transparency, restore trust.

In this thesis, the VSD functions as the operational expression of relational egalitarianism. [Table 1, p.7](#) contrasts the key aspects of earlier project cycles with the relational-egalitarian viewpoint that employs the participatory VSD in design, demonstrating how the current approach both diverges from and extends the project’s previous trajectory. Nonetheless, the implications of ongoing DMS design will be assessed considering metrics such as epistemic parity, procedural fairness, transparency, and the recognition of waste pickers, rather than relying solely on uptime or system performance.

The following section details my earlier contributions to the Egalitarian project and summarises my previous findings.

2.4 Author’s Engagement in the Egalitarian Project

As previously outlined, this research builds upon the author’s continuous participation in the Egalitarian project across multiple cycles since 2024: (a) conducting a field visit to Recicla Mais, proposing EcoClareza and additional recommendations for technological interventions (January 2024, Cycle 1); (b) presenting findings and taking part in the project summit at Aalborg University in Copenhagen (August 2024, Cycle 2); and (c) undertaking a subsequent field visit to Brasília and initiating this MA thesis, centred on the ethical design of the DMS (January 2025, Cycle 3).

In January 2024, I, together with other (03) Techno-Anthropology (TAN) students from AAU, participated in the first cycle of the Egalitarian project and conducted field visits at Recicla Mais. At that time, the Cooperative was struggling with the collection and storage of accurate data during the waste-sorting process, which undermined productivity and limited opportunities to negotiate additional collection zones. The objectives were then to develop ‘*an integrated waste management system*’ with a view to ‘*enhance data accuracy*’, ‘*facilitate government reporting*’, and ‘*cooperative expansion*’ ([Egalitarian, 2024](#)). Although the integrated system was intended to govern waste pickers’ work, positioning them as the

principal stakeholder both in function and in sheer numbers, their values and perspectives remained unconsidered. Furthermore, we observed a persistent conflict between transparency and trust within the cooperative, which reduced waste pickers' influence over their own labour and, in turn, undermined the Cooperative's overall productivity. We argued in our report that without addressing this institutionalised tension, expectations of improving overall productivity would remain unachievable. In response, we recommended incorporating the perspective of frontline users directly into the system's development and grounding the process in an explicit ethical design framework, along with seven other key suggestions. We further advocated for an extension³ of the main DMS to provide waste pickers with real-time information about the operational data, such as the types and quantities of waste being sorted and their individual sorting progress, which ultimately led to the proposal of EcoClareza (Bro et al., 2024). In line with Shaowen Bardzell's (2010) Feminist Human-Computer Interaction (FHCI) framework, the previous study examined generative contributions by incorporating feminist principles and their six qualities to highlight the importance of the waste pickers' active involvement⁴ in system design (Bardzell, 2010; Bro et al., 2024). However, the FHCI qualities guided the consideration of waste pickers' roles and interactions, but they did not inherently provide options for customising values into the technological artefacts to be devised in response to an ethical technology design. This gap highlights the need for an ethical design framework for the current cycle, one that actively involves both the oppressed waste pickers and the cooperative management in system design, while reflecting their values and concerns in the core functionalities.

In the subsequent project cycles (the second and current phases), I continued working independently. Aalborg University hosted the second cycle at its Copenhagen campus in August 2024. The project officials incorporated our recommendations and rebranded the project track as the *Data Management System (DMS)*. The scope of the rebranded track was then modified to focus on creating solutions predominantly for the cooperative, rather than aligning with or providing access to the concerned government officials (Egalitarian, n.d.-a).

³ The extension for the DMS involved installing a large screen at Recicla Mais to display a live dashboard where waste pickers could transparently monitor productivity information, such as who sorted what and how much, in real time. This was not an official objective of the original ISCMS project track during Cycle 1, as it did not include such a dashboard in its initial scope of design. In Cycle 2, a hardware prototype of the extension (an automated weighing and scaling machine) was developed, and in Cycle 3 (during the present thesis work), EcoClareza was taken forward as one of the DMS modules, as described later.

⁴ This involvement took a concrete form by involving the waste pickers through Design Cards, specifically based on the ethnographic fieldwork, observation, and semi-formal interviews. The waste pickers' active involvement was guided by Personas (developed based on Design cards data) and possible Scenarios of EcoClareza operation, as well as a list of Recommendations necessary to follow for any technological intervention (Bro et al., 2024).

The track prioritised the development of EcoClareza to foster a sense of transparency and inclusion. In January 2025, I travelled again to Brazil to join the Cycle 3 conferences and conduct fieldwork, engaging directly with waste pickers and cooperative management. This thesis is part of the Egalitarian project’s third cycle, where the ethical DMS is expected to align with certain SDGs, as described in the next section.

2.5 The Sustainable Development Goals

The Sustainable Development Goals (SDGs), adopted by all United Nations member states, constitute a global framework aimed at promoting peace and prosperity for both people and the planet. The 2030 Agenda highlights 17 interconnected goals that demand urgent collective action across social, environmental, and economic spheres (United Nations, n.d.).



Figure 1: The 17 Sustainable Development Goals – United Nations (n.d.)

Within this thesis and *DMS* as a project track, five specific SDGs are prioritised: Goals 8, 10, 11, 16, and 17, as illustrated in Figure 1, p.10. These goals serve as a guiding framework for designing ethical interventions in the DMS. The Egalitarian project advances Goal 8 (Decent Work and Economic Growth) by addressing the challenges faced by the waste pickers, promoting inclusive economic growth and access to dignified employment. It also supports Goal 10 (Reduced Inequalities) by incorporating the concerns of the waste pickers into the DMS design. Through the ethical design of the DMS, the project contributes to Goal 11 (Sustainable Cities and Communities) by fostering sustainable, community-oriented waste governance. By ensuring data accuracy and strengthening transparency, the DMS also aims to advance Goal 16 (Peace, Justice, and Strong Institutions), helping to mitigate distrust within the Cooperative and supporting fairness and accountability. Finally, the project exemplifies Goal 17 (Partnerships for the Goals) through its inclusive, ethical design, in which the waste

pickers and the cooperative management collaborate to enhance Recicla Mais's productivity and development, aligning with broader sustainable development objectives.

This chapter provides the background to the problem and outlines the designer's standpoint, setting the stage for the next chapter to define the research case, articulate the problem statement, and formulate the research questions that guide the remainder of the thesis.

3. Research Problem, Questions, and Case Context

This section details the case of Recicla Mais, describes its operations, and traces its workflows both historically and currently. We identify various forms of stakeholder resistance and highlight the operational and social pain points encountered in its everyday practice. The section concludes with the problem statement and the research questions that guide this study.

3.1 Recicla Mais Operation and Issues

The waste management process at the Recicla Mais begins with the arrival of recyclable materials, delivered by truck, to the intake area. Here, male waste pickers usually carry out the initial handling, which involves lifting and organising heavy loads to prepare the materials for subsequent stages of processing. This preparatory step is vital for maintaining efficiency, as it ensures that materials are properly arranged before sorting.

Once organised, the waste is moved manually onto a continuously rotating conveyor belt. Along this belt, predominantly female waste pickers are stationed at designated points on the first floor of the building, each responsible for sorting specific categories of material such as plastics, glass, metal, paper, or aluminium containers. Next to each station, there is an opening cut into the floor, directly adjacent to the conveyor belt. A large waste bag is securely suspended below this opening on the ground floor. As the waste pickers sort materials, they drop the selected items through the opening, allowing them to fall directly into the bag below. When a bag is full, it can be detached and removed from the ground floor. This gravity-fed system ensures that large volumes of sorted materials are efficiently prepared for weighing, storage, and further transportation.

During my 2024 field visit, I observed that when a waste bag became full, it was removed, a new one was installed, and the entire bag was weighed in the presence of both the responsible waste picker and either the financial administrator or the Cooperative's assigned leader. The weight data were recorded manually on printed spreadsheets using a pen and later transferred

into a Microsoft Excel file to compile the monthly productivity figures for administrative and reporting purposes. During the 2025 participatory engagements, it was observed that the procedure had been slightly modified. Weighing still takes place in the presence of either the financial administrator or the cooperative leader; however, the recording process now involves sending a photo of the scale reading via WhatsApp to the cooperative leader. The leader notes the productivity data in a notebook, and the financial administrator later inputs the information into a Microsoft Excel spreadsheet to compile monthly production reports. Waste pickers now receive a monthly report of their work at the end of each month. Several changes have also occurred in salary segmentation and incentives. Members were previously paid based on the total weight they collected, and only the top three performers were ranked for bonuses. However, management observed that some members, despite frequently earning above-average amounts of 500–600 reais, often remain absent from work. To address this, the Cooperative introduced a fixed daily attendance fee of 20 reais and a minimum monthly wage guarantee of 600 reais. Additionally, the incentive system now recognises the top six performers, rather than three, and extra incentives are provided to the workers who participate in knowledge-sharing and training activities.

However, weighing and handling weight-calculation data remain central to the data flow, as these figures form the basis for calculating earnings for both waste pickers and the Cooperative. The recorded numbers serve as a key measure for monitoring productivity and assessing efficiency from the perspective of cooperative management. For waste pickers, the weight figures directly determine their wages. During my 2024 visit, cooperative representatives explained that waste pickers prefer paper-based spreadsheets, stating that “*they believe what they see,*” which indicates a lack of trust in data recorded in digital form when it is unseen to them or inaccessible. The subsequent shift from on-site paper-pen records to sharing images reflects the same concern as the waste pickers’ belief system, since the images remain visible in chat histories and phone galleries, providing tangible and lasting evidence. Nonetheless, issues of transparency and trust continue to persist between the waste pickers and the Cooperative, and accurate data handling remains a challenge. Furthermore, the question of how to allocate sorting tasks—deciding *who sorts what on which day*—remains unresolved in the modified workflow, highlighting the need for a fair decision-making system for the Cooperative, which is expected to be achieved through an ethically designed DMS capable of balancing conflicting concerns, rather than favouring any specific stakeholder. The Cooperative still lacks an efficient and organised system to record human resource data, such

as attendance, absences, sick leave, or time allocation, and it has no dedicated system to manage data accurately. This gap leaves both the waste pickers and the Cooperative vulnerable to miscalculating earnings, fostering mistrust, raising concerns about transparency, and causing errors in productivity assessments for the management.

However, the case of Recicla Mais within the Egalitarian project shows that the trajectory of the *DMS* track, and its resulting solution closely resembled an Enterprise Resource Planning (ERP) system (cf. Klaus et al., 2000; Soh et al., 2000)—covering finance, attendance, task allocation, payroll, and reporting—without explicitly naming or reporting it as such. The gradual shift from the initial *ISCMS* concept in Cycle 1 to the *DMS* label from Cycle 2 onwards illustrated this unacknowledged ERP-like evolution. This highlighted both the strength of creating a system with significant organisational depth and the limitation of an uneven conceptual foundation, an acknowledgement that helped lay the groundwork for the thesis's problem formulation.

3.2 Problem Statement

As mentioned, despite the ongoing digitalisation efforts of Cycle 3 at Recicla Mais, the cooperative still faces operational inefficiencies. Although operational modifications have been implemented, these changes have not eliminated the bottlenecks nor allowed for meaningful production analyses. The concerns of the waste pickers regarding distrust and transparency largely persist. However, Recicla Mais operates within a context characterised by multiple, interrelated challenges. It is a waste sorting cooperative where (a) stakeholders with differing mindsets and very low mutual trust must collaborate, (b) tensions around transparency and trust between the workers and the management persist, (c) power asymmetries remain deeply rooted, (d) socio-cultural conditions constantly reinforce distrust, (e) the main stakeholders, namely the waste pickers, are historically marginalised, socio-culturally racialised, and often possess limited literacy and technical knowledge, rarely experiencing inclusivity or respect either in society or at work, (f) the broader context of racialisation and historical neglect leaves these workers vulnerable to exploitation and easily deceived, and (g) key parameters for income calculation, such as the market price of sorted waste and the volume each worker sorts, are subject to constant fluctuation. Additionally, previous digital solutions introduced to address related issues often failed because of superficial problem framing and inadequate consideration of stakeholders' values, needs, and lived realities, which further deepened distrust and undermined confidence in technology as a scalable solution.

These multifaceted issues have persisted over time, primarily rooted in socio-cultural factors rather than just technical aspects. They expose a significant gap between ethical technology design integration and practical usability. What is needed is a participatory, stakeholder-inclusive, and value-sensitive design framework capable of creating an ethical DMS that prioritises the values of waste pickers, the worst-off, while also fulfilling the management requirements. Accordingly, the DMS is named *EcoSistema*, a term that means *ecosystem* in Brazilian Portuguese, to emphasise this goal. The name signifies a system designed to encompass the entire data handling and transmission ecosystem with accuracy and transparency, while concurrently enhancing the cooperative's productivity and advancing broader sustainability goals.

However, to bridge the mentioned gaps and create an ethical DMS, this thesis adopts VSD as both a theoretical and methodological framework. VSD is an iterative, tripartite methodology that incorporates conceptual, empirical, and technological investigations, directly integrating ethical considerations into the design process (Friedman, 2013; Friedman & Hendry, 2019). This approach counters the predominantly engineering-focused orientation of the Egalitarian project by ensuring that ethics is not treated as an external check but as an integral part of DMS design. This research also entails a theoretical shift from my previous work, which employed an FHCI perspective (see Chapter 2), to a VSD approach that systematically identifies and embeds stakeholders' values into digital solutions, rather than relying on a predetermined set of values or normative perspectives. The next subsection outlines the research questions guiding this thesis, along with the effort to translate these ethical and methodological commitments into specific analytical aims and related strategies.

3.3 Research Questions

As this research builds on the ongoing iteration of the Egalitarian project, it seeks to inform and guide future cycles as part of a continuous design process. The following key research questions, therefore, frame the ethical design of the DMS presented in this thesis.

How can an ethical design approach be implemented in the development of the Data Management System (i.e., EcoSistema) to ensure that the values of historically marginalised stakeholders (waste pickers) are acknowledged and integrated, while also addressing the operational needs of the Recicla Mais cooperative?

Sub-questions (SQs):

SQ1: What are the values of both historically marginalised stakeholders and cooperative management, and how can these values be identified and prioritised in the ethical design of EcoSistema?

SQ2: What EcoSistema's features can effectively translate most vulnerable stakeholders' values into practical functionalities of the data management system while simultaneously balancing the cooperative's operational requirements?

Overall, the case description and the problem statement clarify the issue and explain why an ethically designed DMS is necessary, while the research questions demonstrate how this thesis addresses that requirement. Both elements effectively support the shift from the normative-ethical approaches used in my earlier work (i.e., FHCI). The justification for the original theoretical choices in this thesis is detailed in the next chapter.

4. The Theory

This chapter turns to the theoretical foundations of the study explaining the reasoning behind the shift from the Feminist Human Computer Interaction (FHCI) perspective, previously adopted to frame the earlier phases of the Egalitarian project, to the current Value Sensitive Design (VSD) framework, which is applied in combination with participatory methods for eliciting stakeholder values and translating them into concrete technical design and functional features of the system to develop (DMS).

4.1 From a Feminist Human Computer Interaction approach to a Value Sensitive Design

My earlier report, submitted during the first cycle of the Egalitarian project, employed FHCI ([Bardzell, 2010](#)) to highlight the structural inequalities encountered by the waste pickers and to critique the project's technology-focused approach ([Bro et al., 2024](#)).

