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Sustainability Transitions in the Municipal Solid Waste Management Systems of Bolivian Cities: Evidence from La Paz and Santa Cruz de la Sierra

Denise P. Lozano Lazo [1,*] and Alexandros Gasparatos [2]

[1] Graduate Program in Sustainability Science–Global Leadership Initiative (GPSS-GLI), University of Tokyo, Building of Environmental Studies, 5-1-5 Kashiwanoha, Kashiwa City 277-8563, Japan

[2] Institute for Future Initiatives (IFI), University of Tokyo, Administration Bureau Building 2 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8654, Japan

* Correspondence: denise.lozano@s.k.u-tokyo.ac.jp

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Abstract: Municipal solid waste management (MWSM) systems have been evolving across most of the developing world. However, despite decades of refinement, they are still underperforming in many cities, leading to negative sustainability impacts in rapidly urbanizing cities of the global South. Despite similarities in the observed transitions between developed and developing countries, there are important differences in their characteristics and underlying drivers. This study aims to unravel the sustainability transitions of the MSWM systems in the two major cities of Bolivia, La Paz and Santa Cruz de la Sierra, illustrating the role of various actors, and specifically local governments. This is achieved through the analysis of secondary data and expert interviews with stakeholders involved in different aspects of the MSWM system at the national and local level. We identify three partially overlapping sustainability transitions in the two cities, namely "Collection and centralized disposal", "Environmentally controlled disposal", and "Integrated solid waste management". However, timelines, speed and elements of these transitions are somewhat different between cities, largely due to their inherent characteristics, institutions and stakeholder dynamics. Many technological, socioeconomic, and institutional factors converge to facilitate and hinder these transitions, including interactions of government and private sector actors, and the country's broader political context.

Keywords: integrated solid waste management; recycling; sustainability impact; informal sector; Latin America

1. Introduction

Municipal solid waste management (MSWM) is a central function of municipalities around the world. In most developed countries the MSWM systems reached high levels of service delivery long before the end of the 20th century, following decades of refinement since the emergence of serious waste management problems in urban centers [1–4]. The evolution of MSWM systems has followed largely similar pathways across developed countries, being initially driven by public health concerns, followed by pollution control and currently focusing on circular economy approaches to enhance material resource efficiency and environmental protection [5–8].

Conversely, MSWM systems are underperforming in most cities in lower middle income countries, causing many negative sustainability impacts, especially in rapidly urbanizing cities [9–11]. In such contexts, changes in production and consumption patterns, driven by economic development, globalization and technology advancement, tend to combine with local problems (e.g., poverty, inequality, weak institutions) and prevent the improvement of MSWM systems [12–14]. Despite

similarities with the evolution of MSWM systems in developed countries, there is not always a clear sequence over time. Instead many factors operate at the same time driving changes in MSWM systems in developing contexts. This suggests a "double burden", in which cities in developing countries are still dealing with basic waste management issues (e.g., public health), while at the same time facing new challenges (e.g., e-waste) [5,15]. Another example of these major differences between developed and developing countries relates to the recycling sector, which in the latter case is strongly driven by the need for income generation for poor segments of society [5,16,17].

However, as waste management is increasingly being considered a "basic human right" [12], there is growing pressure to improve waste management in cities of the developing world. This is not the least to contribute to the Sustainable Development Goals (SDGs), as waste management is linked to at least 12 of the 17 SDGs [12,15]. Some of the most pertinent priorities for developing countries relate to SDG6: "Water and Sanitation", SDG8: "Decent Work and Economic Growth", SDG11: "Sustainable Cities and Communities" and SDGl2: "Sustainable Production and Consumption" [15,18,19]. For instance, for SDG6, the link is direct through Target 6.3 related to the elimination of solid waste dumping [20]. For SDG8, many studies have suggested that circular economy approaches to solid waste management can contribute to the growth of small businesses, the generation of green jobs, and the improvement of working conditions for informal waste pickers [18,21,22]. The link to SDG11 is through Indicator 11.6.1 regarding waste collection coverage to reduce environmental effects in cities [20]. Likewise, the link to SDG12 is through Targets 12.2–12.5 [20].

A dominant paradigm for sustainable MSWM is the Integrated and Sustainable Solid Waste Management (ISWM) Framework, which originated in the 1990s as a deviation from traditional approaches [9,23]. ISWM advocates the integration of the various dimensions (e.g., technical, cultural, social) needed to achieve environmentally sound, economically feasible and socially acceptable waste management [24]. The ISWM framework consists of six main components, divided in two dimensions [25] (Figure 1).

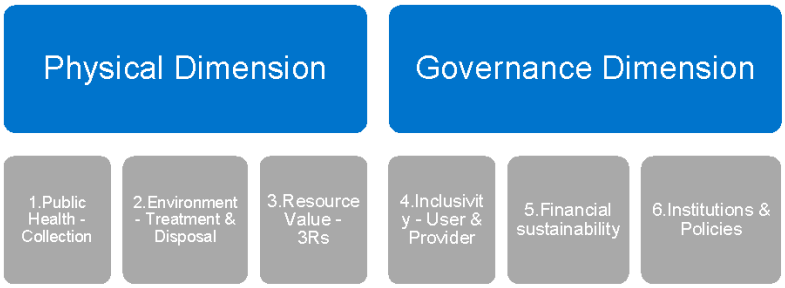

Figure 1. Components of the Integrated and Sustainable Waste Management (ISWM) framework. Adapted from [12].

There are many factors and circumstances that catalyze or hinder the development of basic MSWM systems, as well as their transition to more sustainable approaches (i.e., as envisaged by the ISWM framework). Apart from their purely technical and engineering components, MSWM systems are ingrained in social and economic systems shaped by market forces, actors, regulations, and culture [26]. Furthermore, the long life cycle of MSWM infrastructure, the technical complexities and the large required investment to catalyze change contribute to lock-ins that prevent transformation towards sustainability [27]. Lack of technical capacity at the municipal level coupled with the need to coordinate multiple stakeholders are also important hurdles in such processes [9,15].

Different approaches have been mobilized to explain the factors affecting the evolution of MSWM systems, using disciplines such as political economy [28], political ecology [29], structural modeling [30] and complex systems theory [31], to name but a few. Approaches drawing from sustainability transition theory (see Section 2.1) are gaining momentum, especially in developed countries with a long history of MSWM. For instance, scholars have highlighted solid waste management as a managed transition,

focusing on its history, phases, governance aspects, and factors affecting change [4,32,33]. Other studies in developed countries have focused on the transition from "waste" to "resource" management, following the emergence of the circular economy paradigm [1,34–36]. In developing countries the focus has been on the strategic management of emerging niches (e.g., plastics recycling) [37], or waste-to-energy projects [38,39]. Other studies have focused on the role of specific actors (e.g., religious communities, international donors) in fostering sustainability transitions in the sector [40,41], or how power and trust can permeate the dynamics and direction of sustainability transitions in different MSWM streams (e.g., e-waste) [42,43].

However, despite the relevance of municipal governments in fostering or obstructing MSWM sustainability transitions [44,45], most empirical studies have focused on the energy [46,47], sanitation [48,49] and mobility sectors [50,51]. Furthermore, there is a lack of research on solid waste management transitions in developing countries, particularly in Latin America [52]. At the same time, the study of transitions at the "city" or "urban" scale is still an emerging research area, given the still larger prevalence of studies at the national scale [53–55]. The above highlights the need for a better understanding of transitions unfolding in critical solid waste management systems at the city level, and especially how local governments fit in this process (e.g., by catalyzing or hindering the transitions in its various stages).

The aim of the present study is to unravel how sustainability transitions have unfolded in the MSWM system of cities in developing countries. In particular, the study focuses on the two major Bolivian cities (La Paz and Santa Cruz de la Sierra), and the role of the various actors (and particularly the local governments) across the different transition phases. When discussing the findings, we focus on the main challenges that should be overcome to enable sustainability transitions in the Bolivian MSWM system, and possibly other parts of the developing world.

2. Materials and Methods

2.1. Research Approach

2.1.1. Basic Concepts

We conceptualize sustainability in MSWM systems following the ISWM framework [25] (Figure 1). To explore transition dynamics, we adopt the Multi-Level Perspective (MLP) on sustainability transitions, which is one of the most utilized such frameworks [56]. MLP conceives transitions as the result of dynamics occurring at (and within) three different levels: (a) niche innovations, (b) socio-technical regimes, and (c) socio-technical landscapes.

Regimes represent the stablished sets of practices, rules, markets and public policies that dominate a societal context, and niche innovations constantly push for mainstreaming new practices/ideas/technologies that take place outside the regime [56]. The regimes and niche innovations are contained within the landscape, a broader environment characterized by aspects that are stable for longer periods such as "*material infrastructure, political culture and coalitions, social values, worldviews and paradigms, the macro economy, demography and the natural environment*" [57].

The interactions among these three levels, as well as their characteristics and timing, determine whether the pressures originating from different niches and the landscape itself get aligned, and allow a break into the regime. Through this alignment, innovations would reconfigure the regime, then become a part of it, and eventually start a new cycle [58]. In this sense, transitions are characterized by four phases, namely (a) pre-development, (b) take-off, (c) breakthrough, and (d) stabilization [59].

During the pre-development stage, small changes might occur that are not necessarily perceived yet in the regime. During take-off, niche innovations and pressures from the landscape can interplay in ways that induce change in the regime, with the transition gradually gaining momentum. Eventually a breakthrough occurs, when visible changes create reinforcing dynamics that continue to strengthen the innovations occurring within the regime. During stabilization, the speed of change decreases, and a new state of equilibrium is established [59,60].

When it comes to solid waste management systems, an institutional change analysis in the Dutch context identified three consecutive transitions during the 20th century [33]. While this study follows a somewhat different type of discussion, we adopt a similar lens in establishing a series of MSWM transitions in Bolivia, with a focus on the two cities.

2.1.2. Multilevel Perspective of Bolivian Municipal Solid Waste Management Systems

The socio-technical regime of Bolivian MSWM systems is characterized by a set of technologies, public policies, market practices and actor interactions. This regime is seeking to cope with municipal solid waste generation rates that are still relatively low for global standards (approximately 0.6 kg/capita/day) [61], but are rapidly increasing, especially in major cities (Section 2.2). In terms of composition, the generated waste consist mainly of organic material (>50% in terms of weight), with household waste being the main source (80% of total generation in terms of weight) [61].

In this study, we consider that the regime comprises of the interactions occurring both at the national and the local level. The current regime is characterized by recent policy shifts at the national level, with local governments seeking to ensure the safe disposal of municipal waste, even though many issues related to collection services remain unresolved (Section 3.1). Within this institutional framework, many different actors operate, holding radically different agendas (Section 3.2). In the major cities, the income generation (but also marginalization) of the informal recycling sector is a major aspect of the MSWM system.

The most important niches for MSWM in Bolivia in the present include: (a) informal recycling initiatives; (b) formal recycling initiatives; (c) incineration and other "high-technology" alternatives (Section 3.3.3). Although there is evidence of other niches (e.g., waste reduction and composting initiatives), they will not be discussed in this study, due to their current minimum role within the MSWM system. Niches from previous transitions are briefly discussed in Sections 3.3.1 and 3.3.2.

Key landscape factors expected to influence the MSWM transitions in Bolivia are: (a) demographic and urbanization processes; (b) geography, land use and urban planning; (c) socio-economic patterns and development paradigms; (d) political and regional tensions; (e) state-society relations; and (f) global and national narratives on environmental issues (Section 3.3).

