Evaluating Solid Waste Management in and Around IIT Mandi: A Catalyst for Environmental Activism

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Evaluating Solid Waste Management in and Around IIT Mandi: A Catalyst for Environmental Activism

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Abstract

IIT Mandi's growth has led to increased waste production in its surrounding region, posing health and ecological risks if improperly managed. Our project assessed local waste systems, advocated for community activism, and proposed sustainable improvements. Interviews and observations revealed single-use plastics as the region's major concern. We noted waste segregation issues on campus and misuse of a nearby landfill. Our primary recommendation was to streamline on-campus waste management. We persuaded officials to clean up the misused landfill, piloted an environmental club to promote sustainability, and organized a cleanup drive. Our goal was to improve campus waste management, strengthen ties between IIT Mandi and nearby communities, and promote campus and community activism.

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Executive Summary

Global municipal solid waste (MSW) production has surged over recent decades, reaching an estimated 2 billion metric tons in 2016 and is expected to only exponentially increase (Kaza et al., 2018). This growth is fueled by population growth and urbanization, resulting in larger waste generation per capita. A microcosm of this trend lies in the Kamand valley of Himachal Pradesh, India, where the establishment of the Indian Institute of Technology (IIT) Mandi has spurred rapid urbanization in a once deeply rural and agrarian region.

The influx of university residents and resources has led to the rapid development of shops, restaurants, and services to cater to their needs. However, this surge in population and economic activity has also brought about the uncontrolled accumulation of unsorted garbage, mirroring global concerns. A 2016 study by Worcester Polytechnic Institute (WPI) and IIT Mandi shed light on these challenges, particularly regarding waste segregation and education initiatives, and this project builds upon their efforts.

Inadequate municipal solid waste management (MSWM) poses severe threats to public health and the environment. The first crucial step is waste segregation at the source, a focal point of our study. Regarding categorization, in Indian municipalities, waste is typically sorted into wet (biodegradable) and dry categories. Segregation at the source using these categories enables effective waste management but hinges on community awareness of waste's societal impact.

To address these challenges, our project documented and evaluated waste management systems in and around IIT Mandi, advocated and tested environmental activism initiatives in the area, and recommended improvements to relevant waste management stakeholders.

Methodology

We structured our project around three primary objectives: documenting local stakeholder perspectives and the history of MSWM in the area, understanding local waste composition and infrastructure, and promoting environmental activism in and around IIT Mandi.

Objective 1: Document Stakeholder Perspectives & Local MSWM History

To document local perspectives, we conducted interviews with residents, shopkeepers, and local leaders around IIT Mandi, utilizing questions outlined in ***Appendix B***. These interviews aimed to understand current stakeholder viewpoints on MSWM. Additionally, we interviewed the Municipal Corporations of Mandi and Shimla to contrast our findings with established waste management systems. Afterwards, we transcribed and analyzed these interviews for patterns.

Objective 2: Understand Existing Waste Infrastructure & Composition

We employed various methods to understand local waste infrastructure and composition. Utilizing semi-structured interviews with stakeholders allowed us to ensure basic information

was consistently gathered while the free-flowing conversational aspect allowed us to collect information we did not expect. We also maintained fieldwork diaries with photographs to record our observations of local MSWM systems and conducted site visits to document existing infrastructure and learn from site facilitators.

Objective 3: Promote Campus & Community Activism

Lastly, we aimed to promote environmental activism by facilitating the establishment of the *Wildlife and Ecology Club* on campus. We worked with an IIT Mandi PhD student to draft an official club proposal and conducted a local cleanup drive with twenty WPI students, IIT Mandi students and faculty, and waste management officials to pilot community engagement efforts.

Results & Discussion

Plastic Waste Emerges a Primary Concern

The primary concern among residents in the rural communities surrounding IIT Mandi was the increasing presence of plastic waste. While these communities have historically managed other waste types through established systems, such as feeding food waste to animals for compost, the introduction of plastic disrupted these practices. Although some plastic waste can be repurposed, certain types, like chip bags, present challenges for reuse. Consequently, many residents resort to unsustainable disposal methods: tossing plastic into rivers and down mountain slopes or accumulating and burning it in pits. These reflect an "out of sight, out of mind" approach.