The adoption of FHCI supported two main contributions in the initial phases of the project: (a) a *critical* approach for evaluating existing technologies and revealing unintended effects such as power asymmetries, and (b) a *generative* tool for guiding investigations through six defined qualities (i.e., pluralism, participation, advocacy, ecology, embodiment, and self-disclosure). However, the current task is fundamentally different. The design of EcoSistema requires

reconciling the needs and values of two primary but diverging stakeholder groups (i.e., the waste pickers and the cooperative management). However, the FHCI offers limited guidance for integrating new and context-specific values beyond its set qualities. In order to achieve the aim of this thesis, a broader value framework is required to address the full range of stakeholder concerns and necessities effectively. Moreover, my standpoint as a system designer—based on relational egalitarianism principles (ensuring justice through the elimination of social hierarchies)—entails a commitment to emphasising the dismantling of socio-economic hierarchies rooted in factors such as class or race, which the FHCI perspective cannot adequately address. Although FHCI offers important critical perspectives, it lacks the methodological precision and iterative processes needed to translate diverse situated values into specific system features. These limitations prompted a theoretical-methodological shift to VSD in this thesis, as VSD provides the suitable conceptual and practical tools necessary for the ethical development of the DMS.

In contrast to FHCI, VSD—an interdisciplinary design framework (Friedman et al., 2002; 2013; Friedman & Hendry, 2019)—explicitly embeds values in design from the very first stages of development, treating ethics as integral to design rather than as an external, often a *posteriori*, when the technological design is completed. VSD has been widely applied in software and digital systems, for example, in civic information systems (Jacobs et al., 2021), m-health technologies for behavioural monitoring in individuals with cognitive problems (Cenci et al., 2023), learning analytics design to embed values (Chen & Zhu, 2018), and responsible-AI toolkits’ ethical consideration (Sadek et al., 2024), where concern for specific values is made explicit in design (see also Alidoosti et al., 2022). For EcoSistema, this proven capacity of the VSD to elicit and negotiate values through participatory involvement, to organise them in value hierarchies (Van de Poel, 2013), and to translate them into functional features is essential. Thus, the shift from FHCI to VSD signals a shift from merely and primarily criticising socio-technical inequalities to actively embedding ethics and ethical concerns aligned with the DMS design throughout the development process (from the onset). This transition calls for a closer examination of VSD as a theoretical stance and its core principles, which underpin the theoretical positioning of this thesis.

Since values are the core concept of VSD, it is essential to first clarify their definition and application within the VSD of the DMS conducted in this thesis. Values are understood as “*what a person or group of people consider important in life, and each of them can hold*

numerous values with different degrees of importance” (Alidoosti et al., 2022). They might evolve with roles, contexts, and lived experiences, as they are not static preferences but dynamic and situated concerns that change over time. Following Davis and Nathan’s (2015) interpretation of VSD as simultaneously a theory, a methodology, a set of methods, and an overarching approach for integrating human values throughout the design, implementation, and evaluation of technologies, this thesis adopts VSD as both the theoretical and the methodological foundation for guiding the ethical design of the DMS as a way to better address the diverse values of stakeholders involved in the design process, including the most vulnerable and disadvantaged stakeholders or end users.

The concept of VSD emerged in the 1990s, devised by Batya Friedman and colleagues (2002; 2006; 2013, *inter alia*) to systematically incorporate ethical and social values into technological design through a *tripartite* methodology involving conceptual, empirical, and technical phases. This tripartite approach structures the DMS design itself, where the articulation of stakeholder values, their empirical validation, and their transformation into system specifications unfold as mutually informing tasks. Briefly, VSD is an interdisciplinary field within Science and Technology Studies (STS), closely situated to Human-Computer Interaction (HCI), where the primary focus is to address human values in a principled and systematic way, thereby integrating such values into various technology designs.

In this thesis, VSD is further based on an interactional concept of technology, which sees values as neither solely embedded in technology nor imposed by any external social forces. Instead, it suggests that the outcomes of technology result from dynamic interactions between artefacts, users, and their specific sociocultural contexts (Friedman et al., 2013). Additionally, VSD follows an iterative design process that recognises the evolving nature of technology, also through user interactions. Although not the most common approach (on that, Cenci and Cawthorne, 2020), participatory processes in VSD should involve an initial design, adaptation based on user feedback, and ongoing refinements, similar to how digital solutions gradually improve user experiences over time. However, the interactional understanding of the VSD implies that technologies do not exert fixed effects; in other words, their design cannot occur in isolation, but rather, their meanings and consequences evolve over time as users engage with and appropriate them. Friedman et al. (2013) illustrated this process with the example of a simple artefact, such as a screwdriver, initially designed for turning screws but often repurposed in various ways according to users’ intentions and creativity. In contrast,

EcoSistema has emerged through dynamic interaction with stakeholders and careful consideration of their specific contexts, while also retaining the capacity to evolve its features in line with the Cooperative's changing needs.

Over time, VSD has been enriched and critically refined through sustained scholarly debate and discussion. On the one hand, [Borning and Muller \(2012\)](#) call for greater clarity about whose values are represented and how cultural diversity and designer reflexivity are addressed, warning that value choices must be made transparent. Furthermore, [Le Dantec, Poole, and Wyche \(2009\)](#) argue that values should be treated as lived experiences that are discovered and negotiated throughout the design process, rather than as fixed categories established at the outset. On the other hand, [Van de Poel \(2021\)](#) extends this dynamic view by introducing the concept of *value change*, showing how values may shift as technologies are adopted. Consequently, he recommends design strategies such as adaptability and flexibility to accommodate such value changes. Likewise, [Friedman, Kahn and Borning \(2013\)](#) emphasised that VSD's conceptual, empirical, and technical investigations are mutually informing and should be revisited iteratively as technologies and social practices co-evolve. Thus, most scholars portray the VSD not as a fixed recipe but as a dynamic, context-sensitive framework that integrates ethical and critical reflection, also through continuous stakeholder dialogue, into the design process.

4.2 The Three Phases of Value Sensitive Design (within the Egalitarian project context)

VSD is organised into three iterative and interdependent phases—conceptual, empirical, and technical—that together connect ethical reflection with design practice ([Friedman et al., 2013](#); [Davis & Nathan, 2015](#)). These three investigations inform and reshape one another throughout a project, allowing designers to revisit assumptions and integrate stakeholder insights as the work evolves.

The *conceptual* phase identifies the stakeholders affected by a technology and the values at stake. Stakeholders are seen as roles rather than fixed individuals, and VSD distinguishes between direct stakeholders, who interact with a system, and indirect stakeholders, who may not use it but are influenced by its effects. One person can hold multiple roles; for example, a waste picker might also serve as a cooperative leader, each with distinct interests and potential impacts. Alongside stakeholder identification, this phase involves defining and analysing the values that may be involved in the technology. Designers explore both explicit and implicit

concerns, anticipating potential harms and benefits. The conflict within values in terms of stakeholders' concern often emerges here, and these value tensions influence later empirical inquiry ([Friedman et al., 2013](#); [Alidoosti et al., 2022](#)).

The *empirical* phase investigates how the identified values are experienced in practice. Using both qualitative and quantitative methods, such as interviews, surveys, ethnographic fieldwork, and observation, researchers explore stakeholders' lived experiences, behaviours, and perceptions. This stage validates or refines the conceptual analysis and uncovers unforeseen issues to negotiate conflicting values and the prioritisation of them ([ibid](#)). The significant outcome of this phase is a defined set of values, which is further translated into the related norms within the empirical-technical transition. Norms are prescriptive statements that specify how a system, process, or actor should behave to realise or protect a value ([Van de Poel, 2013](#)). While a value indicates what is considered important, such as 'transparency' or 'fairness,' a norm states what should be done to uphold that value, for example, ensuring 'accurate and reliable data handling.' Multiple values can be linked to a single norm, and conversely, one value can be supported by several norms. Establishing these norms offers practical guidance for design and sets a benchmark for assessing whether a technology genuinely supports the values it aims to embody.

The *technical* phase aims to translate the confirmed values and norms into concrete design requirements or system features, and to evaluate whether these features uphold the intended ethical commitments expressed by formerly identified values. This phase involves two complementary activities. The first is the design of new technologies to embody values, where prototyping, participatory design, and value heuristics are employed to embed stakeholder priorities directly into the system architecture from the outset. The second is the evaluation of existing technologies to determine how current functions either support or conflict with the intended values, thereby revealing unintended consequences and opportunities for redesign. In both activities, the goal is to achieve '*value alignment*' and to avoid '*value misalignment*' (on the alignment problem, see [Christian, 2021](#), and others).

While no design process is perfect, the iterative nature of VSD enables technology to develop in response to real-world use, albeit with several challenges. Since values are the key parameter of the VSD process, as noted by [Borning and Muller \(2012\)](#), VSD sometimes privileges the voices of system designers in value elicitation when presenting qualitative findings, which can overstate the designers' authority. While this power sharing is not an explicit requirement of

VSD, it should be carefully considered/balanced according to its application for an ethical system as output. On one hand, by continually refining the relationship between technology and human experience, VSD helps to minimise unintended harm and keeps design choices flexible to meet diverse and changing user needs (Davis & Nathan, 2015). On the other hand, ongoing refinements through stakeholder involvement can also uncover new priorities or conflicts. For example, in VSD studies on digital health, interviews and co-design workshops identified privacy concerns that had not appeared at the conceptual stage, leading to design changes such as customisable data-sharing settings (Cenci et al., 2023). Cases like these show that true value integration requires not only careful value determination and definition at the conceptual level but also the empirical elicitation of values, supported by back-and-forth interactions, which should be central to any genuinely participatory VSD.

In the case of designing an ethical DMS for Recicla Mais, I argue that a participatory VSD is the most suitable variant to prevent the explicit authority of the system designers (observed in earlier cycles of the Egalitarian project and other project tracks), to avoid the emergence of critical values in later phases of VSD (a concern heightened by the project's semester-centric cycles), and to reduce the risk of value misalignment (which arises mainly from differing socio-cultural contexts compared to Europe). In this thesis, my relational-egalitarianist standpoint and the direct involvement of stakeholders together counteract the explicit authority of mine as the system designer—a major reason why several Egalitarian project initiatives became unusable in the cooperative contexts. Multiple participatory engagements at different stages of the DMS design (see Table 2) further shaped the conception of values in several cases. However, several values and concerns about the DMS design were conceptualised even when the empirical investigations were nearing completion. Additionally, continuous involvement not only revealed new priorities but also shaped how existing values were interpreted within the Brazilian socio-cultural context, necessitating sustained participation to maintain responsiveness and ethical integrity. Some values only emerged during later rounds of engagement. For example, the need for a clear and easy-to-use anonymous/non-anonymous communication channel between waste pickers and the Egalitarian project (which reflects values related to waste pickers' *dignity* and *well-being*) was first raised in a focus group, rather than anticipated in earlier design stages. Furthermore, newly emerged values or divergent interpretations of shared values might cause misalignment, which could only be clarified through ongoing engagement. A specific example is the value of productivity: while my initial conception emphasised how the waste pickers collectively produced sorted waste per unit of

time, members of the cooperative initially equated productivity in terms of individual sorting speed. Through participatory sessions, this tension was resolved by designing features that regard productivity as a collective achievement of waste pickers and management, while their interpretation also complied with the features, thus incorporating fairness and shared responsibility. To support value alignment, the elicitation in the conceptual phase involved multiple participatory engagements with the waste pickers, the cooperative, and the *DMS* team (which included students from diverse disciplines). The empirical insights were sometimes guided by the literature reviews and the earlier project reports. In this phase, values could emerge, decline, or reappear as perspectives shifted or as different stakeholder groups were consulted. The process is not expected to be linear. For example, some waste pickers might prioritise certain values, while others might emphasise different ones, leading to conflicts even within the same stakeholder group. Such conflicting values can repeatedly reduce or increase the influence of a given value in the design process. It was also anticipated that several value tensions would arise over time and continuously influence the evolving value hierarchy.

In order to capture and engage with these evolving dynamics, this thesis introduces the notion of ‘value power’. By value power, I refer to the relative strength or influence that a particular value has at different stages of the design and implementation process. Value power is not represented as a quantitative metric; rather, it indicates the relative importance of a value within the context of design—specifically, how prominently it is prioritised during technical decision-making. A value may gain power when it is strongly advocated by stakeholders or backed by empirical evidence, and it may lose power when it is challenged by competing concerns or deemed to have limited relevance in practice. Consequently, value power fluctuates as discussions evolve, evidence is gathered, and compromises are negotiated. Instead of outright disregarding any particular value, the design process of the DMS continuously adjusts the influence of values across the conceptual and empirical stages of the VSD, ensuring that conflicting and overlapping values are balanced and that the resulting DMS remains ethically consistent. To address these constantly changing conditions, this thesis adopts a participatory approach to VSD, which is fully explained in relation to the DMS in the following section.

4.3 The Participatory Value Sensitive Design (of the Data Management System)

Although VSD’s interactionalism explains how technologies evolve through use, its normative stance can be rooted in procedural ethics. Drawing on the work of [Cenci and colleagues \(2020\)](#),

2023, 2025), this thesis adopts a procedural-deliberative interpretation of VSD to identify and select design values and to integrate ethical concerns iteratively into the design process. In this view, values are not seen as pre-defined or universal, as in rival interpretations based on expert-based, substantive approaches to value identification by ethicists (still dominant in VSD studies). Instead, (chosen) design values emerge through inclusive and situated deliberation among stakeholders, also known as Participatory VSD. Cenci and co-authors (2023) argue that values and design requirements derived via genuine deliberative engagement are ethically robust because they are more legitimate, accountable, and aligned with democratic ideals. Echoing this view, this thesis frames the value-elicitation phase as a collective act of co-determination by relevant stakeholders and users, including marginalised waste pickers, and the cooperative management along with indirect stakeholders. Deliberation enables competing values to be negotiated in situ (Cenci, 2025). The hierarchy of values that results does not assume a universal nature; instead, it develops through situated moral dialogue. In the DMS design, this tenet is reflected in a multi-stage participatory engagement strategy that began with participant observation in cycle 1 (2024) and continued through focus groups, interviews, and weekly meetings during cycles 1 and 3 (2024–2025), with deliberation maintained through iterative design meetings with the Egalitarian DMS track.

While substantive ethical theories propose a fixed set of universal values, the procedural deliberative model of VSD maintains that values should be discovered, selected, and negotiated collectively among relevant stakeholders through structured participatory processes (Cenci, 2025). Relying on such a universal set could even undermine the ethical robustness (Cenci et al., 2023) of the system and raise doubts about its capacity to genuinely be considered as stakeholders' value-sensitive. A participatory VSD approach, therefore, offers a way to elicit stakeholders' values without depending on predefined universals. As mentioned, the conceptual and empirical phases are therefore conducted in parallel rather than sequentially, with each informing and refining the other through iterative cycles. This perspective opposes the paternalism of top-down, expert-led design and instead centres the knowledge and lived experiences of those directly affected by the technological change. This approach is particularly well-suited to contexts involving marginalised or vulnerable communities, where predefined value lists and their hierarchy might inadequately represent lived experiences, socio-technical realities, or culturally embedded knowledge. This is more than a theoretical point in the DMS, which is designed in collaboration with the waste pickers and their cooperative. It is also highly relevant for such an environment marked by structural inequality, institutional oversight, and

socio-cultural power asymmetries, since participatory VSD promotes mutual recognition and iterative adaptation. The procedural orientation of this thesis follows stakeholder involvement not only in articulating values but also in shaping how these values are realised in system functionalities and institutional protocols during the technical phase. In this note, Cenci and colleagues (2023) emphasise that the VSD process must remain attentive to conflicting values, competing interests, and situated expertise. The goal is not merely to design for values, but to negotiate values in practice (Cenci, 2025), thereby producing a system that is both technically functional and socio-culturally meaningful, as well as ethically legitimate. However, VSD's technical work, in general, often remains limited to ad-hoc prototypes or design sketches, rarely connecting back to the values identified in earlier phases, and infrequently documented as an iterative process (Gredes & Frandsen, 2023). In response to this flaw, the DMS design framework conducted the technical phase as a central component to systematically translate stakeholder values and norms into concrete design specifications by forming feature tables (see Appendix B) and conceptual system modules (Figure 5).