When it comes to demographic factors, approximately 40% of the Bolivian population consists of indigenous people. Ethnic identities (and their interaction with class issues) have affected practically all domains of Bolivian society throughout its history [62,63]. At the same time the country has experienced rapid urbanization, with approximately 70% of the national population currently living in cities [64]. Bolivia consists of nine administrative divisions divided in 341 municipalities. Five municipalities are considered to be "cities" according to the UN-DESA classification (i.e., more than 300,000 inhabitants) [65], hosting around 40% of the population. The rest of the municipalities are "urban agglomerations" (i.e., more than 100,000 inhabitants) that contain around 20% of the population, and small municipalities and rural areas containing the rest of the population [61,66]. The massive migration from rural areas to urban centers peaked in the 1980s, and remains among the highest in Latin America (2% annual urban population growth) [67]. People with indigenous origins predominately settle in the periphery of urban centers, which has created an additional layer of urban conflicts [68–70], among which MSWM-related conflicts are not an exception [71–73].

Geography dictates to a large extent urban planning imperatives, which ultimately affects various aspects of MSWM systems such as waste collection, recycling facilities and, the location of landfills. Despite Bolivia's relatively large geographical extent and low population density, it is not easy to identify suitable areas for landfills, especially in large cities (Section 2.2).

Bolivia is also characterized by some of the lowest socio-economic development levels in Latin America [74,75]. Although recent economic growth has improved the quality of life in urban and rural areas, it also transformed consumption and production patterns [76]. This has led to increases in waste generation in urban areas throughout the country [61]. However, this economic growth is fragile as it still continues to be based on fossil fuel exploitation rather than the industrial or service

sectors [77]. The above can have a profound influence on MSWM systems, especially for the recycling industry and the inclusion of actors that are currently working in the informal sector, which according to the International Monetary Fund (IMF), constitutes the largest informal economy as a fraction of the national economy (over 60% of the GDP) in the world [78] (Section 3.2).

Political fragility has been a constant throughout Bolivian history, as the country has experienced the most military coups in Latin America. Following popular revolts in 2003 the then president resigned, and the country experienced a period of political stability [79]. However, this stability has been also characterized by the hegemony of the president's political party in the national government [80]. This has contributed to increasing regional clashes over autonomy, and tensions between the national and the subnational governments, especially in areas where local authorities are aligned to other political coalitions [81].

The lack of trust between the state and society also permeates the Bolivian context, as the rule of government is one of the weakest, most unstable and most corrupted in the region [62,82]. Large segments of the society demand solutions to everyday problems through social organizations and grassroots movements. When discontent escalates to conflict, skepticism and doubt are the common attitude towards governmental agencies and public authorities [83]. This is a crucial aspect in sectors such as the MSWM, where extensive collaboration is needed from the side of the community for any relevant intervention [84] (Section 3.3).

The increasing awareness over environmental issues has provided some short of traction for MSWM issues recently. The current national government has promoted an indigenous-environmentalist discourse that advocates values such as "Living Well" and respect for "Mother Earth", whose symbolism is publicly recognized [85]. At the same time global environmental issues such as climate change have been increasingly influencing public perceptions and environmental awareness, including those related to solid waste [86].

2.2. Study Sites

The two study cities are La Paz, the de-facto capital of Bolivia since the end of the 19th century, and Santa Cruz de la Sierra the largest city in Bolivia. The two cities have different characteristics and urbanization trajectories (Table 1). We discuss below some of the main characteristics, but further information is included in the Supplementary Material.

Table 1. General characteristics of La Paz and Santa Cruz de la Sierra [61,66,68,69,87–90].

CHARACTERISTIC	LA PAZ	SANTA CRUZ DE LA SIERRA
Lifetime as a "city"	- ~70 years - Characterized as an old city	- ~40 years - Characterized as a new city
Economic activities	- - Services, tourism.	- Agriculture, industry.
Geography and climate	- Steep valleys surrounded by hills. - Subtropical highland climate - Altitude: 3200–4000 m. above sea level	- Lowlands - Tropical savanna climate - Altitude: 400 m. above sea level
Size (municipality)	- ~800–900 thousand inhabitants - 149 km^2	- ~1.7 million inhabitants, - 385 km^2
Urbanization process	- Maximum population growth rate: ~4% (1970s) - Current population growth rate: ~1%	- Maximum population growth rate: ~7% (1980s) - Current population growth rate: ~2%
Municipal solid waste generation	- ~0.7 kg/capita-day - ~600 ton/day - ~35% increase from 2003 to 2013	- ~0.95 kg/capita-day - ~1600 ton/day - ~75% increase from 2003 to 2013

Table 1. *Cont.*

CHARACTERISTIC	LA PAZ	SANTA CRUZ DE LA SIERRA
MSWM organizational structure	- Municipal government division	- Municipal cleansing enterprise
MSWM operational setting	- One private company for collection - One private company for final disposal	- One private company for both collection and disposal
Informal recycling networks	- Nonexistent/Incipient	- Around 40 associations grouped in 3 local networks

Note: See footnote 2 for the definition of "city". There are conflicting estimates about La Paz' population between INE [66] and La Paz PTDI [88]. Solid waste generation estimates for Santa Cruz de la Sierra are rough and based on municipal solid waste collection official statistics from 2016 that report 1529 ton/day [72], and official population estimates of 1.6 million people living in the municipality for that year.

La Paz is the political center of Bolivia, and has an estimated population of around 800.000 inhabitants [66,88]. Its extreme geographical features (i.e., surrounded by hills) and colonial practices at the early stages of its development have influenced greatly the urban growth patterns [68,91]. In the 1980s a large part of the city, occupied mainly by migrants from rural areas, became a separate municipality (El Alto). This led to the relocation of most industries to this area, with La Paz becoming a purely service- and tourism-based economy [74] (personal comm: F2; K2).

Santa Cruz is the industrial and economic powerhouse of Bolivia contributing to 30% of the national GDP [92]. It is also the largest city in the country both in terms of population and geographical extent [66]. Unlike La Paz, it is located in a plain and had practically no geographical limitations for its expansion starting in the 1950s [69]. From that time, a large number of migrants (both domestic and international) was attracted by opportunities in the agricultural and fossil fuel sectors. This complicated any urban planning attempt, and in less than 60 years the population increased approximately 30-fold, reaching around 1.2 million people in the early 2000s [93]. The uncontrolled urban growth and migration have caused serious urban challenges related to informal settlements, informal commerce, unemployment, public safety and inadequate public services provision [72,94].

In both cities MSWM collection and disposal are public services for which local residents pay fees to the municipality through the electricity bill since the 90s, based on criteria such as location and electricity consumption [95]. Most of the municipal waste in the two cities is generated by households, institutions and commerce, representing more than 80% of the total municipal solid waste in both cases. The other 20% is composed by waste coming from hospitals, street markets and public spaces. While statistics about waste generation are inexistent, information from collection amounts is publicly available from 2003 until 2016 [90]. This data shows a current MSWM collection of approximately 213,000 ton in 2016 for La Paz and 558,000 ton in Santa Cruz for the same year. A comparison with data from 2003, shows an increase of 35% for La Paz and a 75% for Santa Cruz in thirteen years. Both cities have an environmentally controlled disposal, constituted by one sanitary landfill in each city, which have the minimum measures to avoid environmental pollution (e.g., geomembrane liner, methane flaring and leachate treatment processes) [61]. This comes at stark difference with the rest of the country, as according to the only national report of the current state of MSWM (released in 2011), in medium and small municipalities (with less than 100,000 inhabitants) the collection coverage serves only around 60% of the population [64]. Approximately 90% of the municipalities (representing 40% of the waste amount) in the country carry out their disposal in open dumps [61].

2.3. Data Collection and Analysis

To unravel the transitions of the MSWM systems in each city and understand the role of the local governments in this process, we collected and analyzed primary and secondary data. Secondary data consists of reports, statistics, and policy documents both at the national and local level. At the national level, besides the relevant laws (Section 3.1.1), some of the most important documents reviewed include

the National Report on Solid Waste Management [61], waste statistics from the National Statistics Institute [90], the National Sanitation Plan 2001–2010 [96], and the National Guidelines for Solid Waste Recycling [97]. Similarly, at the city level, apart from relevant municipal laws (Section 3.1.2), other secondary sources include urban planning documents such as La Paz Municipal Development Plan [87], La Paz Integrated Development's Land Plan [88] and Santa Cruz Integrated Development's Land Plan [89].

Primary data was collected through 40 expert interviews (Table 2), of which 39 were conducted between February 2017 and March 2018, and 1 in February 2019. These stakeholders were identified through an extensive institutional analysis (Section 3.1) to represent the organizations that are most involved in the MSWM system at both national and local levels, while also reflecting the ISWM framework (Figure 1) and the context of the country/cities (Sections 2.1 and 2.2).

Table 2. List of respondents and affiliations.

Stakeholder Group	Organization	Affiliation	Reference
National Government	Ministry of Environment and Water	Vice-minister	A1
	Ministry of Environment and Water	Project Officer	A2
Prefectural Government	Santa Cruz Prefectural Government	Environment Control Officer	B1
Municipal Government & Municipal Cleansing Enterprise	La Paz Municipality	Officer	C1
	La Guardia Municipality	Department Leader	C2
	Santa Cruz Municipal Cleansing Enterprise (EMACRUZ)	Projects Officer	C3
	Santa Cruz Municipal Cleansing Enterprise (EMACRUZ)	Director	C4
	Cochabamba Municipal Cleansing Enterprise	Coordinator	C5
	Sacaba Municipal Cleansing Enterprise	Director	C6
	Potosi Municipal Cleansing Enterprise	Communications Officer	C7
International Cooperation Agencies	Japan International Cooperation Agency (JICA)	Program Officer	D1
	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Technical Assistant	D2
Investors/Donors	CAF–Development Bank of Latin America	Environment and Social Risks Executive	E1
Non-governmental/ Non-profit Organizations	HELVETAS	Specialist	F1
	FUNDARE La Paz	Executive Director	F2
	FUNDARE Cochabamba	General Manager	F3
	FUNDARE Cochabamba	Technical Advisor	F4
	FUNDARE Santa Cruz	Executive Director	F5
	AVINA	Program Coordinator	F6
	AMIGARSE	Director	F7
	PAP Foundation	President	F8
	SWISSCONTACT Santa Cruz	Project Consultant	F9
	SWISSCONTACT La Paz	Project Consultant	F10
	SWISSCONTACT Cochabamba	Project Consultant	F11
	CIERVA	Coordinator	F12
Formal Recycling Sector	BOLREC	Operations Manager	G1
	CEDARE	Manager	G2
	EMPACAR	Manager	G3
	GRUPO DEL VIDRIO	Owner/Manager	G4
Informal Recycling Sector	RED DE RECOLECTORES	President	H1
	ARECICRUZ	President	H2
	RECICLA BOLIVIA	President	H3
	DEL NORTE	Representative	H4
Private Cleansing Companies	SABENPE	Legal Advisor	I1
	VEGA SOLVI	Head of Department	I2
	TERSA	General Manager	I3
Industry	EMBOL	Solid Waste Officer	J1
	Laboratorios ALFA	Regent	J2
Academia and Research	Environment Engineers Society	President	K1
	Integrated Solid Waste Consultant and Researcher	Consultant	K2

Each interview covered three main topics: (a) evolution of the MSWM system in Bolivia and specific municipalities in the last decades; (b) role of each stakeholder within the MSWM system and interactions with other stakeholders; (c) key factors (i.e., barriers, enablers) affecting the sustainability of the MSWM system. The survey was semi-structured and the questions open-ended, allowing respondents to elaborate their answers freely at first. The average interview length was approximately 45–60 min, and all participants (with the exception of 2 respondents) agreed to record the interview for further analysis.