Inconsistencies in IIT Mandi's Waste Management System

While staying in IIT Mandi's North Campus hostels, we noticed minimal litter on campus grounds. However, access to dustbins on campus was inconsistent, with colored plastic bins indoors lacking uniformity and clear labeling, posing challenges for waste sorting by residents. Often, stray dogs dug through and knocked over dustbins, especially near canteens and even inside hostels. This highlights the need for improvement waste containment measures.

Disconnect between the Administration and Students at IIT Mandi

Throughout our project, we observed a disparity between the intentions and knowledge of IIT Mandi administrators and the broader university community. For example, the Department of Infrastructure and Services was confused by questions regarding dustbin color-coding and access, indicating a lack of communication between the users of the system and the managers of it. This has led to challenges in waste segregation for students due to the absence of consistent labeling and standardized bins, especially in student hostels.

During our interviews with municipal officials in Mandi and Shimla, we found a shared commitment to addressing MSWM issues. Both administrations emphasized waste segregation at the source as a crucial element of an effective MSWM system. They stressed the importance of minimizing the need for waste filtering at facilities through proper segregation by residents. It

was deemed essential to raise awareness among the population about MSWM to ensure residents' cooperation and investment in the system's functionality. This cooperation is not present at IIT Mandi, causing difficulty in MSWM for both students and the administration.

Additionally, IIT Mandi's officials were unaware of unauthorized dumping in a nearby landfill used by their third-party MSWM company, who is responsible for dry waste at IIT Mandi. The outcome of this interaction is discussed in the following section.

Strong Potential for Environmental Activism at IIT Mandi

During our project, we discovered a nearby landfill causing significant environmental and health risks, which we linked back to IIT Mandi through packaging addresses found in its waste. In response, IIT Mandi swiftly intervened, penalizing the third-party company responsible and launching a cleanup operation. This success highlights the impact of student activism in addressing environmental concerns and advocating for positive change.

Given the waste practices in surrounding villages, waste often accumulates in specific areas. Leveraging its resources, IIT Mandi can lead systematic and regular collection and disposal efforts in these communities. This not only enhances community cleanliness but also strengthens connections with residents of the area and bolsters the institute's reputation.

Recognizing the potential for student-driven environmental initiatives to enact lasting change, we proposed the *Wildlife and Ecology Club* at IIT Mandi. Collaborating with dedicated students and faculty, we refined its official proposal and engaged with local leaders to stress the importance of MSWM sensitivity and activism. While awaiting official recognition by the institute, we conducted a cleanup drive around the previously misused landfill to promote the club's power.

Recommendations

Following our project, we have formulated recommendations to enhance MSWM in and around IIT Mandi. These are directed at two primary stakeholders: IIT Mandi's Office of Infrastructure and Services and the Wildlife and Ecology Club.

Recommendation 1: Streamline Waste Management on Campus

To enhance the MSWM system at IIT Mandi, we suggest streamlining waste segregation practices. This involves accurately categorizing waste into wet and dry types, employing distinct bin colors (green for wet waste and blue for dry waste) and implementing clear labeling. It is vital to provide consistent training for mess halls and canteens to prevent waste mixing and improve collection efficiency. Initial communication efforts, such as posters and emails, can raise awareness, with ongoing support from the *Wildlife and Ecology Club*. By prioritizing simplicity and convenience, this recommendation aims to optimize waste disposal processes for students and waste workers while conserving resources.

Recommendation 2: Actively Monitor Third-Party Company & Disposal Practices

To address inconsistencies in waste disposal by the third-party MSWM company managing campus' dry waste, we propose implementing rigorous monitoring measures. This involves conducting surprise visits to waste collection sites and the misused landfill to ensure compliance with proper disposal procedures. Regular inspections by officials would enable swift action in cases of non-compliance, such as imposing fines or providing retraining for workers. Additionally, establishing a communication channel for students to report MSWM issues would enhance transparency and accountability.