In the following chapter, the methods of participatory VSD implementation in the DMS context, along with the participatory methods used to elicit values, are described.

5. Methodology

This chapter presents the methodological framework that guided the ethical design of the DMS and situates the implementation of the Participatory VSD through various forms of stakeholder involvement, while background research complements the participatory insights (conceptual-empirical), and the translation of elicited values into concrete DMS features (technical).

5.1 Literature Review (State of the Arts on Value Sensitive Design Studies in 'engineering ethics' and 'software development')

A comprehensive literature review was conducted to map the application of VSD in relevant fields, such as 'engineering ethics' and 'software development', as well as its intersections with participatory methods and their implications for digital solution design, attached in Appendix A. The aim was to provide an overview of VSD research, identify the areas where VSD has been applied so far, and learn from the documented evidence and critiques of its conceptual, empirical, and technical stages. Additionally, it sought to explore how scholars elicit values and integrate VSD with participatory methods and stakeholder engagement strategies, which could further guide my value elicitation process for the DMS design.

A *Scopus* search using VSD's full form as keywords yielded 724 records from 1998 to February 2025. After excluding non-English and non-article types, 606 records remained, and their author keywords were analysed through visual network analysis (VNA) following [Venturini and Munk \(2022\)](#). The network revealed core thematic clusters, such as *ethics*, *values*, *human values*, *privacy*, and *participatory design*, indicating VSD's practical applicability within these concerns. The focus was then narrowed to keywords directly relevant to the DMS design, and categorised (in terms of mentioned author keywords) the relevant literature in engineering (27 papers), sustainability (21), software (12), and interface and user experience combined (12)—noting that several papers contained multiple of these keywords. From these author keyword clusters, 45 articles were selected for in-depth analysis, supplemented by 13 additional studies identified through snowball sampling, resulting in a total of 58 thoroughly examined publications.

However, the 58 studies indicate that VSD research is primarily Western in language and geographical scope, focusing primarily on computer science, social sciences, and engineering. Foundational work ([Friedman, 1999](#); [Friedman et al., 2013](#); [Friedman, Kahn and Borning, 2013](#)) establishes the tripartite framework of conceptual, empirical, and technical investigations, while critiques ([Borning & Muller, 2012](#); [Martin et al., 2023](#); [Cenci & Cawthorne, 2020](#)) call for stronger cultural sensitivity, explicit treatment of norms, stakeholders' inclusion and greater designer reflexivity among designers. Broader value theories, such as [Schwartz's \(1992, 1994\)](#) universal values framework, offer additional conceptual foundations for analysing value clusters and tensions. [Alidoosti et al. \(2022\)](#) provide a variety of value definitions and a modified value key map that expands on Schwartz's work. While, norms—defined as prescriptive statements about how a system should act to uphold values ([Van de Poel, 2013](#); [Clancy et al., 2022](#))—further translate values into concrete design guidance.

Within the engineering-related papers (e.g., [Turilli, 2008](#); [Vermaas, 2019](#)), systematic ethical integration with careful attention to designer-user power imbalances ([Borning et al., 2009](#)) is frequently discussed to pivot socio-cultural values (e.g., transparency, autonomy) through the participation of the stakeholders within different value elicitation pathways (direct/indirect, predefined and/or user-defined) and their implication processes. Sustainability-oriented studies (e.g., [Parada et al., 2017](#); [Mok & Hyysalo, 2017](#); [Helbing et al., 2021](#); [Pitt et al., 2021](#)) also highlighted the necessity of participatory methods for involvement in software-focused

research to design sustainable solutions. Interface and user experience-related studies (e.g., Dadgar and Joshi, 2018; Cajander & Grünloh, 2019; Lee et al., 2023) pivot on participatory engagements as well and demonstrate how such involvement can enhance the readability and usability of the designed technologies. On the other hand, Gerdes and Frandsen (2023) highlight in a review that the VSD implications often suffer from ‘*methodological and reporting issues*,’ which means that most VSD studies remain in the conceptual-empirical phases and fail to operationalise a *reproducible method*. The study also advocated for stakeholders' direct involvement in eliciting and embedding values into design features. These strands collectively support the use of participatory VSD methods to elicit values, articulate related norms, and guide the ethical design of the DMS.

In order to maintain the academic rigour of this study, we undertook a focused study on value theories and frameworks relevant to software engineering. This started with Schwartz’s (1992, 1994) universal value framework, which offers a widely recognised map of fundamental human values, and further continued with Alidoosti et al. (2022), who presented a modified value map (in line with Schwartz) with particular attention to software engineering ethics and refined related values’ definitions pertinent to the software engineering domain. The aim of this value study was to maintain a consistent value interpretation to avoid any value misalignment throughout the DMS design. Additionally, the revised value map by Alidoosti and colleagues (2022) was employed to investigate which values could plausibly arise in the Recicla Mais context and to maintain a consistent perception of each value during the design phases.

Collectively, these steps ensured that the values identified and finalised through the conceptual-empirical phases are both contextually relevant and theoretically sound. Drawing on the literature review, the following section describes the Participatory VSD methodology and its implications for the design of the DMS, namely EcoSistema.

5.2 The Participatory Value Sensitive Design as a Method

The following subsections describe each phase of the tripartite, participatory VSD process underlying the DMS, which begins with the integration of conceptual and empirical investigations as a foundation for stakeholder engagement and the value elicitation strategies informing the technical VSD phase, where values are embodied technologically.

Conceptual-Empirical Investigations

The Participatory VSD's conceptual-empirical investigation begins by *identifying stakeholders* who actively engage with the technology (direct stakeholders), and those who may not engage with the technology directly but are nevertheless impacted by its deployment based on the way of their interaction with the system (indirect stakeholders) (Friedman et al., 2013). However, in software engineering ethics, the direct and indirect stakeholders can be categorised into three overarching groups (Alidoosti et al., 2022), as depicted in Figure 2, p.26.

However, this distinction between stakeholder types is critical to understand the values elicited through

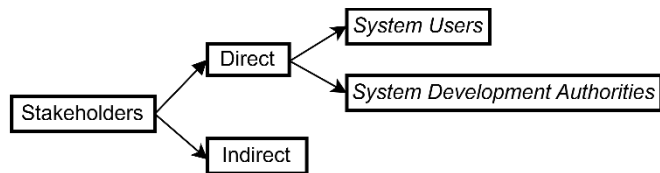


Figure 2: Stakeholders Category

stakeholders' participation and uncover possible value tensions in the subsequent phases of system design.

After identifying and recruiting stakeholders and/or users (see subsection below), participatory methods (rooted in the Scandinavian tradition of participatory design) were used to elicit their perspectives and enable the co-construction of related values through situated, dialogic interaction (Schuler & Namioka, 1993; Bødker et al., 2004). In line with Cenci et al. (2023), empirical research activities—including ethnographic observation, semi-structured interviews, focus groups, and workshops—were then employed to capture stakeholders' impressions to find out the subsequent values and to analyse the consequent value tensions, their relative value power and negotiated trade-offs when values came into conflict. For example, one participatory event at Recicla Mais revealed that the Cooperative struggles to handle data accurately and sometimes even loses valuable records because it lacks an efficient method, which highlights accuracy and efficiency as key values. However, the design cycle proceeds, and further participatory involvements enriches the preliminary value list. These initial value keywords were then explored to identify where they came into conflict with one another and what kinds of negotiations were required to weigh their relative importance (value power) and their placement within the hierarchy. In the same participatory event, waste pickers reported that they believed their wage data might be manipulated (trust emerged as a value) and expressed uncertainty about how the cooperative calculated salaries (resembling transparency as a value). The cooperative, for its part, described these suspicions as “gossip” but nevertheless recognised the need for a system that could transparently inform waste pickers to improve mutual trust between them (transparency and trust emerged as values from the Cooperative management).

In this case, *transparency* and *trust* were prioritised over *efficiency* without compromising *accuracy*, as both stakeholder groups shared concerns about transparency and trust, and accuracy is non-negotiable for creating an actual DMS. In this example, the relative value power for *transparency* and *trust* remained higher than that for *efficiency*, which was also considered when negotiating the value's position in the hierarchy. Through such processes, conflicting values were systematically balanced to derive the final set of values and their relative hierarchies for the DMS design. However, an additional function with a semi-automatic but manual layer for processing sorting data was added as a feature in the DMS (as part of the technical investigation), reflecting the negotiated value power and hierarchical position of the mentioned values. Meanwhile, conceptualisation activities, such as literature reviews, background studies, and value-definition analyses, continued in parallel to feed back into these value tensions, negotiations, trade-offs, and shifts in value power, thereby carrying out the participatory VSD of the DMS. The assumed values were not finalised at first attempts; rather, these values were treated as provisional and refined through continued dialogue with the identified stakeholders.

Between January 2024 and June 2025, participatory methods were employed in Brazil and Denmark to support the tripartite VSD phases: by eliciting values, surfacing normative tensions, and guiding their translation into norms and functional technical features. [Table 2, p.28](#), summarises each participatory method, its timing and purpose, and the stakeholders involved. These initiatives included methods such as participant observation, (two) written interviews, semi-structured interviews, a focus group, (three) participatory workshops, and weekly feedback meetings. Together, they revealed work routines and data practices, articulated stakeholder values and tensions, and enabled iterative co-specification of the DMS. (two) *Written interviews* were conducted, one in English and the other in Brazilian Portuguese, with the help of *DMS track*. *Semi-structured interviews* consisted of open discussions with multiple participants, including Brazilian professors and Social Activists with long-standing experience in waste management and prior involvement in the Egalitarian project. In this approach, questions were not predefined; instead, follow-up questions were guided by the flow of the conversation. The *focus group* took place at Recicla Mais, where subgroups of the DMS track submitted questions for both the waste pickers and the cooperative management through the PMO. Afterwards, a plenary discussion ensued, with the UnB students recording observations and responses. *Participatory workshops* took various forms: during Cycle 2, a workshop in Copenhagen facilitated open discussion and collective idea-sharing through

plenary comments; in Cycle 3, the first workshop invited Egalitarian participants to describe their positionality by sharing keywords through an online presentation platform, moving forward to plenary discussion; the second workshop in 2025 at Centcoop, involving around 10–15 waste pickers, asked participants to write keywords in response to specific tasks and questions, providing material for subsequent focus groups and written interviews. Finally, weekly online *feedback meetings* were held with DMS track participants to share ongoing findings and design updates. Altogether, these sessions ensured that the DMS design was consistently validated against participant feedback and that evolving insights were promptly integrated into functional specifications, thereby maintaining alignment with the project's objectives.

Table 2: Participatory Methods applied in EcoSistema

Method	Period & Description	Purpose / Outcome	Stakeholder Involved
Participant Observation	Jan 2024 (Recicla Mais & Centcoop) Jan 2025 (Centcoop) Field visits conducted at Recicla Mais and Centcoop to observe day-to-day work, organisational routines, and data practices.	Identified informal work processes, social dynamics, and digital gaps that influenced system design priorities.	Direct: Waste pickers, cooperative leaders
Written Interviews	Apr 2025 Targeted written responses from two key stakeholders: (a) Egalitarian project. (b) Recicla Mais Management	(a) Clarified the philosophical and operational vision of the Egalitarian project. (b) Gathered insights into administrative values and system needs for <i>EcoSistema</i> .	(a) Indirect: Egalitarian co-founder (b) Direct: Recicla Mais Financial Administrator
Semi-Structured Interviews	Jan 2024 Q&A informal discussion exploring digital practices and stakeholder definitions of core values.	Surfaced managerial values such as productivity, accuracy, and efficiency; explored differing expectations between cooperatives.	Direct: Admin leaders of Recicla Mais and Centcoop
Focus Group Interview	Mar 2025 Plenum-style discussion with waste pickers and cooperative management in separate sitting, to elicit shared perspectives.	Revealed community values, expectations from <i>EcoSistema</i> , and internal value tensions between visibility, control, and autonomy.	Direct: Waste pickers, Recicla Mais Management
Participatory Workshops	Aug 2024, Jan 2025 (x2) Three workshops combining value mapping, interface sketching, and dialogue. One session focused explicitly on positionality and reflexivity in design.	(a) Discussed strategies for integrating <i>EcoSistema</i> at AAU. (b) Explored waste pickers' beliefs, practices, and system needs. (c) Strengthened ethical awareness and clarified roles through a positionality-focused dialogue.	Waste pickers, Egalitarian participants, Brazilian NGOs, government authorities, and project staff
Weekly Feedback Meetings	Weekly (Feb–Jun 2025) Ongoing iterative meetings with the DMS team, Brazilian PO, and project stakeholders to review evolving designs.	Enabled incremental refinement of functional features, validation of stakeholder priorities, and resolution of emergent issues in the design process.	Indirect: Egalitarian students (DMS track), software developers, project officials

The case of this thesis (described in Chapter 3) on Recicla Mais provided a concrete setting to explore how digital infrastructures are perceived and negotiated within daily life, organisational practices, and the challenges faced by the waste pickers and the cooperative management. This type of problem framing, as a case, helped to highlight socio-technical realities and power asymmetries within the cooperative context. Furthermore, the participatory VSD of the DMS was enriched through case-based ethnography. Fieldwork during the week-long Egalitarian project events at Recicla Mais (2024) and Centcoop (2024 and 2025) involved being present in the cooperative environment, engaging in participant observation, conducting semi-structured interviews, and holding informal conversations that allowed deeper insight into daily practices and relationships. However, ethnography was not limited to data gathering in this context but served as a qualitative and participatory mode of inquiry, which enabled a deep understanding of cooperative work routines, data flows, and stakeholder perceptions on digital solutions (Sharp et al., 2019; Bro et al., 2024). Furthermore, participant observation helped to understand daily practices and informal data exchanges, as well as to identify tensions within daily work that revealed the salience of some values. At the same time, semi-structured interviews with cooperative management and Brazilian professors provided a flexible space to situate the contemporary context of Brazilian waste pickers and to explore managerial concerns without a rigid question set, allowing unanticipated issues to emerge naturally. The focus group brought together waste pickers and management to surface collective concerns, document value tensions, and expose weaknesses in existing practices, which prompted value trade-offs and recalibrated the value power of certain priorities. Participatory workshops supported the co-specification of the functional features and the negotiation of normative standpoints within the DMS track. At the same time, weekly feedback meetings created an iterative testing ground in which I, as system designer, could trace the movement from values to norms to concrete design features and address new value tensions as they arose. Together, these methods were *complementary* to ensure that values were not only elicited but continually examined to be further operationalised.