The interviews were transcribed verbatim and analyzed using Atlas.ti software to identify emerging patterns through coding based on the conceptual framework outlined in Section 2.1. For the two interviews that audio recordings were not available, we created summaries based on the notes taken during the interviews.

3. Results

3.1. Municipal Solid Waste Management Regulations

3.1.1. National Regulations

The first attempt to establish policies related to the sustainability of MSWM systems can be traced to the early 1990s, with the ratification of the first comprehensive environmental law, the "Law of Environment". Despite its broad scope and lack of specificity for the solid waste sector (personal comm: C1; F3), it brought the topic to the public agenda and catalyzed the creation of a dedicated governmental office (i.e., DGIRS) [73] (personal comm: I3; C3; F1). The Law of Mother Earth, (which is part of the current government's discourse on indigenous environmental issues, Section 2.1.2), raised the importance of adopting sustainable production and consumption practices to protect "mother Earth" (personal comm: A1; D1).

A majority of interviewees indicate that one of the most important milestones in the transition to a more sustainable MSWM was Law 755 on Integrated Solid Waste Management (ISWM Law) in 2015. This was the first legal instrument specifically dedicated to establishing a solid waste management agenda in the country. It represents a paradigm shift from a focus on "cleaning" and disposing waste, to managing resources and include all relevant dimensions and actors [98] (personal comm: K1; F11; A1; A2; D1; K2; I1).

According to most respondents, the most pertinent aspects of the law on sustainability are: (i) the plan to cease operation of all open dumps in the country until 2020; (ii) the recognition of waste pickers activities; (iii) the introduction of Extended Producer Responsibility (EPR) obligations, an approach that extends a producer's operative or financial responsibility beyond the consumption stage [99]; and (iv) the introduction of "authorized operators" schemes.

However, despite the general recognition of the symbolic aspect of the law, there were rather conflicting perceptions among interviewees regarding its actual implementation outcomes. In particular, while most actors believe that the law will have tangible positive impacts (personal comm: C2; G3; C3; C4; F4; I2; B1;A1; I3; F5; D2; F10; C6; C1; D1; C7; A2; I1; F7; H3; H1; H2), others are more pessimistic and consider that the success will heavily depend on the actual implementation and monitoring aspects (personal comm: G2; G3; F6; K1; G1; F12; E1; J1; F8). Some actors even consider that there might be unwanted effects if implementation mechanisms are not adequately planned (e.g., closure of open dumps before new disposal sites are available; more dumping to avoid collection fees payment; decrease in business opportunities for SMEs and informal sector due to excessive requirements; unfair competition due to uneven law enforcement among various private actors) (personal comm: F12; G2; F3).

Many of the interviewees raised the need to create specific regulation for the main topics of the law: (e.g., EPR, waste pickers activities, authorized operators, collection fees) (personal comm: I1; F3; G1; A2; F6; F9). More importantly, many respondents pointed to the need to create mechanisms for the successful implementation at the municipal level (personal comm: C5; C1; F4; F12; I3; A1). It is

expected that under the mandate of the national law each prefecture and municipality should create and implement their specific regulations that reflect their local context and particular needs. However, even some years after the enactment of the ISWM law, there are still just a handful of municipalities that have developed new local regulations (personal comm: K2; C1; A1, A2; F12).

The lack of local regulations under the umbrella of the ISWM Law was seen as a major challenge that was repeatedly mentioned. Representatives of the national government recognize that the ISWM Law requires specific regulation, for the municipalities to have better means to draft their own statutes (personal comm: A2). This is a task that is still in progress due the limited resources of the DGIRS division (Section 3.2.1) and the need of inter-ministerial consultations (personal comm: A2, A1). On the other side, local representatives, while acknowledging that local regulation is a responsibility of each municipality, insist in the need to wait for clearer guidelines from the national level (personal comm: C3; C2; I1; F5). The main contributions of the national regulations are summarized in Table 3.

Table 3. Main national regulation related to Solid Waste Management [98,100,101].

Policy Document	Main Contribution	Government Division in Charge	Year
Law 1333—Law of the Environment	• Responsibility related to solid waste management for each government level (national, regional and local) • Creation of the department of Integrated Solid Waste Management [73]	Ministry of Sustainable Development and Environment	1992
Law 300—Law of the Mother Earth	• Obligation of the state to promote sustainable consumption habits and to develop mechanisms for an integrated solid waste management	Ministry of Environment and Water	2012
Law 755—Law of Integrated Solid Waste Management and its specific regulation	• First national law specifically dedicated to the regulation of Solid Waste Management. • Mandates the cease of operation of all open dumps in the country until 2020. • Establishes the Extended Producer Responsibility for producers and distributors for specific sectors (e.g., PET bottles, tires, batteries and pesticides, electric and electronic waste) • Recognizes waste pickers activities and mandates authorities to support and promote training and formalization programs. • Raises the need to evaluate and register private actors as "authorized operators" for solid waste management	Ministry of Environment and Water	2015/2016

3.1.2. Local Regulations in La Paz and Santa Cruz de la Sierra

Tracing the origins of solid waste management regulations in La Paz and Santa Cruz de la Sierra is difficult due to the lack of publicly available historical information. In both cities the first approaches towards solid waste management focused only on city cleansing and solid waste collection (personal comm: C3; I1; F1). It is thus possible to assume that the first relevant policies related to the establishment of the organizational aspects of the solid waste collection in each city.

In La Paz, while there are evidences of a centralized collection system in the 1940s [102], the first reference to "modern" cleansing services dates to 1989 when La Paz Municipal Cleansing Company (EMA) was established to operate the cleansing services in the city, either on its own or through subcontracting schemes [103]. The EMA operated until the early 2000s before it was dissolved and substituted by SIREMU, a department that directly depends on the municipality and is in charge of monitoring and regulating various public services in the city [96,104]. In Santa Cruz de la Sierra, the first autonomous municipal cleansing company, EMDELU, was created sometime in the 1980s,

with a mandate similar to EMA in La Paz. The time when company was created and the changes it underwent during its early years remain unclear. Different sources suggest that EMDELU was created in 1983 (and "re-created" in 1992) [78], or that it was created in 1987 [96]. EMDELU was terminated in 1999 and substituted by another cleansing company (EMACRUZ) [71], which remains up to now the organization in charge of the MSWM system in Santa Cruz.

Contrary to the relative lack of policies at the national level (Section 3.1.1), local governments in both cities have been quite involved in the development of legal instruments and policies related to MSWM systems, and their sustainability (Table 4).

For Santa Cruz de la Sierra, several respondents mentioned the 2006 Municipal Law 043/2006 "Basura Cero" (Zero Waste) as a landmark for the sustainability transition of MSWM system in the city (personal comm: C3; C4; F7; H1; K2). According to this law, by 2017 the city should reach a state where there will be no disposal of valuable materials that could be recycled or reused. This is the first municipal law in Bolivia to envision a future where all the recoverable waste would be adequately treated and re-incorporated in productive value chains (personal comm: F7; H1; H3). The law is also visionary in the sense that it recognizes waste pickers labor and mandates the municipality's financial and technical assistance for waste picker-related projects [73] (personal comm: F7). However, despite its positive aspects, the law was repealed a few years ago, and has been considered a failure by some interviewees (personal comm: C3; C4). Different respondents attributed this to diverse factors: (a) the law was a copy of a foreign law not well-adapted to the local context (personal comm: C3), (b) not receiving the necessary financial resources for implementation (personal comm: C4) or (c) political rivalries within the local government that led to the blocking of funding for the related projects (personal com: F8).

Currently, Municipal Law 295/16—"Urban Cleansing" is the main legal instrument for MSWM systems, which, at the time of the interviews, is the only municipal law in Bolivia under ISWM Law umbrella (personal comm: A1). While this could be considered as a sign of a strength in terms of regulation, the opinions of some of the interviewees regarding the content of the law (personal comm: A1; F2), and a comparison between the regulation found for each city, point at the idea that this aspect may actually be a weakness in Santa Cruz de la Sierra (personal comm: F2; C3; K1). For instance, the "Urban Cleansing" law mostly focuses on "rights and obligations" of the community and the correspondent sanctions (personal comm: A1) and returns to a "public cleansing" approach, which had already evolved to an integrated and sustainable approach in previous decades, with the "Zero Waste" law.

La Paz has followed a somewhat different regulatory approach towards solid waste management (Table 4). Although innovative policies similar to the Zero Waste law have not been enacted in the city, there is relatively large number of local regulation [105], which suggests a more robust regulatory framework (personal comm: K2; I3; F2; C1). The respondents attribute this to various factors such as the longer experience of the city in dealing with MSWM challenges (personal comm: F2; I3), the role of SIREMU in designing norms and regulations for various types of public services for many years, while EMACRUZ's role has been traditionally operational (personal comm: F2), and the higher capacity of local authorities due to their proximity to international organizations and the national government (personal comm: K2).

3.2. Main Stakeholders and Responsibilities in Municipal Waste Management Systems

One of the reasons behind the complexity of MSWM systems and the difficulty of devising and implementing appropriate policies is the wealth of relevant stakeholders. Table 5 outlines the stakeholders in the MSWM systems in Bolivia, the main institutions involved and major roles. These stakeholders operate either directly within the MSWM system or at the intersection with other sectors. The radically different roles and agendas of these actors within the MSWM system can facilitate or hinder sustainability transitions as discussed below.

Table 4. Local Solid Waste Management regulation in Santa Cruz de la Sierra and La Paz [105,106].

Year	City	Policy Document	Relevance to MSWM system	Comment
1989	La Paz	OM 065/89	Creates the Empresa Municipal de Aseo (EMA) La Paz	
2000	Santa Cruz de la Sierra	Law 160-A/2000	Creates the Municipal Cleansing Company "EMACRUZ", to which the Municipal Government delegates the responsibilities for regulating, planning and supervising solid waste management in the city	Solid waste management is carried out by an autonomous and decentralized entity
2001	Santa Cruz de la Sierra	Law 030/01—Solid Waste Management	Focuses mainly on cleansing aspects and hazardous waste.	First municipal law to regulate solid waste management
2003	La Paz	Law 260/03—Creates the department to regulate public services provision "SIREMU"	Creates SIREMU that regulates and monitors municipal public services provision, such as solid waste management	
2006	Santa Cruz de la Sierra	Law 043/06—"Zero Waste"	Aims to reach "zero waste" from recyclable or compostable waste by 2017	First municipal law adopting an integrated and sustainable approach for solid waste management
2006	La Paz	Law 372/06—Regulation of Urban Cleansing	Regulates main aspects of municipal solid waste in La Paz	First comprehensive regulation for the solid waste management in the city. Still valid.
2008	La Paz	Law 692/08—Regulation for Municipal Environmental Management	Establishes the responsibility of public education and communication about solid waste management practices	
2010	La Paz	Law 155/10—Integrated Solid Waste Management Municipal Program	Implements an integrated solid waste management system in La Paz	Emphasizes polluter pays principle
2014	La Paz	Decree 09/14—Regulation for Urban Cleansing, Waste Treatment and Waste Disposal	Broadens the scope of the approach for "Urban Cleansing" to include other components of solid waste management	Substitutes Law 372/06
2014	La Paz	Law 068/14—Development Strategy until 2040 "La Paz que queremos"	Includes the axis for "Efficiency and Sustainability" to integrated and sustainable solid waste management	
2014	La Paz	Law 697/14—Regulation for commercialization of recyclable material	Establishes price ranges for the main types of recyclable material	
2016	Santa Cruz de la Sierra	Law N° 295/16—Urban Cleansing	Establishes the rights and obligations, compliance and sanctions to urban cleansing, aligned with the national Law 755 (Table 3)	Substitutes Law "Zero Waste". Focus on "cleansing activities". No reference to integrated or sustainable solid waste management
2018	La Paz	Law N° 134/18—Electric and Electronic Waste Management	Establishes a partnership with "Estas Vivo" Foundation for e-waste recycling	

Table 5. Main stakeholders in the Municipal Solid Waste Management system.