Recommendation 3: Feed Stray Dogs Food Waste

In response to the presence of hungry stray dogs scavenging for food scraps on campus, we recommend implementing a method to feed them with food waste. The *Wildlife and Ecology Club* can lead this initiative by diverting a portion of daily food waste to alleviate the dogs' hunger. Careful consideration must be given to ensure the safety of the food provided, with research into suitable options advised. This effort not only improves the welfare of stray dogs but also fosters a cleaner campus environment and reduces instances of aggressive dog behavior.

Recommendation 4: Conduct Further Cleanup Drives with Passionate Students

We recommend utilizing students' enthusiasm by organizing periodic cleanup drives on and around campus through the *Wildlife and Ecology Club*. Integrating these events into campus culture would showcase IIT Mandi's dedication to environmental stewardship. Consistent student involvement in cleanup activities can also raise local awareness to environmental issues.

Recommendation 5: Communicate with EWOK for Running a Thrift Drive

Based on our discussions with the Enabling Women of Kamand Valley (EWOK) nonprofit organization, we suggest that the *Wildlife and Ecology Club* partner with them to host a thrift drive on campus. This initiative aims to collect clothing and other items for resale or repurposing in nearby communities. By leveraging EWOK's expertise and resources alongside club members' enthusiasm, this collaboration can foster community connections between IIT Mandi and its surroundings, positively impacting campus life and broader environmental activism.

Future Work and Conclusions

Moving forward, we suggest broadening MSWM projects at IIT Mandi to tackle various facets of MSWM, particularly addressing issues posed by plastic. Partnering with the *Wildlife and Ecology Club* can integrate environmental awareness into both the curriculum and marketing.

This project, initially focused on municipal solid waste management (MSWM) technological recommendations, has transformed into a platform for environmental activism. As we hand over the reins to upcoming student leaders, we encourage efforts to promote environmental consciousness and advocacy.

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Chapter 1: Introduction

Global municipal solid waste (MSW) production has surged over recent decades, reaching an estimated 2 billion metric tons in 2016 and is projected to nearly double by 2050 (Kaza et al., 2018). The consequences of inadequate municipal solid waste management (MSWM) are severe, posing significant threats to public health and the environment (Environment, 2015). Rapid urbanization worsens local MSWM challenges across Himachal Pradesh, India, particularly in Mandi District, where tourism and recently founded institutions like Indian Institute of Technology (IIT) Mandi drive this trend. The increase in population and economic activity has led to uncontrolled accumulation of unsorted garbage, paralleling global concerns.

A 2016 study by Worcester Polytechnic Institute (WPI) and IIT Mandi highlighted existing MSWM challenges in the region, including improper waste separation for processing, limited formal waste collection in nearby villages, and low community awareness (DiSpirto et al., 2016). However, the study's major limitation was its minimal community involvement in recommendations and improvements. While it proposed technological enhancements and curriculum improvements, it overlooked the importance of addressing community awareness and understanding of the necessity for these changes beyond classroom education initiatives.

To address these concerning issues, our project documented and evaluated MSWM systems in and around IIT Mandi. Our approach aimed to understand stakeholder perspectives, assess current practices and facilities, highlight challenges within existing systems, promote environmental activism, and recommend feasible improvements to appropriate stakeholders.

Through interviews, fieldwork diaries, and waste processing facility visits, we aimed to empower and inspire stakeholders with qualitative data-driven insights. Our goal was to pave the way for increased environmental awareness and more sustainable MSWM decisions.

Chapter 2: Background & Literature Review

Focused on Mandi District in Himachal Pradesh, India, this chapter provides an overview of municipal solid waste management (MSWM) and the related context of IIT Mandi. Considering Mandi District's unique challenges, culture, and environment it is essential to promote environmental activism and offer feasible recommendations, as we recognize there is not a universally applicable "technological solution" for MSWM.

Navigating the Global & Local Challenge of Urbanization

Under relentless urbanization and population growth, MSWM must address urban development, public health, environmental sustainability, and societal expectations. MSWM refers to the handling, collection, transportation, treatment, and disposal of urban garbage, including waste from households, institutions, and restaurants. It does not include liquid waste like sewage.