Stakeholder Mapping and Recruitment

As part of the conceptual-empirical phase, stakeholders were identified and recruited through a multi-step process, i.e., informed by the broader Egalitarian project, insights from previous project reports, and my earlier engagement within the project, refined for this thesis. The recruitment combined purposeful and snowball sampling: key informants from Recicla Mais and the Egalitarian project suggested additional participants, while ongoing field visits and

workshops confirmed their interest and involvement. [Table 3, p.30](#), presents the stakeholder types and the actors within each type.

Table 3: EcoSistema Stakeholders' type and actor

Type	Actors
Direct stakeholders (User Types 0–2)	Waste pickers, cooperative leaders, and administrators.
System developers (User Type 3)	The author as system designer, together with <i>DMS</i> track participants.
Indirect stakeholders	The wider Egalitarian consortium (AAU, Saxion, UMinho, UnB), Brazilian waste-management authorities, and organisations concerned with environmental and social justice.

In this thesis, the identified stakeholder groups were subsequently organised into user types 0–3, covering direct users, the cooperative manager, developers, and indirect stakeholders, to facilitate the technical phase of VSD and clarify design responsibilities (see Appendix B, and the technical phase in the next chapter).

Technical Investigations

In the final phase of the participatory VSD, the stakeholders' values are incorporated into the design features and system functionalities. Here, [Van de Poel's \(2013\)](#) 'value hierarchy' device, a pyramid model for value translation, moving from values to norms to design requirements/ functional features, is implemented in the context of the DMS design to extrapolate norms from previously selected values and thus, to identify functional features.

In the Participatory VSD concept, norms occupy the middle level of the value hierarchy ([Van de Poel, 2013](#)): they translate broad values into prescriptive statements of what ought to be done, which then guide technical design requirements. While conceptual-empirical investigations identify, refine and finalise the values, the next subsequent activity is to translate those values to norms, which explicitly show the way to finalise the features/ design requirements. Several values can jointly define a single norm, and a single value can also contribute to multiple norms. [Figure 3, p.31](#), illustrates the hierarchical relationship among values, norms, and design requirements/functional features. For example, the values of *trust*, *transparency*, and *accuracy* together constitute the norm *Transparency & Traceability*. This norm is implemented in the EcoClareza module of the DMS through a real-time cooperative dashboard that displays both individual waste picker productivity and collective cooperative performance—a feature requested by cooperative management during focus-group activities. Similarly, the values of *trust*, *accuracy*, and *efficiency* underpin the norm *Accurate & Reliable Data Handling*, which is realised in the EcoManageria module through vendor-management

activities supported by AI-based predictive assistance. In this way, norms guide and translate abstract values into concrete functional features, whereas attempting to directly encode values could risk losing direction when finalising specific system functions.

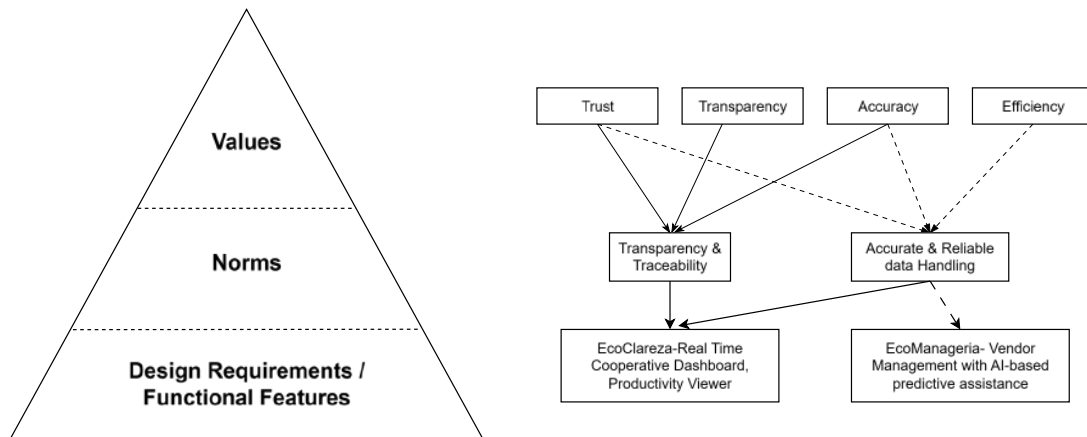


Figure 3: The three basic layers of Value Hierarchy (inspired by Van de Poel, 2013), and an example of value to norms to design requirement/ functional feature translation from the DMS design

The waste pickers, the cooperative management, and the DMS track participants were re-engaged back and forth from February 2025 until June 2025 (Cycle 3) during the technical investigation through participatory, scenario-based discussions (direct stakeholders, system users), usability-testing discussions, feasibility testing of functional features (direct stakeholders, system-developing authorities), and policy discussions within the development team (indirect stakeholders, the Egalitarian project), while earlier ethnographic fieldwork and participatory activities served as the foundation for identifying which features should be included and were continuously refined as new activities emerged. These engagements allowed for the validation of design choices and the surfacing of unintended negative consequences, ethical dilemmas, or mismatches between intended values and user interpretations, which continuously calibrated the value power. Central to this process was the notion of *value embodiment*, where values were translated into operational configurations of the DMS modules (i.e., EcoClareza, EcoManageria, and EcoCatadores; detailed in the next chapter). Another important aspect of the technical investigation was managing *value trade-offs*. In real-world contexts, values often conflict—such as *transparency* versus *control*, a core consideration in the DMS. The investigation addressed these conflicts by exploring design alternatives, incorporating modularity or user choice, or implementing safeguards to mitigate potential harms during feature finalisation. In the DMS, such trade-offs were not resolved unilaterally by developers; instead, they were made visible and negotiable through ongoing stakeholder inputs. Simultaneously, the norms were further operationalised into concrete system features

by operationalising each norm to functional features and validating these mappings through iterative design meetings with the DMS track. In practice, a structured feature table was developed to translate stakeholder input into design requirements/ functional features, organised by components (feature area/domain), feature title, feature description, user groups, associated norms, and user-specific values, as well as the type of user involvement. This table served as the basis for evaluation, linking the design of each module to the underlying values and norms in terms of the features (see Appendix B). The evaluation of whether values and norms were properly embedded was conducted concurrently, using stakeholder feedback to validate the design choices and uncover any misalignments between the intended values and actual features. This phase thus closed the loop of the tripartite methodology while preserving the openness and responsiveness essential to just and inclusive technological innovation. As this work concluded at the design stage rather than full-scale implementation, the evaluation concentrated on verifying whether the conceptual-empirical insights by VSD are faithfully embodied in the associated norms and the proposed functional DMS's features. Consequently, the ethically grounded DMS remains open to refinement during future development and deployment. This is how the evaluation metrics and feature finalisation counter the gap in VSD's technical phase, identified by Gerdes and Frandsen (2023), by mitigating *methodological and reporting issues* through systematic value translation into functional features.

5.3 Ethical considerations in empirical research

The empirical work for the DMS was guided by internationally recognised standards for *research ethics* in anthropology and qualitative inquiry based on honesty, fairness, and diligence (Resnik, 2012), together with broadly accepted ethical guidelines for qualitative fieldwork and interviewing (e.g., American Anthropological Association, 2012; University of Oxford, 2021). These sources emphasise informed consent, respect for participants, and responsible data management, aligning closely with the participatory and value-sensitive aims of this thesis. Throughout the fieldwork, these ethical principles were consistently applied in practice. Above all, the research was conducted with the intention of doing *no harm*, with observations and discussions carefully planned to minimise disruptions to cooperative work, and with no sensitive personal data requested from the Recicla Mais members. The purpose of every participatory engagement and fieldwork was clearly stated in advance. Interview guidelines were provided in both written interviews to explain the objectives, purposes, and procedures of the interview, and also to confirm that permissions were sought for the data being

used. Since the aim of the semi-structured interviews, focus group, and workshops was communicated either in writing (for the Egalitarian participants applying to the project) or verbally (for the waste pickers and the cooperative management during events), both researchers and participants were informed correctly and possibly shared a common understanding of the DMS design's goals. At every stage, the AAU team (myself included) sought to *obtain informed consent and necessary permissions*, including approval for video recordings of workshops and for taking photographs during ethnographic fieldwork and participant observations. Situations that required *weighing competing ethical obligations between collaborators and affected parties* were addressed by documenting and cross-checking inputs from cooperative leaders and financial administrators separately and jointly, as well as by recording concerns of the waste pickers and the management in both shared and private settings. To *make the results accessible*, the findings of this thesis would be compiled into a separate document for the Egalitarian project, which is responsible for communicating the outcomes to future participants, social activists, and concerned authorities. It is therefore expected that Recicla Mais and its members will also receive a version presented in a form understandable to them. All empirical contents have been *protected and preserved [as] research data* through secure storage on encrypted drives and by removing identifying information from any public documents. In order to *maintain respectful and ethical professional relationships*, continuous involvement was conducted with care through sustained dialogue during weekly meetings, culturally sensitive collaboration with Brazilian colleagues, repeated checks for confirmation of interpretations, and positionality exercises designed to reflect on power dynamics. The implementation of such ethical considerations aims to ensure that stakeholder engagement might be ethically robust throughout the project, so that the resulting DMS design could be grounded in democratic practices holding acceptable levels of *accountability and mutual trust* (ibid).

The next chapter discusses the VSD of the DMS and its implications across the three phases, along with its associated values, norms, and functional features.

6. The Value Sensitive Design of the Data Management System: The Three Phases

In this chapter, we elicited values, conducted value negotiations and trade-offs, analysed the value hierarchy, and formulated the values into related norms (conceptual–empirical phases).

We further translated these values and norms into functional features and evaluated whether the features properly embedded the values and the value-power identified in the earlier phases (technical phase), building on the methodologies as described in the last chapter.

Table 4: The VSD phases in terms of Egalitarian project cycles

Design and Test Phases	Project Cycle	Participatory Tasks and Strategies
Preliminary phase of VSD	Cycle 1, 2, 3	Ethnographic fieldwork, stakeholder/user observation, participatory workshops with users and designers, understanding the problem space, and defining the design strategy.
VSD Conceptual-Empirical phase	Cycle 3	Ethnographic fieldwork, participant observation, written interviews, participatory workshops, and focus group interviews with the waste pickers and the cooperative management, and weekly DMS meetings to: (a) Understand the needs, expectations and concerns of the waste pickers and the Recicla Mais management regarding the DMS. (b) Identify pain-points in work, value-power and its trade-offs, conduct value negotiation back and forth to inform value hierarchy, and further value to norms translation. (c) Gather insights to understand to what extent a specific value or norm should be prioritised, for supporting the functional features translation, serving as input for the technical phase.
VSD Technical Phase	Cycle 3	Weekly DMS meetings were conducted to: (a) Translate the values, value hierarchies and norms into the functional features of the DMS. (b) Evaluate all the modules of the DMS to determine whether they reflect the empirical findings and values that complement the preliminary design commitments. (Prototype development, user test and other tests are expected to be conducted on future cycles).

Due to the cycle-based structure of the Egalitarian project, my engagement with the three phases of VSD spanned all project cycles until Cycle 3. The preliminary phase of VSD, during which the initial conceptualisation of the DMS and its ethical design imperatives emerged, continued through all three cycles. In contrast, the full implementation of the conceptual-empirical and technical phases was focused mainly on the third cycle. At each stage, participatory methods were employed to ensure ongoing stakeholder involvement, as described in [Table 4, p.34](#).

6.1 The conceptual-empirical phases for the Data Management System

The conceptual-empirical phase serves as the foundation for aligning the cooperative's lived practices with the design of the DMS. This phase began with a stakeholder analysis, which identified who holds a stake in what capacity, with what interests, and their potential vulnerabilities.

6.1.1 Stakeholder Analysis

As [Manders-Huits \(2010\)](#) articulates, every VSD process begins with a thorough stakeholder analysis to identify and classify both direct and indirect stakeholders, as seen in the Egalitarian

project. They classified the stakeholders of the *DMS* track into six main groups: waste pickers, Recicla Mais as a cooperative, cooperative managers (including the Financial Administrator and Cooperative Assigned Leader), UnB, AAU, and UMinho, as well as participating teachers and supervisors (Egalitarian, 2025c, pp. 34–38). Considering the provided stakeholder categories, this thesis differentiates and presents stakeholder groups with greater contextual nuance, as illustrated in Table 5, p.35. This mapping, however, ensured that diverse perspectives, explicitly from the waste pickers to the cooperative managers, project partners, and external institutions, are recognised in the design process.

Table 5: Stakeholder Group, Roles and Affiliation

Stakeholder Level	Stakeholder Type	Stakeholder Group	Affiliation / Role
Direct	System Users	Waste Pickers	Recicla Mais – Primary users of the system.
		Financial Administrator	Recicla Mais – Conducting administrative activities, operational oversight, coordination, and managing the system
		Cooperative Assigned Leader	Recicla Mais – Leadership, community representation, manages several system functionalities
		PMO of DMS	UnB – System super admin responsible for troubleshooting, fixing errors, and ensuring uptime
	System Developers	Software Engineering student(s)	AAU & UnB – Involved in system development
		Computer Science student(s)	AAU – System design and programming
		Techno-Anthropology student(s)	AAU – Ethical consideration in design, socio-technical research and design alignment
		Production Engineering student(s)	UMinho – User journey team.
		Industrial Engineering student(s)	UnB – System functionality and user feedback.
		Other Participants in the <i>DMS</i> track	Saxion - Observers and contributors through Erasmus+ participation
Indirect	-	Participated Teachers and Supervisors	UnB, AAU, UMinho, Saxion – Provided academic and technical supervision
		Erasmus+ Egalitarian Project	International collaboration framework, policy analysis and funding support.
		Social workers and other delegates (Open Day)	Gave input from a social, ethical, and institutional lens
		Government (Waste Management Ministry & Concerned Authorities)	Policy influence, regulatory alignment
		Other participants (non- <i>DMS</i> track)	Occasional input/observation during events, insights into the <i>DMS</i> project
		Recicla Mais as a Cooperative	Incorporating a more transparent and positive workplace.

The identification of stakeholder types and the clarification of their affiliations played a central role in determining, examining, and interpreting the value concerns specific to each group.

Furthermore, this analysis provided a structured framework for conducting value elicitation, and the strategies behind it are described in the following section.

6.1.2 Value Elicitation Strategy

The identification of values for the DMS followed a combined strategy that involved both empirical engagement with stakeholders and conceptual reference to the literature.