Stakeholder Group	Stakeholder	Main Institutions	Dimension (Physical/ Governance)	Element (Collection/ Disposal/ 3Rs)	Main Role
Government	National Government	Ministry of Environment and Water	Governance	All	- Formulates the national ISWM policy framework and implementation strategies. - Facilitates access to funding from internal and external sources - Performs capacity building for municipalities
	Prefectural Government	Secretary of Sustainable Development and Environment Secretary of Mother Earth	Governance	All	- Formulates the prefectural ISWM regulation - Oversees the implementation of ISWM Law in its jurisdiction - Mediates and coordinates joint projects with various municipalities
	Municipal Governments	SCZ Municipal Cleansing Enterprise (EMACRUZ) LPZ Municipal Regulation System (SIREMU) Secretary of Environmental Management	Physical Governance	All	- Formulate the municipal MSWM regulation - Plan and execute MSWM activities - Monitor and control the negative impacts of MSWM activities
Formal Private Sector	Private Cleansing Companies	SCZ VEGA SOLVI LPZ TERSA SABENPE LA PAZ LIMPIA	Physical	Collection/ Disposal/3Rs	- Execute operational activities according to the specific conditions of municipal contracts
	Recycling Industry (Procesors)	EMPACAR (Plastics) COPELME (Paper/Cardboard) Scrap metal exporters Other smaller enterprises	Physical	3Rs	- Re-introduce the recovered materials into productive value chains
	Consummer Goods' Producers	Drinks Industry Electronics Importers Tires Importers	Physical	3Rs	- Implement Extended Producer Responsibility (EPR) measures
Informal Private Sector	Waste pickers	SCZ RED DE RECOLECTORES RECICLA BOLIVIA ARECICRUZ	Physical	3Rs	- Collect recyclable material and sell it to middlemen and recycling industries.
	Middlemen	Small enterprises	Physical	3Rs	- Accumulate recyclable material collected by waste pickers and improve its quality before selling to industries.

Table 5. *Cont.*

Stakeholder Group	Stakeholder	Main Institutions	Dimension (Physical/ Governance)	Element (Collection/ Disposal/ 3Rs)	Main Role
International Organizations	Investors/Donors	Interamerican Development Bank World Bank CAF Development Bank of the Americas	Physical	All	- Provide funding for large projects, mainly related to infrastructure provision
	International Cooperation Agencies	JICA (Japan) GIZ (Germany) SDC (Switzerland) KOICA (Korea)	Physical Governance	All	- Facilitate access to external funding - Perform capacity building activities for various actors - Develop and execute joint projects through NGOs and other actors
Civil society and research organizations	NGOs/NPOs	SWISSCONTACT FUNDARE AMIGARSE FUNDACION PAP AVINA	Physical Governance	3Rs	- Develop and execute small/medium projects - Foster collaboration among different actors in the MSWM sector
	Universities	UAGRM, UNE (SCZ) UMSA (LPZ)	Physical Governance	All	- Undertake research and knowledge dissemination related to the MSWM sector
	Professionals Associations	Society of Engineers	Physical Governance	All	- Provide advice on issues related to technological development
	Chambers of Industry and Commerce	CAINCO (SCZ) CANACO (LPZ)	Physical Governance	3Rs	- Promote MSWM initiatives that benefit the private sector and broader economic development

3.2.1. Government Organizations

The Bolivian political administration has the three levels of government: national, regional (prefectural), and municipal. Each of these levels plays a specific role in the provision of public services such as MSWM according to the various laws and policies discussed in Section 3.1.

At the national level, the Ministry of Environment is the main institution involved in the MSWM sector, leading any major relevant project or program through a dedicated division: the Department of Integrated Solid Waste Management (DGIRS). The DGIRS has been identified as one of the enablers in the sustainability transition of the sector (personal comm: F10; F1; D1; D2). Despite the limited human resources in the division (personal comm: C4; F9; F6; A1; K2), many respondents highlight the commitment and leadership of the unit to promote sustainability within the sector (personal comm: D1; C4; D2). Other ministries such as the Ministry of Planning and Finance, the Ministry of Health, and the Ministry of Productive Development are briefly mentioned, with most respondents, however, perceiving the considerable lack of involvement and coordination between ministries on municipal waste management (personal comm: C1; C7; F9; I1; F4; H1; F3; D1; K2). Various of the respondents attributed this to rivalries among different ministries (personal comm: K2); lack of mechanisms for inter-ministerial coordination (personal comm: F2); or bureaucracy (personal comm: G1).

Despite some apparent legal ambiguities on municipal waste management, most respondents agree that a major role of the national government (beyond policy formulation) is to facilitate access to internal and external funding to enable municipalities implement MSWM projects and support them through capacity building and training [61,73] (personal comm: A2; A1; F5; F7; D2; E1). In fact the role of municipal governments is recognized as particularly important in the MSWM system, as they are in charge of planning and executing all necessary activities for adequate MSWM operation and implementation [61,73] (personal comm: B1; I2; F9; K1; F5; F7; F8; J1; F2; E1).

Many of the larger cities in Bolivia have established a system that delegates solid waste management responsibilities to autonomous or semi-autonomous organizations. These organizations are usually called "Municipal Cleansing Enterprises" (MCE), or in the case of La Paz a municipal division called "Municipal Regulation System" (SIREMU), which is in charge of all public services in the city. In the major cities such as La Paz and Santa Cruz de la Sierra, there is the tendency over the past two decades to subcontract one or more large private companies specialized in solid waste management, to undertake waste collection and landfilling. Under this modality, both SIREMU (in La Paz) and EMACRUZ (in Santa Cruz de la Sierra) are in charge of planning, contracting, supervising and monitoring the activities of private cleansing companies (Section 3.2.2).

There seems to be a blurred boundary between MCEs and the municipality itself. While MCEs are supposed to be completely autonomous and independent institutions, functioning almost like private enterprises, in reality they seem to be very reliant to the municipality both in terms of financial support and political influence [96] (personal comm: F2; F8). Additionally, the fact that the MCEs focus mostly on operational aspects, but at the same time they are considered the main responsible organizations for MSWM activities, creates a grey zone in that policy, regulation and governance responsibilities are not undertaken by any of the municipal government divisions (personal comm: F8; F2; I2; C3).

Finally, the functionality of prefectural governments is neither clear and nor fully implemented in the MSWM system. One of their main clear responsibilities is to implement hazardous solid waste management schemes (personal comm: C3; I1; C1). Other respondents indicate that they can help small municipalities or metropolitan regions to implement joint MSWM projects, allowing them tackle issues related to the high costs of facilities (personal comm: F12; A2; D1; E1; F11). In any case, most actors either consider that regional governments are currently irrelevant in the MSWM system (pers comm: C3; H3; D2; F8), or even forget to mention it when identifying the relevant actors in the system.

3.2.2. Formal Private Sector Organizations

Formal private sector actors include enterprises that are formally constituted under Bolivian law and are engaged in different aspects of the MSWM systems. This mainly includes: (a) private cleansing companies, (b) recycling companies, (c) consumer goods' producers.

Currently, private cleansing companies tend to be large companies, sometimes funded through foreign capital, that have enough financial capacity to invest in the machinery and equipment necessary to undertake waste collection and/or final disposal (personal comm: I1; A2; F2). These companies participate in public bidding processes announced by the municipality, and following the necessary evaluation, the winner is awarded a cleansing contract that lasts usually at least 5 years [73]. In Santa Cruz, the private cleansing company is Vega Solvi, a company funded from the Brazilian transnational Vega. Vega Solvi is in charge of 13 services related to public cleansing in the city, with the MSW collection and final disposal being the most important (personal comm: C3; I2). In La Paz, two main cleansing companies operate, TERSA, which is in charge of the final disposal and waste collection in the peripheral areas of the city, and "La Paz Limpia" which is in charge of the collection activities in the core areas of the city (personal comm: I3; F2). Various respondents have praised the performance of both companies, indicating that in operation terms, the MSWM system in La Paz is the best in the country (personal comm: I3; K2; F2).

Recycling/exporting companies are enterprises that either transform the recyclable materials into new products or productive inputs; or sell the materials (e.g., scrap metal) to foreign buyers in the global markets, in cases where no local industries can process them. These companies buy recyclable material from middlemen or waste pickers according to their requirements in terms of quantity, quality and price (personal comm: G2; F2; H1; H3); playing an important role in the activity of these stakeholders (Section 3.2.3).

Consumer goods' producers do not play a major role in the Bolivian MSWM system at the moment. This category includes manufacturers and importers of consumption goods (e.g., companies from the drinks sector). While currently they are barely aware of their role, the Extended Producer Responsibility (EPR) under the new ISWM law requires them to be responsible for the adequate recovery/disposal of the waste from commercialized products (personal comm: A2; I3; F3; C5; C1; F7). These actors should consider important issues such as products design and the material selection, which ideally should reflect the recycling alternatives that exist in the country. Currently, EMBOL, which owns the Coca-Cola franchise in Bolivia, is one of the few companies that has started complying with some EPR requirements, e.g., by using bottles manufactured with 30% of recycled PET (personal comm: J1; DSIW; I2; G2; F8; G3).

3.2.3. Informal Private Sector Actors

As in many other developing countries, material recovery from waste is undertaken almost completely by informal private actors who collect, select, prepare and commercialize the recyclable material obtained from waste [107–109]. These actors recover the recyclable materials and sell them either to recycling companies or exporting companies, usually focusing on metal scrap recycling (personal comment: G2; F5).

Waste pickers are considered to be the most important actors in the recyclable material value chain in Bolivia. "Urban mining" activities performed by these actors are essentially the starting point for the recycling industry (personal comm: K2; F6; I3; F7; F3; F12). However, the distinction between the formal and informal sector is not always clear. In Bolivia this ranges from waste pickers who work completely independently, outside municipalities' registries, in situations of extreme poverty, risky working conditions and sometimes alcohol-drug abuse; to waste pickers who belong to associations that are legally recognized as non-profit organizations, and often form alliances with the municipal government, companies or NGOs (personal comm: F6; G3; H2; K2; H1; H3).