The scale of global MSW generation is staggering, estimated at 2.01 billion metric tons annually in 2016 and projected to rise to 3.40 billion tonnes by 2050. Additionally, it is estimated that at least 33 percent of this waste was not sustainably handled, and 12 percent of global waste is specifically attributed to plastic waste, a type of waste with dangerous environmental impacts (Kaza et al., 2018). While communities worldwide face MSWM difficulties, developing countries face amplified challenges due to limited resources and infrastructure, especially as the composition of waste evolves and becomes increasingly complex to manage (Ferronato & Torretta, 2019).

Shifting to the local context of Mandi District, the establishment of IIT Mandi in 2009 triggered rapid transformation in the region. Despite drastically varied elevations, IIT Mandi's campus, located along the bank of the Uhl River at Kamand and Salgi villages, lies within the lowermost climatic zone of the Himalayas, as seen in ***Figure 1*** (IIT Mandi, 2024a). Spanning an area of 538 hectares over two campuses, IIT Mandi houses over 2000 students and nearly 200 faculty and staff members (IIT Mandi, 2024b).

Figure 1: Satellite imagery of IIT Mandi's campus (Google, 2024).

Given the region's rural nature, the establishment of a technology-oriented institution and student influx have led to significant changes in the once deeply agrarian area, prompting nearby communities to undergo accelerated development. These communities have adapted by establishing service-oriented businesses, including housing, eateries, and shops. As IIT Mandi has emerged as a major solid waste generator, it has also introduced new volumes and types of waste in the region, heightening the urgency to address SWM within the campus and surrounding villages. These communities are grappling with unfamiliar waste streams, indicating that IIT Mandi should bear partial responsibility for its impact on these fragile environments.

Recognizing the urgent need for improvement, a 2016 study conducted by WPI and IIT Mandi students assessed the MSWM systems in and around IIT Mandi. The study developed models for each system and revealed that while IIT Mandi provided colored dustbins for waste, they were not appropriately labeled, resulting in minimal waste separation. If waste is not segregated at the source, waste management facilities incur higher costs and longer processing times due to manual segregation by laborers. The study found that nearby communities lacked MSWM education in their curricula.

The team prototyped painted labels for the dustbins and designed corresponding lids to clarify waste segregation. For instance, the food waste bin featured a lid with an apple symbol. Additionally, the team suggested educational initiatives, like environmental brochures and Earth Day events, and establishing recyclable collection through a third-party in communities that lacked one. However, these changes were only prototyped and not officially implemented. (DiSpirto et al., 2016).

The 2016 study highlighted the need for continuous research to monitor MSWM challenges in IIT Mandi and neighboring villages to offer insights for sustainable decision-making and potential case studies. However, the report's impact on IIT Mandi was limited due to incomplete implementation of recommendations and insufficient community involvement. Considering IIT Mandi's resources and location, our project initially focused on campus, then extended efforts to actively engage local communities, aiming to broaden environmental awareness beyond campus borders.

Understanding MSWM: Definitions & Categories

Municipal solid waste (MSW), commonly known as 'garbage,' encompasses various waste types encountered daily worldwide, including household, office, institutional, and retail waste (University of Michigan, 2023). To aid in better management, MSW is categorized based on its composition. GreenSutra, an environmental consultancy based in Mumbai, classifies MSW into two main categories commonly used across India: dry and wet waste. This separation is crucial to prevent contamination when storing these types of waste together. If mixed, the waste is often difficult or costly to separate for treatment, leading to untreated waste being dumped in landfills

(GreenSutra, 2017). Consequently, we have adopted this waste categorization for our project.

Dry waste includes non-soiled materials, including recyclable and non-recyclable items. Recyclable waste includes waste such as bottles, cans, paper, glass, and certain plastics that can be recycled into new products (Waste Management, 2024). Non-recyclable waste, or 'residual' waste, comprises materials unsuitable for recycling or composting. It is often mixed with soiled materials, hindering efficiency (Felder et al., 2001; Valley Waste Service, 2019).