Value elicitation for the DMS evolved across three project cycles, shifting from exploratory engagement to targeted design guidance. Early ethnographic fieldwork and observations in 2024 uncovered trust issues with data accuracy and demonstrated that technical fixes alone would not resolve the underlying organisational and cultural challenges. Building on these insights, a workshop at Aalborg University in August 2024 shifted the project's focus from technical solutions to the socio-cultural aspects of sustainable digitalisation, emphasising that enhancing the well-being of waste pickers required their direct involvement in the design process. These activities marked a turning point in the initial phases of VSD, when comprehensive background studies were conducted. As the project moved to Brazil in early 2025, participatory activities deepened. A January workshop at UnB explored and compared the positionalities of technology designers and implementers with those of waste pickers. Participants described themselves with terms such as *highly educated*, *privileged*, and *rich*, while the waste pickers' realities were captured in a contrasting word cloud highlighting *marginalisation*, *inequality*, *lack of trust*, and *poverty*. This comparison emphasised the social gap between the waste pickers and the Egalitarian participants, guiding ethically conscious design decisions. Subsequently, a Centcoop workshop with around 10-15 waste pickers revealed how they wished to be perceived in public settings and confirmed their willingness to contribute ideas for digital solutions, alongside the need for inclusive communication. Building on this, a focus group at Recicla Mais in March 2025 offered the most detailed input on values. Conducted in separate sessions with five to ten waste pickers and two management representatives, the sessions highlighted concerns about financial insecurity, social undervaluation of labour, and ongoing doubts regarding fairness and transparency in payroll and data handling. Management acknowledged workers' contributions but noted the difficulty in explaining income sharing and dealing with fluctuating market prices. Both groups affirmed the Cooperative's economic growth as a shared aim, but with different priorities on organisational performance versus individual earnings. To deepen and refine these insights, two written interviews were conducted in April 2025: one with the Recicla Mais's Financial

Administrator and another with a co-founder of the Egalitarian project. Drawing on predefined value keywords derived from earlier fieldwork, workshops, and the March focus group, the Financial Administrator selected ten values to promote worker well-being and eight to balance control, autonomy, and participation, with an emphasis on data consistency as a basis for system reliability. Her description of daily tasks helped to pinpoint key functions and guided subsequent value negotiations. The Egalitarian co-founder focused on employee well-being and fairness, clarifying how the DMS could align with the project's broader vision and emphasising design priorities identified earlier. These interviews jointly confirmed the alignment of cooperative and project-level objectives, offering concrete guidance for translating elicited values into norms and system features. Finally, weekly meetings from February to June 2025, involving the *DMS* track participants and occasionally the Egalitarian project officials, created an iterative forum where emerging values were consistently tested (by myself) against technical feasibility. Insights from focus groups, workshops, and interviews were revisited, allowing the adjustment of priorities, the identification of new tensions, and initial assessments of whether proposed features embodied the negotiated values. These ongoing exchanges ensured that the evolving design remained true to, and continuously refined, the collective value commitments. The positionality word clouds, focus groups and written interviews are attached in [Appendix C](#).

Importantly, the elicitation and finalisation of values did not occur in a linear fashion but unfolded iteratively and cyclically, as

illustrated in [Figure 4, p.37](#), through a blend of VSD's conceptual and empirical phases into an ongoing, situated process. Each value keyword emerging from participatory engagements, earlier Egalitarian work, and the system designer's standpoint underwent a systematic review. First, its definition and presence were verified against the taxonomies of [Alidoosti et al. \(2022\)](#) and [Schwartz \(1992, 1994, 2007\)](#); if not directly included, related concepts were examined or cross-checked within the context of software engineering ethics. Second, the value was interpreted in the

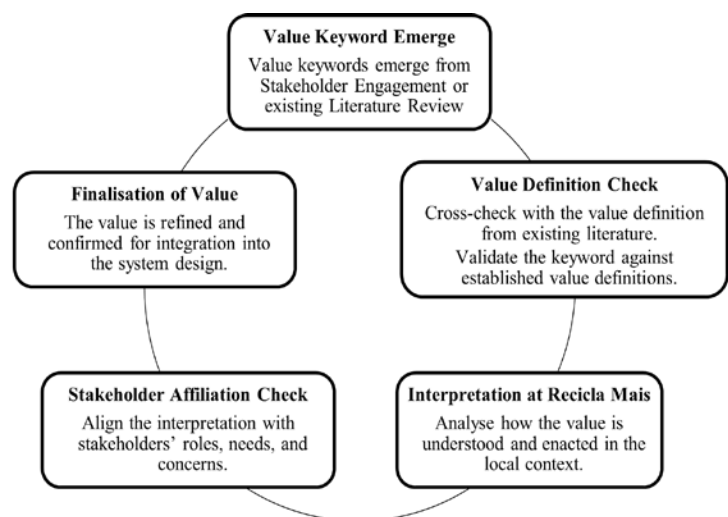


Figure 4: Value Elicitation Strategy

within the context of software engineering ethics. Second, the value was interpreted in the

cooperative context to capture how waste pickers and managers understood it. Third, its relevance to specific stakeholder groups was analysed to clarify for whom it was significant. Throughout, value tensions were tracked to assess which values should carry greater value-power in relation to others, drawing on the stakeholder reasoning as well as the system designer's normative standpoint. Only values that passed this multi-step process were retained, after which associated-norms were derived to guide the technical phase.

The following section presents the values underpinning the DMS, as elicited and refined through the strategies described above.

6.1.3 Values Underlying the Data Management System

As mentioned, the values were elicited through a multi-step process. This section presents each value, along with its associated concerns regarding value tensions and the rationale for its selection. For every value, the discussion addresses its relevance to the DMS, how it is perceived by waste pickers, cooperative management, the Egalitarian project, and the Cooperative principles, as well as the tensions it creates with other values that inform its prioritisation within the design.

Transparency emerged as a non-negotiable and primary value for upholding **trust** among the waste pickers at Recicla Mais, a value that was repeatedly voiced during every participatory involvement. The socio-cultural context of Brazilian waste pickers also shaped such priorities. Doubts about wage calculations persisted from the 2024 field visit into the 2025 focus group. Workers described the current workflow as an “(...) *automated spreadsheet, but don't know how it works.*” Management acknowledged a trust problem, interpreting it as “(...) *some gossip about management changing the data and lying about the numbers (...).*” An Egalitarian official stated that “(...) *transparency brings trust (...), [that] makes you happier to do your job,*” tends to the value *self-respect* and *influential*, while the Financial Administrator noted that “(...) *it's good to improve transparency in information.*” Here, transparency is not only a technical property but a condition for *fairness, accountability, social justice*, and the *sense of ownership* and *belonging* that a cooperative depends on. The primary purpose of the DMS is therefore designing it in such a way that workers can follow their own data in simple, legible ways and managers can trace decisions with audit trails. The DMS proposes daily, transparent breakdowns of earnings and productivity, as well as personal access for the workers and reliable summaries for the managers. Tensions within *transparency* and *control* were addressed directly. The management was struggling about “*showing the data and explaining [it] in a*

*clear to understand way (..),” while they currently “(...) provide individual reports to avoid conflicts (...),” and further clarified that “(...) it is up to the members whether they choose to share and compare reports with others (...).” During my 2024 fieldwork, I observed that the cooperative did not intend to publish the unit prices of sorted waste due to its radical fluctuations and the risk of creating unintended competition with other cooperatives. This practice reflected a tendency to retain *control* over the transparent disclosure of unit-price data. Nevertheless, waste pickers expressed doubts about the accuracy of these prices, and rumours persisted about possible sabotage of their income. In addressing these conflicts, *transparency* was prioritised as a higher-order value—since without it, both *fairness* and *trust* would collapse. The design, therefore, proposes features that inform workers about their income with *transparency* yet preserve managerial *control* over sensitive pricing data. I further argue that the principle “*open enough to verify, closed enough to protect*” should guide these design choices, so that *transparency* strengthens *trust* rather than provoking conflict.*

Accuracy was repeatedly highlighted by all the direct stakeholders and framed as compulsory by both the Cooperative management and the Egalitarian project. The ISCMS track during Cycle 1 described the core challenge as accurate collection and storage of sorting data, with an objective to “*address the data accuracy issues faced by cooperatives during waste sorting processes*” (Egalitarian, 2024). On the ground, the cooperative leader reported that currently she “*(...) records productivity observations in [a] notebook, though she mentioned having difficulty (...).*” The Financial Administrator acknowledged that “*some records are not accurate or are not made,*” and warned that “*if the information is not carefully systemised and (...), [it] can generate questions for the cooperative.*” She also pointed to a “*delay in realising information,*” which obstructed timely monitoring and further questioned about *productivity*. Inaccuracies threatened workers’ earnings and distorted productivity assessments. During peak hours, tensions between *accuracy*, *certainty*, and *efficiency* were visible, for example, when “*(...) the sorting workers, after weighing the recyclables, send photos of the weights directly to [the cooperative leader] via WhatsApp.*” The DMS prioritises *accuracy* as a higher-order and non-negotiable value, ensuring that *fairness*, *trust*, and *freedom from bias* can be upheld. Furthermore, inaccuracies in data handling not only create the risk of data loss but also undermine *transparency*, which might fuel distrust among waste pickers. Fundamentally, errors in wage calculation could potentially miscalculate workers’ income while also distorting measurements of their *productivity*, which risked influencing how they were perceived or valued within the Cooperative. Furthermore, the Cooperative’s primary concern and

expectation from a DMS is accurate data handling, which even entitles the earlier project cycles ([ibid](#)). It is essential to assess the productivity of both the workers and the cooperative itself without bias—*freedom from bias*—a core value in the Egalitarian project as well. *Accuracy* is therefore chosen as a core value because it speaks to both the technical integrity of the DMS (Egalitarian project's objectives as well) and to broader concerns of *equality* and *social justice*. At the same time, it supports what Schwartz's modified value map would frame as *inner harmony*—motivating waste pickers to work attentively and with confidence. The DMS therefore embeds accuracy not only in data entry but also in validation and correction processes, making errors visible, traceable, and rectifiable without suspicion through its functional features. From a broader perspective, accurate data is the foundation of *fairness*, *accountability*, and *trust* as values in any cooperative system. Conflicts between *accuracy* and *efficiency* emerged in several instances, but as a trade-off, *accuracy* combined with *transparency* was consistently prioritised. For example, during peak hours, an additional checkpoint for verifying sorted-weight data might slow down operations compared to the quick exchange of photos. However, the system deliberately incorporates additional checkpoints into its features. Moreover, *accuracy* in data handling remained a core value for the system designer, and during feedback meetings, careful consideration was given to ensure consistent and reliable data handling.

Involvement, understood as meaningful participation, is central to the DMS. In 2024, a non-user-involved QR code system for Centcoop was developed but was never adopted because workers found it difficult to understand and irrelevant to their environment ([Bro et al., 2024](#)). Several front-end attempts for the DMS in an earlier cycle were also abandoned due to their complex design and inaccessible data representation, which exemplified a less participatory design movement. In the 2025 focus group, a leader described how “(...) *Recicla a Vida* system was quite complex for her and other workers to grasp (...)” and further noted regarding the “(...) difficult[ies] [in] understanding the system app due to its complexity (...)” These experiences illustrate that without genuine inclusion, even well-intentioned tools might fail. From an ethical standpoint, it also raises the question of whether it is defensible to design systems for users who have little or no say in their creation. The Financial Administrator insisted that “(...) it is important for the cooperative member[s] to be involved in this [design] process, because [they] are the one[s] who will use the platform,” adding that “if [workers] are unable to view the information [in the] correct way they may not use [the] platform (...),” which can only be confirmed through the direct *involvement* of the waste picker. *Involvement*

further aligns with the cooperative's democratic practice that “(...) *they make decisions in an assembly with all the interested workers.*” However, *involvement* is tied not only to values like *usability* but also to the *well-being* of the workers, which directly aligns with the broader aim of the Egalitarian project (Egalitarian, 2025a). To maintain a balance between *usability* and *involvement* as values, the DMS is designed to involve the waste pickers in everyday operations without creating a technical burden. *Involvement* primarily supports *transparency* and *trust* as core values, since meaningful participation could bring the transparency initiative of the Cooperative to the forefront, which can also influence trust issues among waste pickers and the Cooperative. Furthermore, involvement supports multiple values, including *autonomy*, *dignity*, *togetherness*, *respect for tradition*, *social recognition*, and *a sense of belonging*. It also nurtures *inner harmony* and *calmness*, since “(...) *they believe what they see (...).*” Nonetheless, conflicts arose between *involvement* and *efficiency*, since broad consultations can slow down decision-making in some cases. To balance this, the DMS expects to reserve full participation for feature-level changes throughout its technical phase, which might result in a slower design phase but will yield a *transparent* and trustworthy system.

Efficiency (mostly interpreted as *productivity*) matters to management and workers alike. Earlier project work often treated *efficiency* as a straightforward outcome of technology integration. This thesis/ design initiative reframes efficiency as a cooperative value that should raise collective output and income without inviting rivalry. For example, “(...) *an intuitive didactive app (...)*” as a replacement for a notebook could empower the cooperative leader's work and upvote efficiency. For the financial administrator, a centralised platform for her daily tasks and reporting links empowerment and motivation (*influential* as a value), strengthening trust, transparency, and fairness, while also fostering *a sense of ownership* without reducing performance to individual competition. Similarly, informing waste pickers about sorting data can be *influential* for them, which may enhance the notion of *efficiency* in their work. I argue that *efficiency* as a collective value for the Recicla Mais could be achieved by designing a DMS that is easy for waste pickers to understand, functional for the cooperative management, and demonstrably usable through its features—a concern repeatedly raised during the meetings.

Control was one of the most discussed and conflicted values. From the design standpoint, control empowers stakeholders in their respective roles without undermining *cultural* or *spiritual values*, *privacy*, *self-respect*, *dignity*, or *integrity*, aligning with Alidoosti et al. (2022). Waste pickers wanted control over their own data and visibility of their results, while managers

needed secure oversight and clarity about permissions. The DMS expects to implement *control* through *informed consent*, role-based permissions, and explicit audit trails from the feature perspective (described in next section). The design calibrates *control* and *transparency* through a hybrid flow by embedding the existing work process of the Recicla Mais rather than altering it. From the Cooperative perspective, *control* is not about centralisation but about clarity—making sure every member knows who can act, when, and how. However, conflicts inevitably surfaced between *control*, *trust* and *efficiency*. If *control* became too strict, workers risked feeling disempowered (resulting in *trust* issues); if too loose, managers feared losing oversight. The waste pickers and the Cooperative management frequently voiced this tension. As the Cooperative manager stressed, there should be “(...) *a restricted area in the app where only the management can enter data. Only the management would be able to edit, while cooperative members could only view (...).*” The waste pickers, meanwhile, wanted an assurance that they could monitor their own contributions without interference, along with a demand for an intuitive app. To reconcile these expectations, the design proposes that permissions and responsibilities be made explicit and visible. Instead of hiding access rules in technical jargon, clear audit logs record who edited or updated which data and when, making every action transparent and accountable. *Control* is also connected to the value of *choosing one’s own goals*. When workers can review their work history, earnings, and progress, they gain practical *authority* over their own pace and planning, reinforcing *autonomy* and *dignity* while supporting broader values such as *fairness*, *social recognition*, and a *sense of ownership*. From a design standpoint, *control* thus becomes a keystone value linking technical security with ethical legitimacy. By ensuring that both workers and managers can see how responsibilities are allocated and exercised, the system aims to embody a negotiated balance between personal rights and organisational responsibilities, transforming potential conflicts between *control*, *trust*, and *privacy* into opportunities for shared *accountability*.

Several related values enrich the ethical foundation of the DMS. ***Support and protection*** were repeatedly emphasised to prevent technological change from exposing workers to further marginalisation, which requires continuous, respectful communication with the Egalitarian project, so that workers feel supported with ***dignity*** rather than surveilled. ***Knowledge*** was a frequent theme, since workers stressed the need for “*training, classes (...) for the workers (...),*” and valued “*training from someone at UnB,*” which ties learning to credibility and empowerment. Knowledge connects with ***ambition***, since understanding and controlling one’s own data encourages workers to imagine themselves as ambitious participants in the

cooperative's future. **Safety** was highlighted, especially in relation to data ethics, with a clear requirement for “*data protection and not letting the waste pickers' data [be] exposed (...)*.” Social recognition aligns with *fairness* and *ambition*. Making contributions visible strengthens *accountability* while affirming waste pickers as skilled contributors to the city's sustainability. Values such as *respect for tradition*, *togetherness*, *create a world at peace*, *sense of belonging*, *inner harmony*, and *ownership and property* can deepen the Cooperative fabric through the designed DMS. They are consistent with the Cooperative's own articulation that “*they [the cooperative/ Recicla Mais] try to work as a family*,” and they support the ongoing legitimacy of the DMS as a sociotechnical practice rather than a mere tool.