Santa Cruz has the largest number of waste pickers, being estimated a total of 8000 people involved in the activity [97]. The formalization process is more advanced in this city, with various

small associations grouped in three large networks: "Red de Recolectores", "Recicla Bolivia" and "ARECICRUZ". Although there are no reliable statistics about the number of associated waste pickers in the city, some sources report around 2500–3000 people with waste picking as their main occupation [73]. The self-reported number of members by each network leader are: 600 members for "Red de Recolectores", 1000 members for "ARECICRUZ" and 150 members for "Recicla Bolivia (personal comm: H1; H2; H3). "Red de Recolectores" and "Recicla Bolivia" originally belonged to the same network, which split due to internal conflicts, while "Arecicruz" was more recently created but not recognized by some actors who refer to them as "not real waste pickers" (personal comm: H1). Since 2013 the private sanitation company and some waste picker associations have worked together for the recovery of recyclable materials, through a service that is part of the new cleansing contract operating in the city (See Section 3.3.3). In La Paz it is estimated that some 3000 informal waste pickers operate [97], however, there does not seem to be relevant formalization attempts, which is partly attributed to the lack of initiative from the municipality, and partly by the absence of an industrial sector that could catalyze the formation of such initiatives (personal comm: K2; F2) (Section 3.2.2). Other actors even mention that political or conflicting interests from the leaders of an incipient waste pickers movement, prevented any further efforts from NGOs working on this issue in the early 2000s (personal comm: F7; K2). The municipal government, on the other hand, mentioned during the interviews its interest in the formalization process. However, they also believe that formalization approaches such as the one followed in Santa Cruz de la Sierra and other cases, have not been successful, which makes them unsure of how to approach the problematic (personal comm: C1).

Middlemen or intermediaries are micro and small enterprises that buy recyclable materials for resale to recycling industries, which often require larger amounts of recyclable materials and higher quality. Middlemen have usually greater human and financial capital compared to waste pickers, and thus have a competitive advantage for recyclable material storage and processing (personal comm: F8; I3; F3; G3). For instance, middlemen usually operate warehouses with better infrastructure, and essential machinery to wash, press and pack the recyclable materials. The perceptions regarding middlemen are varied. Some actors consider they are detrimental to the recycling value chain due to their impact on waste pickers' activities (personal comm: F3; F2). On the other side, other respondents think there is a place for all the actors if the adequate collaboration, regulation and monitoring are implemented (personal comm: K2; F12).

3.2.4. International Organizations

International organizations are important actors to the MSWM system in Bolivia. They have often influenced the development of MSWM initiatives, and/or affected the evolution of existing one through financing and/or technical cooperation (personal comm: F1; D1; A2; F10; I2; C6; C1; C3). The main categories included are investors/donors and international cooperation agencies.

The donors are usually multilateral organizations and development banks that provide the funding for MSWM projects, often related to infrastructure that requires large initial capital investments (see below). The main institutions carrying out that role have been the Inter-American Development Bank (IADB), CAF Development Bank of Latin America, and the World Bank. Several of the interviewees mentioned that the provided financing is an important enabler in the sustainability transition of MSWM systems in the country (personal comm: F12; A2; D1; E1; F1). The funding is usually utilized to conduct large projects, from the feasibility study until the project implementation, such as the construction of sanitary landfills. For instance, CAF provides the funding for the new sanitary landfill in Santa Cruz de la Sierra (which is supposed to be finished in 2019) (personal comm: A2).

International cooperation agencies contribute smaller amounts of funding, and mainly through technical cooperation and project implementation activities. The cooperation agencies with the largest presence in the country are the SDC (Switzerland), JICA (Japan), GIZ (Germany) and more recently KOICA (South Korea). Despite the smaller size of funding, they have large impacts through community education/awareness campaigns, capacity building for municipality officers, and creation of networks

with different stakeholders' groups (personal comm: C3; C1; C6; D2; F2; F1; A2; D1; F11; K2). Similar to donors, many stakeholders point that the support of international cooperation agencies is one of the main enablers for sustainability transitions in the sector (personal comm: C1; D2; D1; K2). In this sense, many interviewees note that the decrease in international cooperation that is occurring at the moment could influence negatively in many aspects of the transition (personal comm: K2; F7; F8; D1; F6).

External actors have a considerable influence at the national level. However, as their offices are located in La Paz, some respondents pointed out at their particularly significant benefits for this city's MSWM, in terms of spillover effects related to better technical and normative capacity, smooth coordination, and networks creation (personal comm: K2; C1).

3.2.5. Civil Society and Research Organizations

The main actors in this group include NGOs and NPOs that undertake relevant activities at the local level. Some NGOs are closely related to cooperation agencies and work as the main counterparts in local projects/programs related to source separation activities, community education, awareness raising, and capacity building for small enterprises, to name a few (personal comm: D1; F11; F10; H1; F8; F1; K2). SWISSCONTACT is one of the NGOs that has had a major presence in the country as a whole, through its projects funded from the Swiss cooperation agency (personal comm: K2; D1; C3; F9; F10; F11; F5; G2; G1; F7; F2). FUNDARE is another NPO that is very active in the main cities of La Paz, Cochabamba and Santa Cruz. This NPO works under the umbrella of the Industry and Commerce chamber, which explains its rather business-like mindset, compared to other NGOs (personal comm: F2; F5; I3; F3; F10; J2).

It is important to note that the "golden" period of NPO/NGO influence in the MSWM sector was the early 2000s (personal comm: H1; F8; F7; H3), when Santa Cruz de la Sierra attempted the first waste picker formalization process (Section 3.2.3). At the time 6 NGOs formed a council that established a coordination scheme through which significant steps were taken towards what was branded as "inclusive businesses" in the recycling value chain (personal comm: F7; F8; H3).

Universities could also potentially play an active role in the MSWM system (and its sustainability) through academic research and training programs geared towards the local needs in each city. However, most of the interviewees acknowledge that this is not yet done, possibly with the exception of La Paz, and to a lesser extent, Cochabamba, where the current input of the local public university is positively regarded (personal comm: J2; F12; F8; A2; D1; F11; C1). Associations of professionals can play a similar positive role, and especially the society of environmental engineers (personal comm: F8; K1; I2).

Finally, chambers of commerce and industry have also recently appeared in the MSWM discourses, through their efforts to promote circular economy approaches, which contributed to the strengthening of the recycling industry (personal comm: D1; F12; F5; F11; F7). However, as some of the interviewees commented, their interventions have at times drawn criticism or distrust, due the perceived self-interests (personal comm: H2; I3; F2).

3.3. Sustainability Transitions in Bolivian Municipal Solid Waste Management Systems

Based on the primary and secondary data analysis we identify three different transitions in the MSWM systems of the two cities: (a) Collection and centralized disposal (Section 3.3.1); (b) Environmentally controlled disposal (Section 3.3.2); (c) Integrated solid waste management (Section 3.3.3). Each of the three transitions has been characterized by a specific type of regime shift, which allowed for the mainstreaming of relevant niche innovations at specific points in time (Table 6). Regarding the landscape factors (Section 2.1.2), while most of them have been present in all three transitions, their strength and relevance have varied.

At the local level the transitions have been characterized by specific milestones, barriers, enablers, as well as different types of engagement and commitment from the municipal government. Table 7 details the characteristics of these three transitions for La Paz and Santa Cruz de la Sierra.

Table 6. Main elements of Municipal Solid Waste Management system transitions in Bolivia.

	1st Transition: Collection and Centralized Disposal	2nd Transition: Environmentally Controlled Disposal	3rd Transition: Integrated Solid Waste Management
Landscape factors	- Population growth - Demographic factors - Geographical characteristics-Urbanization patterns	- Land availability - State-society relations - Political and regional tensions-Environmental narratives	- State-society relations - Environmental narratives-Socio-economic patterns
Regime shift	- Dumping practices to collection systems.	- Open dumps to sanitary landfills	- No recovery to material and energy recovery
Niches	- Micro-enterprises collection services-Corporate collection services - Curbside collection - Container collection	- "Controlled" dumps-Landfill technologies	- Community recycling-Informal recycling - Formal Recycling - Energy Recovery

Table 7. Municipal Solid Waste Management System transitions in La Paz and Santa Cruz de la Sierra.

City	Aspect	1st Transition: Collection and Centralized Disposal	2nd Transition: Environmentally Controlled Disposal	3rd Transition: Integrated Solid Waste Management
	Period	**1940s–2010s**	**1990s–present**	**2000s–unknown**
La Paz	**Milestones**	• Collection services operating since the 1940s, with disposal in small dumps across the city and the Choqueyapu river • Centralized disposal at least from 1970s at Sopocachi's and Mallasa open dumps • Technological shift in 2016 (e.g., use of containers, mechanized sweeping)	• Mallasa landfill operating from the1990s until 2004 • Alpacoma landfill operating from 2004 (perceived by the municipality as a "role model" in Latin America) • Accidental landslide in Alpacoma in 2018 leads to closure	• Community recycling projects promoted by NGOs in 2004 • Source separation program in all governmental offices in 2011 • Green points implemented by the municipality in 2014
	Barriers	• Topography of the city	• Lack of funding for initial investments in infrastructure and operation • Political rivalries with neighboring municipalities	• Lack of industrial sector for recycling value chain • Lack of formalization processes for waste pickers
	Enablers	• Role of the local government (for the most recent milestone)	• International cooperation and donors support to develop landfill facilities • Community education and awareness	• Leadership of the municipal government • Community education and awareness • Influence of international cooperation stakeholders and the national government • Long term vision of the city
	Role of municipal government	• Manage the negative impacts of population increase in the city (in early stages) • Improve public services in the city • Undertake strategic decision to invest in the modernization of the MSWM system.	• Political will to address the municipal waste problems, aided through international cooperation • Flaws in risk assessment, monitoring and response to disasters	• Undertake communication campaigns • Develop recyclable material recovery initiatives • Overcome the lack of approaches to include waste pickers

Table 7. *Cont.*

City	Aspect	1st Transition: Collection and Centralized Disposal	2nd Transition: Environmentally Controlled Disposal	3rd Transition: Integrated Solid Waste Management
	Period	**1970s–2010s**	**1990s–present**	**2000s–unknown**
Santa Cruz de la Sierra	**Milestones**	• Privately paid collection and disposal at abandoned areas in the periphery of the city • Collection services and centralized disposal from 1970s to 1994 in "El Gallito" open dump. • Improvement of collection coverage through contract with multinational company in 2013	• Normandia landfill operating from 1995. Currently operating almost at full capacity. • Uncontrolled human settlements within a 500 m of the landfill since the early 2000s • New landfill expected to start operating in 2019.	• Zero waste initiatives in 2004 • Waste pickers formalization process from 2005–2013 • New municipal cleansing contract with expanded scope in 2013
	Barriers	• Unplanned growth and extent of the city • Lack of community education and awareness of appropriate MSWM practices	• Lack of funding for initial investments and operation • Illegal settlements around the landfill areas • Inadequate landfill operation by various private companies	• Conflicts among waste pickers and other actors • Resistance from local residents for establishing recycling points • Frailty and small size of industrial sector • Lack of municipality leadership in MSWM processes • Lack of political priority of MSWM issues
	Enablers	• Private sector's initiatives • Leadership and vision of representatives of EMACRUZ in early stages	• International cooperation and donors support to build landfill facilities • Hiring of technical officers with environmental focus in EMACRUZ	• Vocal NGOs involvement in waste picker formalization process • Municipal government support during the early stages of the waste pickers formalization process. • Increased scope of the cleansing contract
	Role of municipal government	• Increase collection service provision during the early stages • Manage the negative impacts of population increase in the city (in early stages)	• Political will to address the municipal waste problems, aided through international cooperation • Failure to control human settlements around the landfill	• Innovative Zero Waste policy • Support during the early stages of waste pickers formalization process. • Lack of leadership to develop coordinated efforts among all actors • Lack of political priority of MSWM issues

3.3.1. 1st Transition: Collection and Centralized Disposal (1940s–2010s)

The first transition is characterized by the shift from a regime where the solid waste generated was dumped, to a regime where the respective municipalities organized collection activities and established centralized disposal sites. It is safe to assume that this transition is currently at a stabilization stage in both cities, with their respective systems reaching a state of equilibrium.