Wet or 'compostable' waste includes organic materials like food scraps, wrappers, paper towels, and shredded paper, suitable for composting, a process that converts them into nutrient-rich compost, enriching soil and promoting plant growth (US EPA, 2023). ***Figure 2*** highlights these two main categories and how easy it is to differentiate between them.

Figure 2: India's main categories for municipal solid waste (Adapted from GreenSutra, 2017).

Exploring the MSW Cycle: Phases and Processes

When modeling MSWM systems, MSW's lifetime is usually composed of four phases: generation, collection and transport, treatment and repurposing, and disposal (Demirbas, 2011).

- Generation: Generating waste from residential, commercial, and institutional activities.
- Collection and transport: Collecting waste from various sources and transporting it. Efficient MSWM often requires segregation at the source, where waste is placed in designated bins according to its type.
- Treatment and repurposing: Treating MSW to transform it into a more benign state or recover usable materials. This can include reducing volume, toxicity, and environmental impact. Repurposing converts waste into new products and can ideally loop back to the generation phase.
- Disposal: Disposing of remaining waste, typically through landfilling or incineration.

In Himachal Pradesh, wet waste dominates, with 67% of its population directly relying on agriculture for their livelihood (Directorate of Urban Development, 2015b). This still reflected in more urban areas, as an examination of an open dumpsite in the Mandi area revealed that approximately 56% of its total waste, by weight, was organic (Sharma et al., 2018).

MSW collection and transportation in the region are inconsistent, with communities using different collection methods such as door-to-door collection and communal waste bins. The mountainous terrain of the region massively increases the cost and difficulty of this phase. Some areas outside municipal jurisdiction lack a formal system entirely, leading to common practices of open dumping and burning. In these cases, informal collectors, known as rag pickers or Kabariwalas, collect valuable waste and sell it without formal regulation (Directorate of Urban Development, 2015b).

Limited treatment, repurposing, and disposal facilities exist in Mandi District due to its mountainous terrain and high maintenance and transportation costs. A flowchart illustrating the MSW cycle in Shimla, Himachal Pradesh, is provided in ***Figure 3***. Key features include the presorting unit at the MSW facility, where waste is segregated onsite rather than at the source, requiring more manpower and separation technology. Additionally, refused-derived fuel (RDF) is produced from various types of MSW, including non-recyclable plastics and paper cardboard. RDF is utilized in costly but sustainable waste-to-energy facilities to generate electricity and thermal energy.