However, these values are translated into norms, which further guide specific design features, as described in the next section.

6.2 The Technical Phase for the Data Management System

The technical phase of the DMS, namely EcoSistema, explains how elicited values are transformed into norms and further translated into functional features and assesses whether these values are fully embedded into the actual design. To achieve this, empirical studies, direct observations, and ongoing participatory involvement informed and further evaluated every specification of the DMS.

The values elicited on the conceptual-empirical phase were ultimately operationalised as a coherent set of norms—among these, **transparency and traceability** emerged as foundational, requiring that every key operation, from data entry to salary calculation, remain visible and verifiable. This norm responds directly to the waste pickers' repeated concerns about data sabotage, complementing managers' wish to “*(...) improve transparency in information (...)*,” ensuring that trust and fairness are sustained. **Accurate and Reliable Data Handling** is a norm designed to represent the designer's commitment to guarantee an error-free recording and availability of information, echoing the Financial Administrator's warning that “*if the information is not carefully systemised ... [it] can generate questions for the cooperative*,” which complements another norm, **operational continuity and resilience**. **Inclusive and Accessible Design** gives concrete form to the value of *involvement* by requiring that every interface remain usable and straightforward for users with little prior digital experience, reflecting the focus-group call for a system that is “*(...) easy to understand (...)*” and adaptable to daily work. **Worker Rights and Well-being** addresses the demand that technology protect dignity, health, and equitable participation, ensuring that control mechanisms and productivity

metrics cannot be used to marginalise or stigmatise workers. Another key norm, **access control and governance**, integrates *fairness*, *freedom from bias*, and *social justice* by mandating auditable decision logs and balanced mechanisms for distributing tasks and income. Around these anchor points, other norms reinforce and extend the ethical framework, including the notions of **privacy protection and data security**, which prevent the exposure of sensitive information. In contrast, **support and protection** ensure that technological change does not generate new vulnerabilities. Additionally, **knowledge and training** mandate continuous learning opportunities. For the EcoSistema design, the norms that complement the designer's standpoint are **data protection and ethical compliance** (highly prioritised by the Egalitarian project), **user support and responsiveness** (informed by all stakeholders) to design a system which will assist managers with **decision support and strategic planning**, while ensuring **onboarding fairness** and **organisational effectiveness** of Recicla Mais as a cooperative.

Building on these norms, EcoSistema is organised into three tightly interconnected modules: *EcoClareza*, *EcoManageria*, and *EcoCatadores*, each addressing distinct yet interdependent needs. Figure 5, p.44, presents the key features of EcoSistema, organising them by module to show their main functions at a glance.

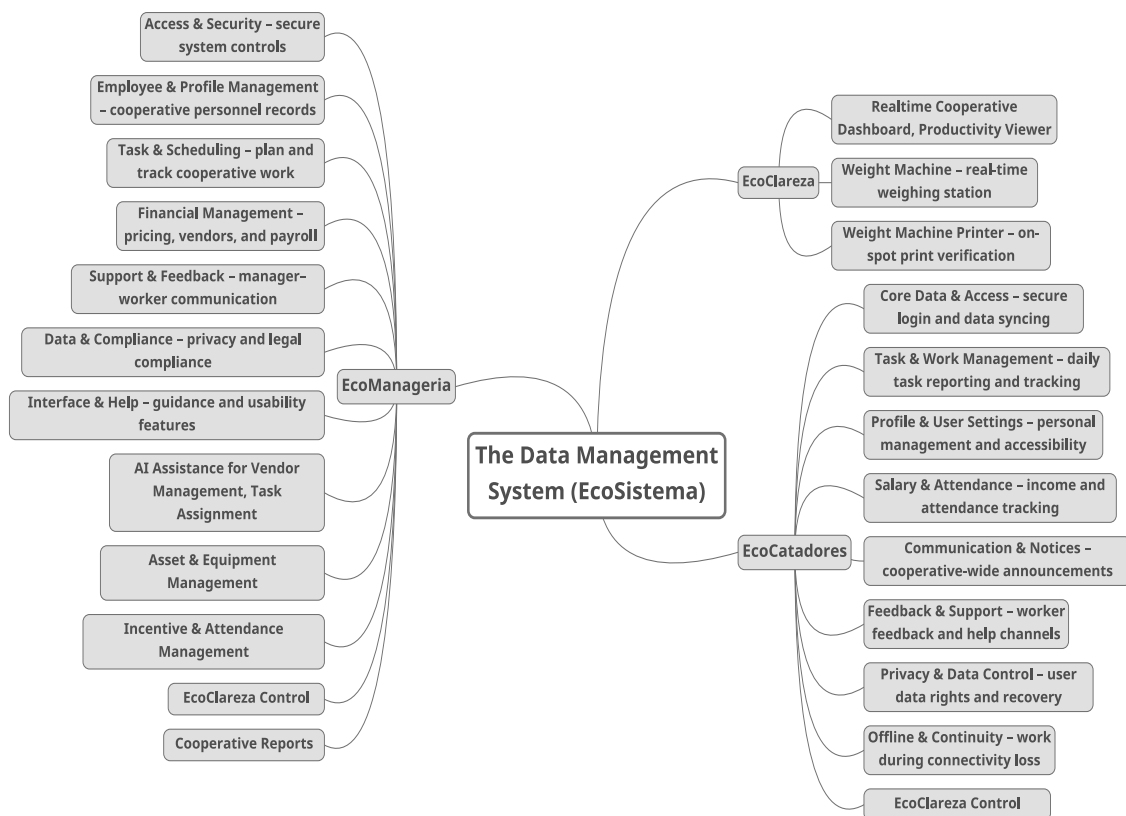


Figure 5: The module-wise features for EcoSistema

EcoClareza functions as the “*live operational window*,” where automated weight machines record sorted materials, weight machine displays and portable printers facilitate on-the-spot verification, and a central dashboard provides real-time productivity data. The EcoClareza dashboard is intended for installation on a large screen within the Recicla Mais cooperative, allowing waste pickers to monitor their productivity, read scrolling notices, check the current time, and view top performers. EcoManageria constitutes the *management framework*, consolidating secure access, role-based permissions, employee and profile management, task scheduling, pricing controls, and payroll processing. It incorporates predictive assistance to balance workloads and optimise vendor management, and offers tools for asset and equipment management, as well as comprehensive reporting and compliance. EcoManageria is proposed to be designed as both a mobile application and a web platform. Additionally, EcoManageria manages access to the EcoClareza dashboard and transmits pertinent data and notifications to EcoCatadores, the *worker-facing* module. EcoCatadores, proposed to be designed as a mobile application, is primarily targeted at waste pickers, enabling them to receive task notifications, confirm completed work, monitor daily and cumulative earnings, and manage their personal profiles. The module also allows workers to exercise control over the visibility of their productivity in shared EcoClareza spaces, with consent-based permissions. Collectively, these three modules establish a continuous cycle of data collection, managerial validation, and collective review, embedding stakeholder values throughout all phases of cooperative work.

[Appendix B](#) presents the full feature table, which serves as a detailed functional and ethical specification of the EcoSistema. The table is organised by all three modules and lists every feature together with a concise description, the intended user groups, and the norms that each feature supports. It further identifies the values relevant to each user type, clarifying which values are associated with whom, and describes how users may be involved in the conception, testing, or ongoing use of each feature. This format explicitly documents the translation from stakeholder values to norms and then to concrete design requirements, demonstrating how each module’s functional features are both normatively justified and participatorily grounded. The subsequent section provides an in-depth examination of EcoClareza, illustrating its features that embody the values finalised during the conceptual-empirical phase.

6.2.1 EcoClareza

EcoClareza embodies the design commitment to *transparency, accuracy, fairness, trust, and dignity* in its daily practice. The use of this mobile application starts each workday when the

manager assigns tasks and activates the dashboard via the management system (EcoManageria). The waste pickers receive notifications on their EcoCatadores mobile app; once they accept, their names and corresponding real-time productivity bars appear on a large screen inside the Recicla Mais facility (Cooperative Dashboard), unless they have kept visibility turned off. At each sorting station, automated weighing machines with digital displays show the live weight of each bag, allowing workers to check their progress instantly. As sorting proceeds, the productivity bars on the dashboard update at customisable intervals. When a bag is complete, a single tap prints a ticket with the date, worker's name, station number, waste type, and measured mass. The cooperative leader and the financial administrator review and approve each record, both manually and automatically, before the verified data and earnings are reflected in the worker's EcoCatadores profile. Through this cycle of task assignment → source measurement → immediate display → managerial confirmation → cooperative overview—this module incorporates stakeholder values into daily operations and balances efficiency with accuracy, openness with privacy, and managerial oversight with worker autonomy.

This continuous visibility of sorting data creates a shared sense of *fairness* and motivates performance. The act of tracking productivity and having self-access to what to reveal even fosters more involvement in work and a *sense of ownership* in one's performance, strengthening the cooperative ethos. At the same time, EcoClareza empowers management, allowing leaders to track productivity and coordinate operations more effectively while still respecting workers' rights to control how their contributions are displayed. EcoClareza is deliberately designed to prioritise *accuracy* and *fairness* over speed (equivalently *efficiency*). Earlier practices that use picture sending systems might favour quick throughput, especially during busy hours, but they compromise *accuracy*. By adding controlled validation, the new system slightly slows data entry but strengthens *trust*, *transparency*, and *social justice*. Multiple verification points and real-time synchronisation make errors visible, traceable, and rectifiable without suspicion, ensuring that numbers are not only correct and consistent but also believed. On the other hand, such verification processes may raise concerns about complexity. To address this, EcoClareza deliberately follows the cooperative's existing workflow, in which verification and communication of sorted amounts currently occur via WhatsApp. The system reproduces this familiar routine by using the weight-machine printer and, for *transparency*, also provides a paper ticket, which is regarded as trustworthy by waste pickers in the Cooperative setting. The dashboard uses normalisation to account for productivity measurement for differences in

material density (for example, 20 kg of glass versus 5 kg of plastic) and a daily bar-position shuffle to prevent hidden bias or rivalry, demonstrating that position does not equal rank, so that visual comparisons remain fair and free from hidden bias. These mechanisms counteract rivalry and maintain dignity, which were repeatedly endorsed in weekly Egalitarian meetings where engineering students and cooperative representatives argued for strengthening accuracy and fairness. *Transparency* can sometimes conflict with *privacy* and *dignity*; EcoClareza allows each worker to decide how much of their productivity is publicly visible. Waste pickers can operate anonymously, while bars might be visible on the dashboard, but without the worker's name or photo. There is also a fully anonymous mode where the productivity bar is hidden. Rolling notices and weekly cost overviews keep workers informed about the Cooperative expenses and top performers without revealing individual earnings. Equipment-status displays help them anticipate delays and gain insight into the Cooperative's broader economic situation.

A delicate balance of *control*, *fairness*, and *social justice*, exercised with respect, is embedded in EcoClareza. Waste pickers might be empowered since they receive transparent confirmation of their work. Managers, for their part, retain the ability to monitor collective productivity and validate data. This dual arrangement cultivates *trust* and supports worker *well-being*, yet it also carries potential risks. If productivity metrics are used as implicit measures of individual performance, they can unintentionally marginalise a specific worker or generate personal tension, an observed unintended negative consequence of such a system (Bro et al., 2024). When EcoClareza therefore treats *control* not as unilateral oversight but as a negotiated space, designed to protect *dignity* while still ensuring *accurate* and accountable cooperative records.

6.2.2 EcoManageria

EcoManageria functions as the back-office brain of the DMS, where daily operations, financial management, and long-term planning converge.

The typical workflow for a financial administrator begins with assigning sorting tasks to waste pickers, supported by predictive assistance that manages workloads and income distribution. This built-in predictive system ensures *fairness* and *efficiency*, allocating tasks based on capacity without bias. Once the schedule⁵ is saved, automatic notifications are sent to the

⁵ Notably, publishing a weekly work schedule (sorting material type) is intentionally avoided at this stage due to the inconsistency of the unsorted amount. The cooperative, even on maximum days, cannot predict how much unsorted waste will arrive and how much will be sorted. Once this version of EcoSistema is released and operational, this feature might be added in a future update.

EcoCatadores mobile app, further activating the cooperative dashboard. These notifications facilitate *continuity* and *transparency* in communication, keeping schedules visible to all and allowing collective review if disputes arise. As sorting continues, tickets printed at the weighing station transmit verified data back to the system. After approval, these records are instantly uploaded to each worker's EcoCatadores profile, updating daily earnings in real time. The seamless flow of validated data guarantees *accuracy* and *transparency*, while the need for managerial approval emphasises cooperative *control* and *responsibility*. During the focus group, the financial administrator highlighted difficulties with managing vendors efficiently — a task crucial to sustaining cooperative income. In response, this module also incorporates an AI-assisted predictive analysis tool that compares prices from different buyers to support informed strategic sales decisions. Currently in beta, this feature allows users to upload, copy, paste, or input prices for predictive suggestions. This cautious rollout reflects the organisation's values of *responsibility* and ensures that predictive functions remain transparent and adaptable, preventing them from becoming an opaque algorithmic authority. The financial administrator also noted challenges in tracking vehicle status, conveyor belt speed, maintenance records, and other assets, which are still managed manually. The EcoManageria module addresses this by enabling digital tracking of equipment and automatic streaming of operational status, allowing workers to anticipate downtime and plan accordingly. Currently, the cooperative management uses a physical board for its general assembly discussions, where waste pickers can write comments or concerns, sometimes without signing their names. Although intended as an anonymous process, this method can still compromise privacy because handwriting might be recognisable, or someone could observe the act of writing. To enhance both *dignity* and *social justice*, this module introduces a digital feedback management system that allows waste pickers to send text messages, pictures, or voice notes (via EcoCatadores) either anonymously or with their names attached. For voice submissions, a proposed voice-masking technology ensures that the sender's identity cannot be inferred from their speech. This design directly responds to concerns raised during the Egalitarian event, where a Brazilian professor with two decades of experience in the sector emphasised that power asymmetries and the fear of job loss can often prevent waste pickers from expressing their problems openly. A secure and straightforward anonymous reporting lowers these barriers for communication, while embedding values of *fairness*, *self-respect*, and collective *dignity* into everyday practices. It also integrates feedback management and support channels by enabling cooperative management to request technical assistance or escalate urgent issues to the Egalitarian project team as required. In practice, the Cooperative need to prepare reports regularly, e.g., monthly earnings and expenditure

summaries, cost analyses, and other records, that are currently compiled manually, as the financial administrator explained in her interview. EcoManageria streamlines this process by introducing automated reporting through cross-module data synchronisation, thereby reducing the risk of human error and improving the reliability and *accuracy* of financial information. The design also accounts for the cooperative leader, herself a waste picker with limited but gradually expanding digital experience. To support her role, the system employs a role-based login that restricts access to her task-relevant functions, while a dynamic homepage adapts to her usage patterns. In addition, simple and advanced view modes are proposed, allowing her to choose an interface suited to her level of digital familiarity. This approach encourages gradual learning and builds confidence, enabling her to adopt digital tools at her own pace while sustaining respectful and professional relations with colleagues. Drawing on fieldwork observations, the module further promotes inclusive and timely communication by allowing the cooperative leader to send notices and updates directly to waste pickers via the mobile app, reducing misunderstandings and ensuring that essential information reaches all members. EcoManageria is further proposed to have a direct link to the *EduCado*⁶ learning platform for ongoing training, while documenting permissions and their rationale ensures management decisions remain transparent and understandable. Collectively, these features pivot a culture of trust, competence, and shared responsibility, making daily management more coherent and equitable.