As mentioned in Section 2.1.2, there are various landscape factors that can influence MSWM transitions. In both cities, the break-through of the first transition originated from sudden population growth, which created a real need to deal with the generated waste in an organized manner. Geographic conditions have largely influenced the choice of technologies (e.g., use of containers, type of collection trucks) and the choice of original disposal sites. Urbanization and demographic patterns have influenced the collection quality and its different formats in wealthier and poorer areas.

In La Paz, there is evidence of the break-through of centralized collection and disposal activities around the 1940s (Section 3.1.2), though at that time the collected waste was frequently disposed in the Choqueyapu river, which crosses the city and remains severely polluted until now [102,110]. Open dumps operated until the 1980s, considering that the first sanitary landfill in the city ("Mallasa" landfill) started operating in the 1990s (Section 3.3.2). At least two open dumps operated during that period, one in the "Mallasa" area where the new landfill was built some years later; and the other in the "Sopocachi" neighborhood inside the city [111]. The latter gained attention in recent years due to landslides that affected illegal settlements built on the area after its closure [112].

In recent years the waste services in La Paz have undergone an important technological shift, from a purely curbside collection system to a mixed system that incorporates containers in various districts [113] (personal comm: C1). Following this shift, the current collection services in La Paz are considered to be some of the most advanced nationally, due to both the technological aspect and the good response from the population (personal com: I3; K2; F2; C1; D1). Reasons that have possibly influenced this positive response include (a) the long history of waste collection services in the city (personal com: I3; K2; F2), (b) the education and awareness campaigns carried out by different actors (personal com: C1; F10; D1), (c) the awareness raised by recent negative experiences from extreme flooding events in the city, intensified due to solid waste blocking the sewage (personal comm: D1; E1), and (d) the growing awareness about local and global environmental impacts (personal comm: I3; A1; E1). A major concern about collection services in the city is the high capital (e.g., equipment) and operational cost (e.g., frequent emptying of containers to avoid overflowing) (personal comm: F9; I1; C1). These have raised questions over the economic impact of the MSWM system on the city's budget, and its long-term financial sustainability (personal comm: F9; I1).

For Santa Cruz de la Sierra, there is evidence of a pre-development stage in the 1960s, when a private company collected waste without the involvement of the municipality as a paid service for residents [114]. The first municipal collection services started around the 1970s, with a small enterprise collecting the waste for the municipality, and dumping it in an open field that became the first open dump in the city [114]. This first open dump (called "El Gallito") operated formally between 1978 and 1994 when it was replaced by the sanitary landfill "Normandia" [114] (Section 3.3.2). However, even until the early 1990s, the collection services were very deficient and was still common for people to throw away their garbage in the street [115]. Nowadays, "El Gallito"area is completely urbanized with lower-income households. The only impact assessment study conducted on it considers the area to be safe for human settlements, identifying "mild" groundwater pollution as the only negative impact [114]).

During the 1990s international cooperation efforts at the national level strengthened collection micro-enterprises and engaged them as service operators [95] (personal comm: I1). As a result, for some years micro-enterprises carried out collection services in some urban areas, usually in the periphery. Eventually, due to problems with service quality and financial problems of the micro-enterprises (personal comm: I1), this arrangement changed to the current one, with cleansing contracts granted to one or two big corporations (Section 3.2.2).

In recent years, collection services improved substantially in terms of effectiveness and coverage, which now stands at around 90% [61] (personal comm: C3; I2). Still, some actors question the quality of collection services (personal comm: F6; F8; J1; C3), pointing that small illegal dumps have proliferated outside the city center (personal comm: C3; F8). As a response, the MCE has increased the number of collection rounds in the problematic areas, and even requested the development of a specific service in charge of illegal dumps. However, this seems to have created a vicious cycle, in that the higher the collection frequency in dumping areas, the more waste is dumped (personal comm: C3).

Finally, as in most developing countries [15,116,117], the cost of waste collection and disposal is not covered through the revenues from collection fees, but from municipality funds budget and other sources. In this sense, the new ISWM law includes the possibility to use funds from the fossil fuel industry revenues for solid waste management activities (personal comm: I2; C3) (personal comm: C3; C1; C7; I2; I1). The deficit in collection fees is an important constraint for the prioritization of MSWM policies at the national and the local level (personal comm: C7; D2; F11), with the financial sustainability of the MSWM system identified as an important barrier (personal comm: F2; C2; D1; E1; K2). While municipalities in large cities such as La Paz and Santa Cruz have access to more funds and higher collection fees compared to smaller municipalities, both cities still highly subsidize their services. This would most likely require a substantial redesign of the collection fee schemes at some point (personal comm: C3; F9; A2; C1; F2), increasing the risk of social conflict (personal comm: I2; K1; D2; F12; A2; K2) (See Section 4.3). In this sense, Santa Cruz de la Sierra seems to have had more progress in the collection of fee charges, having updated the tariffs twice in the last two decades (the last time was in 2012) [118]. La Paz updated its tariffs only once in 2007 [105].

3.3.2. 2nd Transition: Environmentally Controlled Disposal (1990s–~2030s)

The second transition reflects the regime shift from disposal methods that are harmful for human health and the environment (e.g., open dumps), to practices that guarantee the minimum conditions for environmentally sound solid waste management (e.g., sanitary landfills). Unlike countries with relatively limited land availability, Bolivia is a rather large country. This favored the choice of sanitary landfills over other waste management practices such as incineration (personal comm: I2). Despite this, finding suitable places for sanitary landfills has become increasingly difficult due to various political tensions (Section 4.3).

Currently there are no additional transfer or treatment stages (e.g., incineration, pyrolysis), which means that waste is directly taken to disposal sites after collection. Following the 1st transition (Section 3.3.1), La Paz and Santa Cruz de la Sierra were the first cities in Bolivia to adopt sanitary landfill technologies, and remain among the few cities with this type of technology in the country.

Until recently, "controlled dumps" were the preferred practice in other cities. However, they are not considered to be environmentally adequate, as they focus only in the use of specific types of soil (e.g., clay) to act as a filter for leachate and cover the waste to avoid disease vectors and odors (personal comm: C1; C7; F2).

The Mallasa landfill in La Paz operated for around 13 years, until it ceased operation in 2004. The new sanitary landfill ("Alpacoma") was considered for many years to be the state-of-art in Bolivia in terms of technology and performance (personal comm: F2; I3; K2; F1). However, in January 2019, following a period of heavy rains, Alpacoma suffered a serious landslide that caused severe environmental impacts and social conflicts with neighboring local communities at the Achacollo municipality [119]. These events led to a "sanitary crisis" in La Paz city, due to the inability to conduct the collection services as local communities blocked the access of waste trucks to the landfill for around two weeks [120]. The conflict lasted more than a month and led to the premature closure of the landfill, which was originally supposed to function for at least another 8 years [121,122]. While climatic factors certainly contributed to the accident, there has been evidence of bad management practices [123] (personal comm: K2), which combined with the lack of emergency procedures and political conflicts between the two municipalities, lead to this outcome [124] (personal comm: K2; F2). The additional

interview carried out in February 2019 (Section 2.3), pointed this case as an important lesson in terms of how the lack of adequate monitoring and quality control across the MSWM sector, can combine with political rivalries and other conflicts, to affect the broader MSWM system (personal comm: K2).

In Santa Cruz de la Sierra, the Normandia landfill remains operational until now. However, the landfill is located within the urban area of the municipality, and is reaching the end of its life span. It was originally authorized to operate until 2018 [114], but was ultimately given an extension of one additional year. The landfill has been widely criticized during its operation, particularly due to the bad management of some private cleansing companies, which implies that some negative environmental impacts might have manifested [114] (personal comm: E1; F6; I2; K1; F7). However, the main problem has been the failure to restrict human settlement in its periphery. While most relevant legislation bans any human settlement within 2 km of the landfill, Normandia has entire neighborhoods only within a 500 m radius [114] (personal comm: G2; F7; I3; K1).

Even though La Paz and Santa Cruz de la Sierra are clear frontrunners in the MSWM sector in Bolivia, their experience shows that the transition to environmentally controlled disposal is not yet completed, and the situation is still far from ideal. Furthermore, in most of the rest of the country most disposal sites are still open dumps, with few (or even no) mitigation measures (Section 2.2). Although the National Law 755 establishes that all open dumps should disappear from Bolivian cities by 2020, most respondents are skeptical whether this will materialize (personal comm: F2; A2; K1; F2; K2). In this sense, even though the transition to environmentally controlled disposal is still unfolding, it is expected to last much longer in the entire country, possibly at least ten more years (personal comm: F3).

3.3.3. 3rd Transition: Integrated Solid Waste Management (2000s–Unknown)

The 3rd transition consists in the shift towards an Integrated Solid Waste Management system (Section 1). This would entail the inclusion of multi-stage MSWM approaches that allow material or energy recovery from the solid waste and include social and institutional dimensions that were not previously prioritized. This transition was largely influenced by landscape factors such as the global and national environmental narratives, which have increased community awareness about the need for sustainable MSWM practices. Other influential factors such as the socio-economic and development patterns, and the state-society relations are discussed below.

The transition essentially started in the early 2000s with the implementation of several programs and projects in the cities of La Paz, Cochabamba, and Santa Cruz de la Sierra, led by various international cooperation agencies and NGOs (personal comm: F9; F10; F11; F8; C3; C4; C1; F7; H1; H3; DELNORTE). These projects have included recycling activities, community education and awareness campaigns, source separation schemes, and processes to formalize the waste picker sector (personal comm: K2; F10; F11; F9; F8; F7).

In La Paz, institutions such as FUNDARE, JICA and SWISSCONTACT have played a visible role through projects such as the "Eco-Vecindarios" project in 2009. These projects focused on community recycling in which neighborhoods undertook recyclable recovery and benefited from the selling profits. The projects are believed to have empowered neighborhoods and catalyzed the emergence of community leadership (personal comm: F10; D1; F2; I3). More recently, the funding and activities from international cooperation agencies and NGOs started declining, which has led to the termination of most project activities. At that point (around 2014) the municipality took over the recyclable material recovery schemes (personal comm: C1; F10), establishing drop-off facilities in various districts, where local residents bring the recyclable material. This scheme seems to have improved recovery rates (personal comm: C1; D1; E1).

In Santa Cruz de la Sierra the first milestone of this new transition relates to the Zero Waste initiatives of 2004 (Section 3.1.2) (personal comm: C3; C4; F7; H1; K2). From that point on, and for a period of around ten years, a group of NGOs, EMACRUZ and Red de Recolectores constituted the Bolivian Council of Solid Waste (COBORESO) (Section 3.2.5). This consortium adopted an ISWM vision

and aimed to find solutions to prevailing problems for the MSWM system, with a special focus on financial and technical viability, social inclusion and citizen participation (personal comm: F7; F8; H3).