Furthermore, this module includes additional safeguards, e.g., automatic alerts for the financial administrator and the Egalitarian project whenever a data breach or cyberattack occurs. Super-administrator access is limited to the Egalitarian project at initial design (also proposed to be the same at least until the beta features are developed on their final version), specifically the PMO from UnB, who is responsible for the project track and DMS integration. Granting full administrative rights to the Cooperative at an early stage might risk data loss, accidental disruptions, or other unintended consequences. The financial administrator, however, retains the highest level of operational access, ensuring that daily management remains under cooperative control. From a design perspective, this setup is intended as a transitional phase. As the Cooperative becomes more familiar with the system's purpose and governance, the distribution of authority is expected to shift gradually towards full cooperative ownership and control. This strategy safeguards system stability while supporting the long-term goal of self-

⁶ *EduCado* is an initiative from the Egalitarian project, which was initiated to work as a learning platform for the waste pickers

managed data stewardship. The following section introduces the third module, EcoCatadores, and the primary user of this module is the waste pickers.

6.2.3 EcoCatadores

EcoCatadores constitutes the assembly- and worker-facing module, designed to strengthen collective *accountability*, promote *transparency* within cooperative assemblies, and *empower* waste pickers through instant access to their verified records, which is currently not available in Recicla Mais settings.

A typical working day with this module begins when a waste picker accepts the assigned sorting task, which automatically activates the cooperative dashboard. If a worker prefers *privacy* and *anonymity*, the visibility of this performance indicator can be turned off. This careful integration of accessible information with personal *autonomy* reflects *respect*, *dignity*, and *fairness*, ensuring that *transparency* does not turn into surveillance, while keeping waste pickers actively engaged in the system. Such unintended negative scenarios were anticipated in my earlier report on the Egalitarian project, where we cautioned that visual bars for measuring personal productivity might create unforeseen pressures and other unintended consequences (Bro et al., 2024). After ticket printing and approval, EcoCatadores displays the worker's verified contribution, including the quantities sorted and the earnings calculated from the unit price set in EcoManageria. This step deliberately omits the price on the printed ticket; instead, the amount appears solely within EcoCatadores, as a visible figure on paper might be discussed among colleagues and inadvertently incite competition. Additionally, since the price of sorted waste fluctuates regularly, showing immediate earnings might induce unnecessary stress and anxiety among workers. This module enables each picker to review their verified historical records, including attendance, earnings, and bonuses, without relying on managerial disclosure through a customisable earnings report view and download feature, helping workers to track their performance and payments over time. These mechanisms build *trust* and *accountability*, since the Cooperative stated that the system should “*show them [waste pickers] how the money is being distributed and the general balance of the cooperative.*”

The user can view their own productivity bar over the course of the week within the application, which empowers them and provides *control* over their work while reinforcing their *sense of belonging* within the Cooperative. EcoCatadores captures the Cooperative's statement that waste pickers believe what they can see into tangible features that promote productive habits and show that working efficiently can eventually boost earnings. To address the mentioned

communication challenges, notices and notifications dispatched by the Cooperative remain permanently accessible within the application, thereby supporting *dignity* and ensuring that the vital information reaches all stakeholders. Workers can raise issues or share suggestions either anonymously or non-anonymously (as detailed in the EcoManageria section). Feedback that users choose to make public appears in a format reminiscent of a manual writing board, maintaining a familiar practice while transforming it into a secure digital medium. This module features voice assistance, an intuitive interactive interface, and an optional easy/pro mode (similar to EcoManageria) to enhance navigational adaptability, reflecting the workers' own request for a user-friendly application to manage their work. An important feature also permits waste pickers to contact (either anonymously or non-anonymously) the Egalitarian project directly, broadening the scope of support and protection. During workshops and focus groups, it was evident that members exhibited significant enthusiasm about cooperation, and the design aims to sustain that momentum.

From the design perspective, the EcoSistema features for all modules are designed in such a way that do not alter (in most cases) their current working procedure, while adding daily productivity visualisations to empower them in the broader picture. In 2024, waste pickers relied exclusively on manual methods to track their earnings, and by 2025, they transitioned to sending photographs. The DMS/EcoSistema is therefore deliberately structured to anticipate technological advancements without becoming an encumbrance, accommodating familiar habits while guiding users towards a more sustainable and dependable digital process. Several security and accessibility safeguards are incorporated into the proposed design of all three modules. The modules are capable of synchronising over the local network (the same Wi-Fi) without requiring external internet access, as empirical findings have indicated that the cooperative's internet connection is often unstable. Every change is automatically logged to ensure traceability and *transparency*. However, access to these logs is restricted to the super-administrator to prevent the emergence of everyday power practices that could compromise *fairness* and *trust*. For continuous learning and clarity of purpose, EcoManageria and EcoCatadores are directly linked to the *EduCado* platform, allowing both managers and workers to access guidance whenever needed. Collectively, these interconnected features establish an accurate and resilient flow of data, where *operational transparency* is prioritised without disrupting the cooperative's established daily routines. The following section evaluates the EcoSistema as a whole to assess how effectively values are incorporated into its features and to analyse their relative frequencies.

6.3 Evaluation of the design of the Data Management System

The evaluation of the EcoSistema as an ethical design relied not only on narrative justification but also on a systematic mapping of the associated values and norms to diagnose whether the empirical findings align with the design, using the complete functional-feature table (Appendix B) as the dataset. Three diagrams visualise these relationships at the module level—Module → Value (Figure 6), Module → Norm (Figure 7), and Module → Value → Norm (Figure 8)—with flow thickness indicating the value power, i.e., how strongly a given value or norm is embodied in the system. This quantitative mapping complements the qualitative analysis by showing the relative weight of values and norms across modules.

The value and norm mappings provide an evaluative and diagnostic account of how much each EcoSistema module reflects stakeholder values and norms in translating them into functional features. EcoClareza incorporates the empirical findings that identify *transparency*, *accuracy*, *involvement*, and *trust* as central values, while the value mapping in Figure 6, p.53, confirms that these values have the greatest value-power in the design. Consequently, the norm analysis in Figure 7, p. 53, shows a higher weight in norms such as *transparency & traceability*, *accurate & reliable data handling*, and *workers' rights & well-being*, demonstrating that the features meet both the empirical and technical expectations. The functional features of EcoManageria address managerial needs for *accuracy*, *efficiency*, *control*, and *transparency*, and the value mapping similarly highlights these as most prominent. The norm evaluation underlines strong commitments to *data protection and ethical compliance*, *transparency & traceability*, *accurate & reliable data handling*, and *decision support & strategic planning*, which were central to the values expressed by EcoManageria users. Likewise, EcoCatadores supports cooperative assemblies by promoting *control*, *autonomy*, *involvement*, *dignity*, and *transparency*. Here, the value mapping assigns significant importance to these concerns, and the norm analysis confirms their embodiment in *inclusive & accessible design*, *transparency & traceability*, and *worker rights & well-being*, aligning with empirical findings and technical expectations. Zooming out from the module level, the combined evaluation indicates that EcoSistema as a whole embodies the stakeholder values and norms most frequently voiced and weighted during the empirical phase, demonstrating that the overall design phases faithfully operationalise the users' priorities and complement the designers' commitment in its final design.

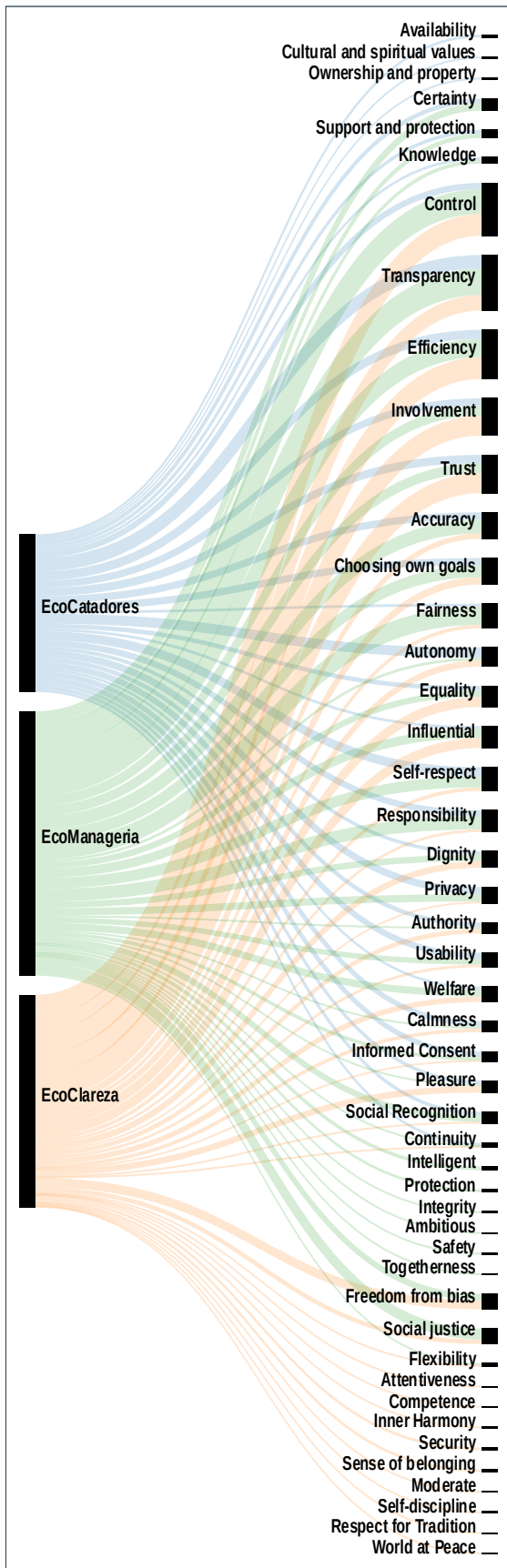


Figure 6: Values across the EcoSistema Modules

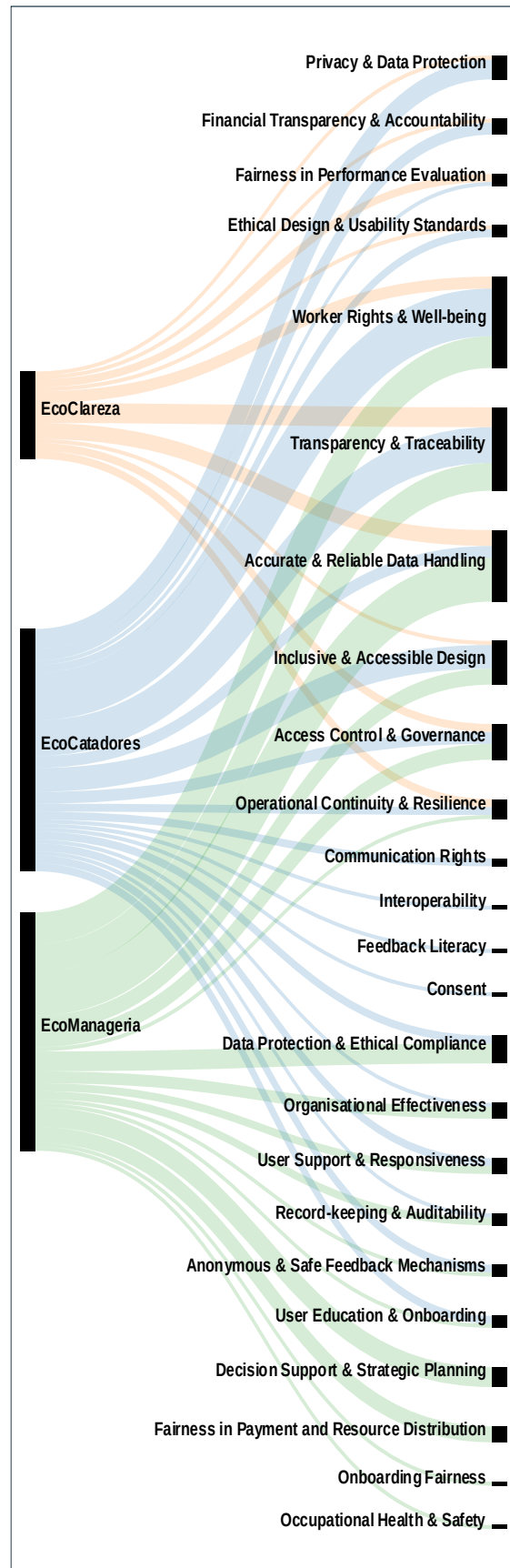


Figure 7: Norms across the EcoSistema Modules.

Furthermore, [Figure 8, p.54](#), links modules, values, and norms in a single view, clarifying how specific values are associated with corresponding norms. For example, *transparency*, *accuracy*, and *trust* cluster around the norm of *transparency & traceability*, while *accuracy*, *productivity*, and *efficiency* align with *accurate & reliable data handling*.

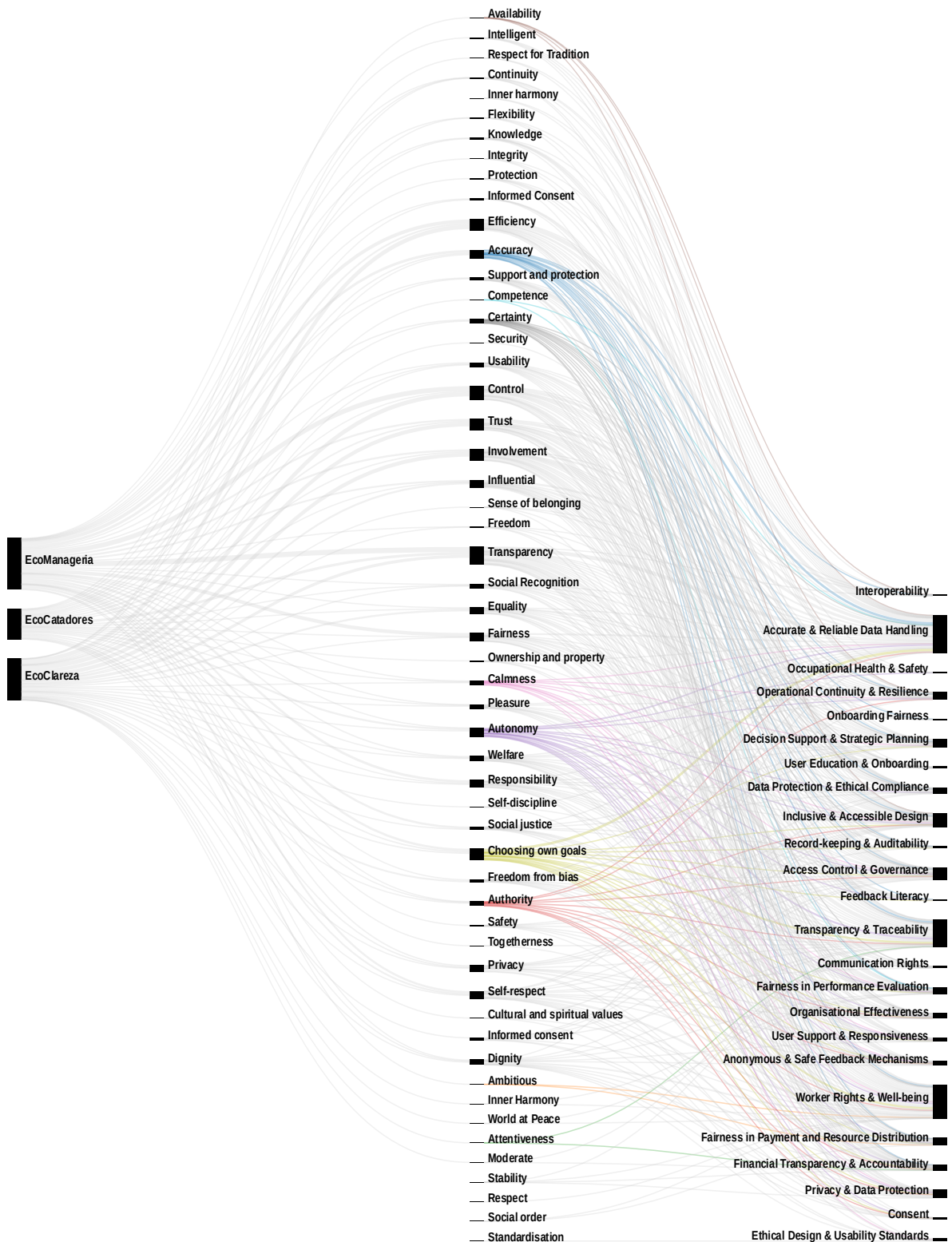


Figure 8: Relations among EcoSistema modules, values, and norms.