One of the main achievements was the formalization of waste pickers, which reached its highest point around the early 2010s [73]. After this peak, there was a deceleration of formalization processes, manifesting through the various internal and external conflicts that led to the fragmentation and weakening of the associations [73] (personal comm: H1; H3; C4; F8). Although the reasons are not clear, some respondents point that the sudden termination of NGO support left the waste pickers' associations in a fragile state (personal comm: F8; C4). Other respondents point at the (a) conflicts with some NGOs due to the apparent funding mismanagement (personal comm: H3; H2); (b) conflicts among associations' leaders that led to fragmentation (personal comm: H2; H3; C3; K1; I2); and (c) formalization attempts under the new municipal cleansing contract in 2013, which seem to have undermined the organizational processes within associations, further contributing to internal conflicts [73] (personal comm: F8; H3).

Interestingly, respondents perceive very differently the new cleansing contract of 2013. Some consider it to be one of the main causes behind the collapse of the waste pickers' formalization process (see above), while others consider it to be an important step towards ISWM (e.g., by expanding the scope of MSWM services far beyond waste collection and disposal) (personal comm: F7; H3; K2; F10; C3). However, it is a completely different discussion whether the goals of the contract were actually achieved. For instance, the contract established separate collection schemes, which have, so far, dubious results (personal comm: C3; H3; F9; J1; G2). While some actors seem to be positive overall about the outcomes of the program (personal comm: I2; C3), others deem it as to be a failure (personal comm: G2; J1). Another unmet contract clause has been the failure to establish the various drop-off facilities in the city (called "Eco-points") due to community opposition (personal comm: C3).

Another important element of this transition relates to the landscape factor linked to the socio-economic patterns and development paradigm in the country (Section 2.1.2). As discussed, the industrial and commercial sector are not yet fully developed in Bolivia. Although the situation is a bit better in Santa Cruz compared to the rest of the country, companies still point at the excessive bureaucracy barriers and investment risks that hinder the development of a robust recycling industry (personal comm: G3; F7; F3; F5; F9; G1; G2; F12; G3). Furthermore, the small size of the national domestic demand for recyclable material prevents the development of economies of scale, which further prevents the development of a vibrant recycling industry (personal comm: G2; I3; G3; F2). In this context, the local and national recycling industry is unstable and fragile, which threatens the sustainability transition (personal comm: F5; I3; F2; E1). To enable the effective transition there would be a need for added incentives from the government to help the expansion of the recycling sector (personal comm: C1; C4; G3; F7; G2; F3; F5; F9).

It is interesting to point that there is still no clear definition and understanding of the type of niches that the current IWSM transition will favor. Our analysis suggests that the transition could move across three possible pathways. The first pathway could entail a shift to "high technology alternatives", which are common in more industrialized contexts characterized by higher waste generation levels with lower organic fraction. Such technologies could include incineration (personal comm: C3; I1; I3; F1; A2); pyrolysis (personal comm: C5; C3); and waste bio digestion (personal comm: C6; C3; F10; D1) to name a few. The main inhibiting factors relate to the financial viability of such projects and include (a) the high capital and operational costs of facilities, (b) heavy subsidies of fossil fuel energy in Bolivia (personal comm: C3; I3). It is also unclear the extent to which such alternatives could affect other existing niches, such as the informal and formal recycling initiatives (personal comm: I1).

The second pathway could favor material recovery alternatives, such as the formal recycling niche and the informal recycling niche. For example, the circular economy approach and the new ISWM law prioritize material recovery over energy recovery (Section 3.1) (personal comm: I1; K2). However, some actors seem to support the latter as a better alternative for revenue generation, considering the limitations of the recycling industry outlined above (personal comm: C5; C3; F2). Other respondents suggest the "vested interest" of some companies trying to introduce these technologies in the country,

regardless of their suitability to the local conditions (personal comm: I3; K2; I2). If "high-technology" alternatives do not muster enough support, then municipalities could choose to continue formalization efforts (e.g., in Santa Cruz) or the implementation of municipal or formal recycling initiatives (e.g., in La Paz).

It is highly possible that neither of these pathways succeeds in mainstreaming new practices. In this case the transition will continue with waste disposal in landfills as the main MSWM alternative. The focus would probably be on small changes for improving current operations and reducing current impacts. This could entail technological improvements (e.g., landfill gas capturing) (personal comm: I3; I2; E1) or improved regulation, enforcement and conflict management with communities near landfill sites.

3.4. ISWM Elements in Municipal Solid Waste Management Systems Sustainability Transitions

When examining the components of the ISWM framework (Sections 1 and 2.1.1) and the transitions across time we obtain a clearer understanding of their evolution and particularities for each city (Figures 2 and 3). In both cities the transitions have caused change in the ISWM elements following a largely similar order, starting with the "Public Health" and "Environment" elements, which is the common progression for MSWM transitions (Section 1). Similarly, the elements related to the "Governance" dimension are addressed in much later stages. Among those, the "Inclusivity" element, seems to be the most neglected in both cities (personal comm: D2; F7).

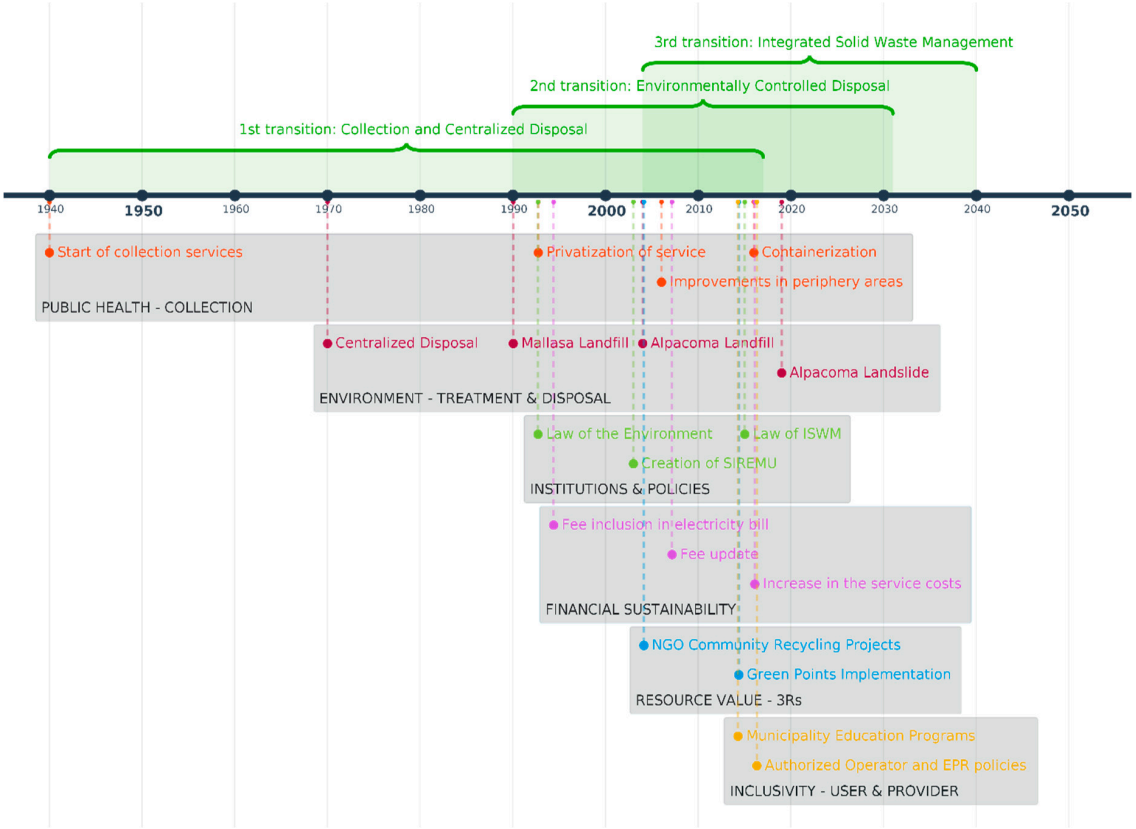

Figure 2. Timeline of Municipal Solid Waste Management Systems sustainability transitions and ISWM elements for La Paz.

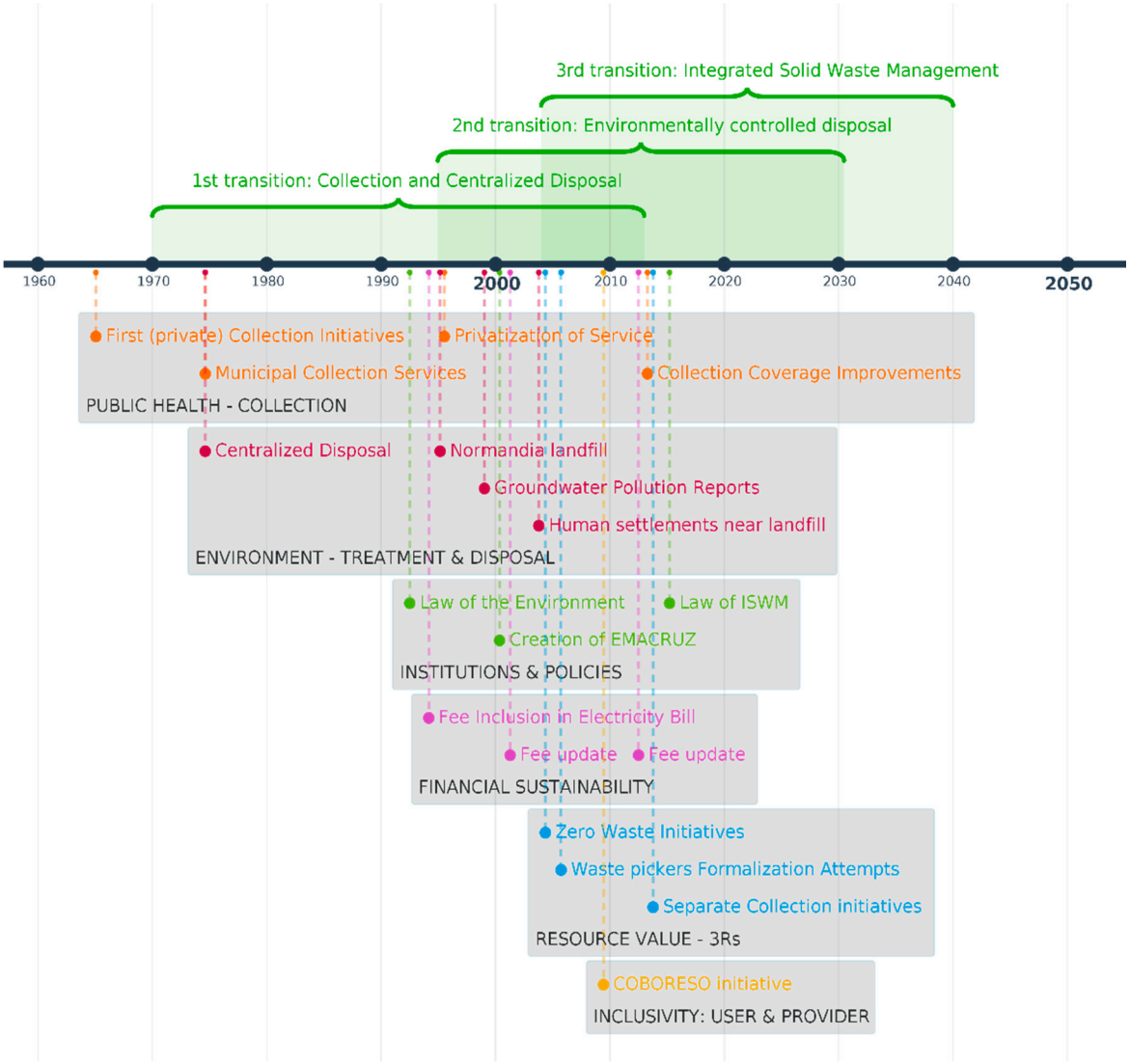

Figure 3. Timeline of Municipal Solid Waste Management Systems sustainability transitions and ISWM elements for Santa Cruz de la Sierra.

In La Paz the first transition started much earlier, which resulted in a longer period without overlap with next transitions. This could have influenced the apparent maturity of the waste collection system (Section 3.3.1), which allowed the municipal government to focus more on other transitions and ISWM elements. It is worth pointing that while most ISWM elements have followed a positive evolution throughout the transitions, the "Environment" (Section 3.3.2) and "Financial Sustainability" (Section 3.3.1) elements have suffered setbacks in recent times.

For Santa Cruz, the transitions have occurred in a shorter period of time, which has added complexity for the management of the transitions. In spite of this, the city has been able to catch up, with notable advances in elements such as "Financial Sustainability" (Section 3.3.1) and "Resource Value" (Section 3.3.3).

4. Discussion

4.1. Convergences and Divergences in Transition Pathways

La Paz and Santa Cruz de la Sierra have experienced largely the same transitions in their MSWM systems (Table 7). Both cities followed a transition from "collection and centralized disposal"

(Section 3.3.1), to "environmentally controlled disposal" (Section 3.3.2), and "integrated solid waste management" (Section 3.3.3). However, the timelines, speed and elements of these transitions are somewhat different between cities, largely due to their inherent characteristics (Section 2.2), institutions (Section 3.1.2) and actor dynamics (Section 3.2).

Santa Cruz de la Sierra is essentially a young metropolis whose development is largely driven by private sector initiatives (Section 2.2). This socioeconomic context has influenced positively some aspects of the MSWM transitions by creating an enabling environment for actors in the formal and informal recycling sectors to thrive, and become catalysts for the 3rd transition (Section 3.3.3). At the same time, the rapid population growth during the last decades led to a largely unplanned urban development, which has hindered the stabilization of the 1st and 2nd transitions (Sections 3.3.1 and 3.3.2).

La Paz is an older city, characterized by a much slower development pace that is more reliant on the national government (Sections 3.1 and 3.2.1). This has resulted in stronger governance capacity within the municipality that also benefits from the much smaller and less populated urban area. This has resulted in better urban planning, and policy implementation and control that have favored the stabilization of the first two MSWM transitions (Sections 3.3.1 and 3.3.2). This was assisted by the close proximity to international donor organizations and NGOs that provided funding and technical assistance (Sections 3.2.4 and 3.2.5). However, the decreasing presence of a strong industrial sector within the city (Section 3.2.2) seems to be hindering the 3rd transition (Section 3.3.3).

4.2. Challenges for Enabling Municipal Solid Waste Management Systems Transitions

4.2.1. Dynamics within and between Government Levels

Sections 3.1 and 3.2.1 outline the responsibilities of each government level in the MSWM system in Bolivia, and how their interactions can have important ramifications for the transitions. In particular, many respondents specifically mentioned the lack of coordination among different government levels, and between government and other actors as an important barrier (personal comm: I2; F9; F2; G2; G1; J2; F8; J1; F6; K2; F10; E1). This results in institutional gaps and overlaps, which often cause confusion or resistance from local and regional governments to assume their institutional responsibilities (personal comm: A1; A2; F1; D1; C1; D2; K2; F12).

A possible reason for this (though not directly related to MSWM systems) is the decentralization process that has been ongoing for the past 30 years (Section 2.1.2). Though not inherently negative, this process has been blamed for delaying the process and being indirectly responsible for the failure of local authorities (at different levels) to assume their responsibilities (personal comm: I1; F10; A2; D1; F6). In this sense, the ignorance or misinterpretations of the current legislation (Section 3.1), coupled with political rivalries, are major factors for government's dysfunctionality in the MSWM system (personal comm F10; F2; A1; E1; F11; K2).

Related to this dysfunctionality is the perceived lack of leadership and capacity of municipal governments and cleansing companies (personal comm: I2; K1; F5; H1; F7; F8; F2; G1; E1; J1). While this perception can be affected partly by managerial issues such as the type of MSWM organizational structure (MCE or municipal division) (Section 3.2.1), we believe that this "lack of leadership" is highly influenced by political issues (see Section 4.3). For example many respondents mentioned the "selfish" interests of politicians in relation to MSWM initiatives (personal comm: C3; F9; F10; J2; F12; F8; G3; I3; F2; A1; E1; K2), and the political will (or the lack of it) to address them (C3; F9; F2; G1; F8; I3; F1; A1; D1; F6; F11; K2).

The above illustrates how elements of the MSWM socio-technical regime (i.e., government dynamics) are influenced by landscape factors such as the political and regional tensions (Section 2.1.2). In a context where at least two transitions occur simultaneously in different cities, and within the same city (Table 7), there is a clean need for a strong governmental role to assist decision-making and setting priorities within the MSWM sector [10,15].

However, it is important to note that the two transitions are at different stages, which would require different consideration from the government. In particular for both La Paz and Santa Cruz, the 2nd transition is most likely at a stabilization stage (Section 3.3.2), while the 3rd transition is probably at a pre-development or take-off stage, depending on the niche (Section 3.3.3). This suggests that the role of the local governments should be different in both cases, focusing more on consolidating and avoiding the negative impacts in the stabilizing transition (2nd transition), and leading and reinforcing the transition that is taking-off (3rd transition) [59]. This would indeed require very different capacities, incentives and processes, which, as discussed throughout this paper, are often lacking. In order to stimulate the transition there is a clear need to maintain a broad range of communication channels to include the various actors to create a common vision [47,59], which is regrettably lacking according to the interviews.

4.2.2. Dynamics among Private Sector Actors

Dynamics among market actors can also play a major role in fostering or preventing transitions. For instance, many interviews highlight how the recycling value chain can catalyze the 3rd transition, and the conflicts arising through the competition among various niches and mainstream MSWM practices (Sections 3.2.2 and 3.3.2).

First, conflicts often occur between private cleansing companies and recycling initiatives, which, if not adequately addressed by municipal governments, could hinder the ongoing attempts to boost recycling (personal comment: C3; H3; F7; H1; F3). This situation arises, partially, from the fact that municipal cleansing contracts establish a payment scheme based on the amount of waste collected and disposed. This reduces the incentive of cleansing companies to collaborate in the implementation of source separation and recycling programs driven by municipalities (personal comm: K2; F2; I3; G3; F10; F11; F12; F7). Furthermore, there is an apparent systemic neglect of monitoring and evaluation to assure the compliance with contractual obligations (personal com: K2; F10; F8).

Second, semi-formal waste pickers often conflict with cleansing companies (personal comm: C3; F3; H1; F7; H3). This is particularly evident in Santa Cruz de la Sierra, where the formalization process is more advanced (Section 3.2.3). In this case, a major aspect of the conflict is the access to the recyclable material and the participation of waste pickers in partnerships for recycling activities (C3; I2; H1; H3). From the perspective of the private cleansing company, the current partnerships (Section 3.3.3) benefit primarily the waste pickers associations. Thus, the private cleansing company regards this joint work as a corporate social responsibility (CSR) activity, which even though it is considered successful, it essentializes waste pickers as a "complicated sector" due to their internal conflicts and general distrust (personal comm: I2). From the perspective of the waste pickers, the conflicts originate in (a) the unfavorable conditions of these partnerships, (b) the disregard of the waste pickers demands for inclusion and support from the authorities and the private company, and (c) the attempts to weaken associations and "take away" their recycling niche (H1; H2; H3).

Third, there are also conflicts between waste picker associations, and recycling companies, and middlemen (C1; F8; I3; H3; K2). Recycling companies tend to complain about the quality of the recyclable material, and the lack of understanding of the associations about the international oil prices dynamics on recycling material price (personal comm: F2; G3; G3; H3; H2). Conversely, the waste pickers point that recycling companies and middlemen take advantage of their bigger negotiation power (personal comm: I3; F8; H3; K2), especially considering that the value chains of most materials are oligopsonistic (personal comm: G2; F5; E1).

4.3. The Political Aspects of Municipal Solid Waste Management Systems Transitions

Section 4.2 highlights the importance of stakeholder dynamics in enabling or hindering MSWM transitions. These dynamics are deeply rooted in economic interests and are key in determining the transitions pathways [37,125]. However, how these dynamics unfold also largely depends on the capacity of the different stakeholders to achieve political influence and mainstream the niche that is

more favorable to their own interests. In this sense the political context and tensions are one of the most relevant landscape factors influencing MSWM transitions (Section 2.1.2).

However, transition theory has been criticized for not paying enough attention to how power relations influence the construction of the dominant narratives that lead the transitional processes [55, 57,126]. Recent studies on solid waste management transitions (e.g., e-waste), have focused on how power dynamics can unfold transitions [43], and impose vested interests that lead to problems of trust and legitimacy.

As discussed above, the economic interests of actors involved in MSWM systems play an important role in the transitions. In this sense, it is expected that the actors with more economic strength will ultimately be able to exert more influence [125]. Studies from the Urban Management Program on MSWM in Low-income Countries in 1995 [127], which included the city of La Paz, already pointed to how contracting conditions favorable to cleansing companies could have a negative impact on recycling initiatives. Section 4.2 shows that the current situation in both cities is similar, pointing at the importance of local governments to fulfill their role as "clients" in public-private partnerships common in MSWM systems [15]. However, with changes in landscape factors such as land use issues and environmental awareness (Section 2.1.2), combined with the strengthening of recycling niches (Section 3.3.3), the transition pathway could change in the near future.

When it comes to government actors, power and trust issues take a different meaning, which is more related to the clashes between national and subnational governments [53] (Section 4.2.1) that originate on the political situation in the country (Section 2.1.2). This ultimately manifests in the "selfish interests" mentioned in Section 4.2, which in this case arise from political calculations about the possible political outcomes of any event or decision (e.g., how it can offer an advantage over political rivals), rather than the public benefit. A telling example of political self-interest has been the case of the Alpacoma landfill (Section 3.3.2).

Finally, when it comes to state-society relationships, many local transition scholars have argued that trust-building is crucial for adopting a common transition vision, which could facilitate public acceptance, and ultimately the allocation of funds to steer effectively the transition [43,128,129]. As our case studies portray, trust in state-society relationships is a fundamental element of MSWM activities, from accepting changes in collection fees (Section 3.3.1), to allowing the construction of recycling facilities near residential areas (Section 3.3.2). For example, the unfulfilled promises of local authorities and the high turnover of government officials contributed to the absence of trust in a waste management project in a semi-rural Bolivian municipality [75].

5. Conclusions

This study unraveled the transitions in the MSWM systems in two Bolivian cities, and the factors that have enabled and hindered them. The two cities have experienced largely the same transitions in their MSWM systems, from "Collection and centralized disposal", to "Environmentally controlled disposal", and "Integrated solid waste management". However, the observed transitions took much longer to occur compared to other developed countries. Furthermore, the timelines, speed and elements of these transitions are somewhat different between cities, largely due to their inherent characteristics, institutions and stakeholder dynamics.

This has led to a complicated panorama where it is difficult to prioritize approaches or concentrate resources in a few goals. However, the results indicate some common challenges and opportunities for enabling the transitions, including the need to enable effective collaboration among different government levels, and align the economic interests of the various actors involved in MSWM systems. Issues related to the political system, power and trust are among the most important landscape factors influencing the MSWM transitions in the country.

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