The evaluation, however, offers both quantitative and qualitative insights, diagnosing the relative weight of values and norms across modules and tracing their origins and trajectories within the design. However, in terms of functional features (see Appendix B), it reveals that values, such as *transparency*, *involvement*, and *productivity*, are systematically embedded into the technical features, while others, including *cultural and spiritual values*, *inner harmony*, and *a world at peace*, serve as supporting values. This is not because they are less important to stakeholders, but because they are embedded throughout the process and overall system.

The following chapter (Discussion) expands on these findings to examine how the designed DMS demonstrates its ethical character through its theoretical and methodological choices, while also addressing the limitations and challenges encountered during the research.

7. Discussion

This chapter weaves together the conceptual, empirical, and technical strands to answer how a participatory VSD can facilitate the ethical design of a DMS for the Cooperative. It begins by discussing that EcoSistema is ethical in both necessity and realisation, reflecting on how a participatory VSD ensured ethics were built directly into the design process itself, rather than serving merely as an evaluation metric at the end.

7.1 EcoSistema as an Ethical Design through a Participatory Value Sensitive Design

EcoSistema can be understood as an ethical design, both in terms of why it was necessary and how it was realised. From a European perspective, the situation of Brazilian waste pickers differs markedly from that of traditional wage earners working in Europe, specifically in Denmark. Their labour involves intense physical effort, low wages, and minimal societal recognition, positioning them far outside the regulated labour markets more common in Europe. From that perspective, the designed DMS for Recicla Mais is therefore ethical because it tackles institutionalised exclusions of a specific citizen group (the waste pickers) in a society and builds digital infrastructures that recognise them as co-decision-makers in overseeing their work. Additionally, EcoSistema's ethicality lies in its process, outcomes, and orientation. In this initiative, ethics was not treated as an external factor to be evaluated after the DMS design, but as part of the design process itself, following the approach of *embedded ethics*, which refers to the methods that integrate ethical reflection directly into the stages of system development, ensuring that normative concerns are not an add-on but co-evolve with technical work (Floridi

[& Strait, 2020; Umbrello & van de Poel, 2021](#)). The outcomes of EcoSistema demonstrate how ethics have been put into action by operationalising justice through concrete socio-technical outcomes.

An ethically designed DMS has the natural potential to reshape relationships between workers and management within the cooperative, since its features are deliberately user-sensitive and oriented toward inclusivity. With proper adaptation, EcoSistema may empower waste pickers by fostering a stronger sense of belonging and recognition as respected members of the community. Such socio-cultural change, however, is unlikely to occur swiftly; rather, EcoSistema can serve as a starting point, a first stitch in a longer process of transformation. From an organisational perspective, the system can also strengthen transparency and accountability, offering waste pickers greater visibility, respect, and attention in decision-making. Yet it is important to recognise the limits of design: entrenched power asymmetries within cooperative life cannot be eliminated by a DMS alone. Potential factors, such as infrastructural fragility or the politics of collaboration — whether or not they are present in this particular cooperative — may undermine the enactment of values in practice, reminding us that even well-designed ethical artefacts might not guarantee ethical outcomes by themselves. In this note, EcoSistema should be viewed as an ethical design, both in its aims and its practice, yet also as provisional. EcoSistema further serves as a reminder that an ethical design is not about producing harmony, but about developing systems where conflicts are visible, negotiable, and accountable.

However, EcoSistema's ethicality is evident not only in its features and focus but also in the methodological choices that underpin its design, described in the following section.

7.2 Methodological Reflections

This section reflects on the methodological choice of the Participatory VSD for the DMS design, rather than relying on alternative methods to finalise its functional features. The aim for using a Participatory VSD in the DMS/EcoSistema design, is not only to determine which values should guide the design, but also to ensure that the design process itself remains ethical, that proves to be the most appropriate option in a context where the stakeholder concerns act as the central commands, where value tensions require careful negotiation, and where design needs to remain responsive to the lived realities of marginalised groups such as waste pickers.

The core feature of a participatory VSD, i.e., parallel conceptual and empirical investigations, is the most well-suited approach in the Recicla Mais setting, since the conceptualisation of the

problem shifted over the years, my socio-cultural perspective on the Brazilian waste pickers evolved, and even the aims and motives of the Egalitarian project changed. The structure of the Egalitarian project also reinforced the suitability of a participatory VSD in my situation, since I had the opportunity to work through all three phases and directly observe how the design perspective evolved within the *DMS* track. If the conceptual and empirical phases in the EcoSistema context proceed sequentially—that is, without running in parallel—they might risk merely feeding into a separate empirical phase for value finalisation. Such a one-way progression could lead to severe value misalignment because socio-cultural learning was continuous, grounded in cycle-wise participatory involvement that continually feeds back and calls for ongoing refinement of the parallel conceptual and empirical phases.

In contrast, conventional methods, such as requirements engineering for finalising functional features, focus primarily on technical functions and user needs, offering no systematic way to integrate ethical reflection or address value conflicts. By comparison, the Participatory VSD integrated ethical reflection into the *DMS* design process rather than treating it as an afterthought, which was crucial in the *Recicla Mais* context. At the same time, carrying out a participatory VSD in this setting faced several material constraints. Methodologically, operationalising certain values revealed a known limitation of VSD: not all ethically significant commitments can translate smoothly into functions or user interfaces. Additionally, the adoption of a relational egalitarianism standpoint and design choices sometimes privileged fairness, transparency, participation, and recognition over narrow throughput gains. While these strategies do not eliminate bias, they are context-dependent, which enhances transparency about how claims were made and how ethical intentions were translated into practice. Contextually, this is not a neutrality failure, but a normative commitment made explicit. At the same time, this positionality necessitates transparency regarding where the designer's judgment intervened. The following section discusses the limitations and challenges encountered in the design of EcoSistema.

7.3 Limitations and Challenges in Designing the Data Management System

Several limitations and challenges accompanied both the Egalitarian project and my own research process for the *DMS* design. This thesis elicited stakeholder values through direct involvement, providing a conceptual groundwork for future *DMS* iterations in any other cooperatives. Some *DMS* features remain in beta because of limited interaction and/or

empirical data and are proposed for further development through continued stakeholder engagement. Rather than explicitly closing the loop of design, this open-endedness offers a scope for the iterative refinement and should be viewed as an invitation for further work rather than as a flaw. The implementation of the DMS and its long-term user-journey evaluation ideally belong to VSD's technical phase; however, this study necessarily stops at the design phase to fit the project timeline and to hand over the design for potential implementation within the Egalitarian framework. Stakeholder participation was central, yet field conditions limited the use of additional participatory design methods, which may have left certain socio-cultural nuances underexplored. For example, it was initially reported that the maximum waste pickers lacked the digital skills to use digital applications, whereas by 2025, focus groups documented routine photo capture and sharing via WhatsApp that challenged earlier interpretations. This emerging shift in practice cannot naturally be attributed to a sudden technological leap in a single year and instead suggests capacities that went unnoticed within the Project. Similar, hidden, and/or under-recognised capabilities may still exist. Nevertheless, these constraints do not render the DMS unusable or irrelevant, since the feature-level data were gathered and validated through ongoing engagement, and the few features left in beta are ready for further refinement, ensuring that the design remains grounded in stakeholder needs while allowing for future iterative improvements.

Furthermore, the international collaboration to design an ethical DMS was challenged by an engineering-led mindset. Except myself, all participants finalising the DMS came from engineering departments (mostly Computer Science) and naturally focused on the technical functionalities, whereas my concern lay in ensuring ethicality in design principles. For many team members, concrete values or norms carried little immediate meaning. My technical background and prior software-design experience were crucial for bridging this gap, enabling me to translate ethical considerations into technical terms that the DMS team could readily understand. Additional challenges arose from the practical conditions of international collaboration, such as differing academic calendars, geographic distance, cultural differences, and participants enrolled in specific academic courses with defined intended learning outcomes (ILOs) for that cycle. My back-to-back participation in three project cycles, however, provided continuity and allowed me to navigate these constraints effectively. Language barriers during fieldwork also posed difficulties, as my exchanges with waste pickers were mediated through translated summaries that occasionally obscured emotional nuances.

However, these limitations and challenges do not diminish the value of the work, but they highlight the conditions under which EcoSistema is designed and evaluated. These challenges not only defined what could be achieved within this project, but they also directly indicate areas where future efforts should focus. The following chapter concludes the thesis by synthesising the main findings, directing future research, clarifying contributions to theory and practice, and outlining the broader significance of designing ethical digital infrastructures for marginalised communities.

8. Conclusions and Future Research

The aimed design of the Data Management System (DMS)/EcoSistema for the *Cooperativa de Catadores Recicla Mais Brasil*, however, demonstrated how the values of marginalised stakeholders can be elicited, negotiated, and prioritised in design, whether the concrete functional features are explicitly guided by the elicited values and norms.

Theoretically, this thesis extends Value Sensitive Design (VSD) by emphasising that values should not only be elicited from stakeholders but also articulated through the acknowledged standpoint of designers. By explicitly incorporating the designer's positionality at the pre-conceptual and/or conceptual–empirical phases, the work argues that design processes can achieve greater ethical reflexivity and transparency. The normative lens applied here is relational egalitarianism, which foregrounds fairness, recognition, and inclusion; however, the broader contribution lies in showing that any explicit ethical standpoint—when critically acknowledged—can inform how values are interpreted, prioritised, and negotiated in design. Furthermore, this thesis draws conceptual attention to *value power*, demonstrating how certain values become dominant or marginalised within Cooperative settings depending on institutional structures, (mostly) stakeholder engagement, and the ways in which designers and participants negotiate them. In this way, the thesis advances VSD as a framework for value negotiation that incorporates both stakeholder perspectives and designer commitments, while also making visible the dynamics of power through which values gain traction in practice.

Methodologically, this thesis advances existing VSD studies in two main ways. First, it demonstrates how participatory practices can be integrated throughout all three phases of VSD, particularly the technical phase, to enhance the empirical basis of value identification, negotiation, and prioritisation. This integration ensures that abstract values are systematically translated into concrete design requirements and technical solutions in a manner accessible to

technology implementers (e.g., software engineers), enabling them to effectively understand the functionality and design the intended system. Second, it presents a systematic method for evaluating the resulting features in relation to the values and norms from which they originate, making explicit how values are weighted and how their influence is traced through to specific system functions. This approach provides a more transparent way of assessing how well ethical and stakeholder concerns are incorporated into the final technical design. These methodological contributions advance VSD's application by documenting the pathway from conceptual–empirical insights to technical design, operationalised through *engineer-decodable* (ethical) functional features and their evaluation, thereby remedying the persistent absence of technical investigations in VSD studies (see Gerdes and Frandsen, 2023). In this note, I argue that an ethicist with technical or software-design knowledge can decode ethical concerns into technical language, translating values and norms into concrete system features that are understandable and actionable for developers and implementers—a role I was able to take in this project. Furthermore, it also established a *reproducible method* for value elicitation, prioritisation, and negotiation, accounting for the dynamics of value power and translation into functional features in relation to the designer's standpoint, together with a concrete evaluation process that can iteratively inform the technical phase and ensure its ethical alignment.

This study offers direct, practical implications for cooperatives and policymakers seeking to digitalise waste-management workflows ethically, providing a reusable, modular foundation for community-based recycling initiatives. Its participatory co-design process can also inform broader public-sector digital transformations. However, the findings remain limited by the focus on a single cooperative context (Recicla Mais) and a small number of participants, and the system has not yet been evaluated through long-term deployment. However, future research direction and recommendations are explained in the next section.

Recommendations and Avenues for Future Research

The immediate recommendation for future cycles in the Egalitarian project is twofold: (1) conduct persona- and scenario-based analyses, complemented by other ethical assessment frameworks such as Ethical Technology Assessment (eTA) (see Palm and Hansson, 2005)—which primarily evaluate existing technologies—to deepen the ethicality of the designed DMS (for techno-anthropologists); and (2) develop in-depth technical specifications for each module (for software developers) based on the functional features described in this thesis. Prototypes should be developed in alignment with these features, and each development stage should

include user testing followed by iterative modification based on feedback. In addition, user-journey testing should be undertaken after each module, or even after individual components, as this provides crucial insight into the perspectives of waste pickers on the evolving system. If operational changes occur at Recicla Mais during development, the specifications should be adapted accordingly—always in ways that empower the Cooperative rather than disrupt its core workflow.

Future research could also explore the creation of AI-generated responsive personas of waste pickers to evaluate the designed DMS, assessing whether its features genuinely reflect the values identified in the current evaluation, thereby complementing VSD when participatory engagement is not always feasible or unattainable to conduct (see Silva et al., 2025 for waste pickers' personas). Outside of the specific case of Recicla Mais and the Egalitarian project, this thesis also opens broader avenues for future VSD research. The proposed framework of translating values into norms and functional features could be applied in other domains of public-sector or community-based digitalisation, such as health technologies, educational platforms, or digital governance systems, to test its transferability and robustness across contexts. Further research could also develop the notion of value power as a conceptual lens for examining how institutional structures, socio-cultural dynamics, and designer standpoints influence which values are prioritised or marginalised and their relative weight in design. In addition, comparative studies could explore how the explicit articulation of the designer's standpoint within VSD differs from, and/or complements, other approaches to ethical technology design, such as agile (see [Khanam et al., 2023](#)) or DevOps (see [Umbrello & Gambelin, 2023](#)) practices.

Overall, this thesis demonstrates that ethical digitalisation is achievable when technological development is treated as a socio-technical practice rooted in a techno-anthropological mindset, where ethics are translated into engineering language in ways that are viable for developers. The work thus offers both a tangible technological artefact and a methodological framework for future research, embedding ethicalities in design to place sustainability, inclusivity, and fairness at the core of software development.

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