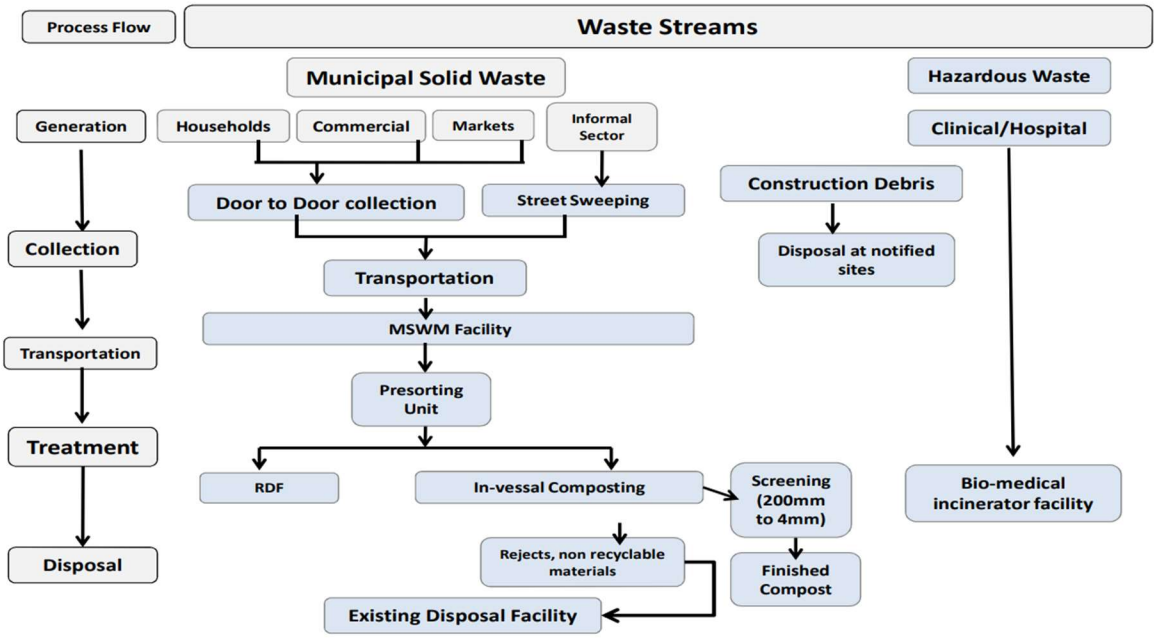

Figure 3: A MSW Cycle Flowchart for Shimla (Adapted from Bharti et al., 2014)

The Adverse Impacts of MSW

In Himachal Pradesh, open dumping and burning of trash are prevalent issues, particularly in rural communities (Balu et al., 2020). These practices lead to alarming public and wildlife health implications, particularly deadly disease transmission through poorly maintained facilities and unregulated practices (Ziraba et al., 2016). Water runoff from trash accumulations further pollutes local ground and surface water systems, posing chronic ecological and public health risks (Mukherjee et al., 2015; Sharma et al., 2018). Moreover, they contribute to mental health issues among residents due to unsightly appearances and harmful odors, while also creating breeding grounds for disease vectors like mosquitoes (Balu et al., 2020; Njoku et al., 2019).

Additionally, unmanaged waste burning emits harmful substances, worsening respiratory diseases and increasing cancer risks due to released carcinogens (Estrellan & Iino, 2010; Vinti et al., 2023). Addressing these challenges requires a comprehensive approach that integrates effective waste collection, treatment, disposal, and community involvement.

MSWM Stakeholders and Public Perception in Himachal Pradesh

Stakeholder involvement is vital to Himachal Pradesh's waste management, given its fragile ecosystem and rapid development. In Himachal Pradesh, governmental MSWM stakeholders are broadly categorized into three levels: government bodies, directorates, and municipalities (Pandey et al., 2015). The government provides land for MSWM infrastructure, while directorates act as intermediaries, with subcommittees overseeing various MSWM aspects.

Municipalities, including Panchayats (village councils), educational institutions, shopkeepers, and homesteads, are responsible for MSWM at the local level (Directorate of Urban Development, 2015). Despite government initiatives and policies, many small municipalities struggle due to inadequate infrastructure and funding, leading to harmful MSWM practices as discussed earlier (Ministry of Housing and Urban Affairs, 2018). Among municipal stakeholders, Panchayats, chosen by their communities for their wisdom and conflict resolution skills, are pivotal in implementing MSWM practices and driving change (PRIA, 2024). In Himachal Pradesh, grassroots MSWM initiatives, often led by Panchayats, are prevalent in many villages due to the limitations of top-down access and policies in rural areas.

Our background research highlights the MSWM challenges of rapid urbanization in areas like Mandi District. Rural residents often shoulder the burden of MSWM due to their exclusion from municipal jurisdictions, resulting in limited resources for education and sustainable practices (Gupta & Thakur, 2022). A challenge lies not only in understanding MSWM but also in fostering public motivation for modern practices, especially concerning waste segregation and plastic disposal. MSWM issues in rural communities have only intensified with the influx of plastics, presenting new challenges to traditionally effective MSWM practices. Our project aims to understand these issues through local perspectives for effective community activism.

Chapter 3: Methodology

This methodology chapter outlines the techniques employed for data collection and analysis during the fieldwork phase of the project. With our overall project goal being *"To evaluate and improve MSWM systems in IIT Mandi and nearby communities, promote campus and community environmental activism, and identify feasible MSWM improvements,"* we have summarized our objectives, methodologies, and action items in ***Figure 4***.

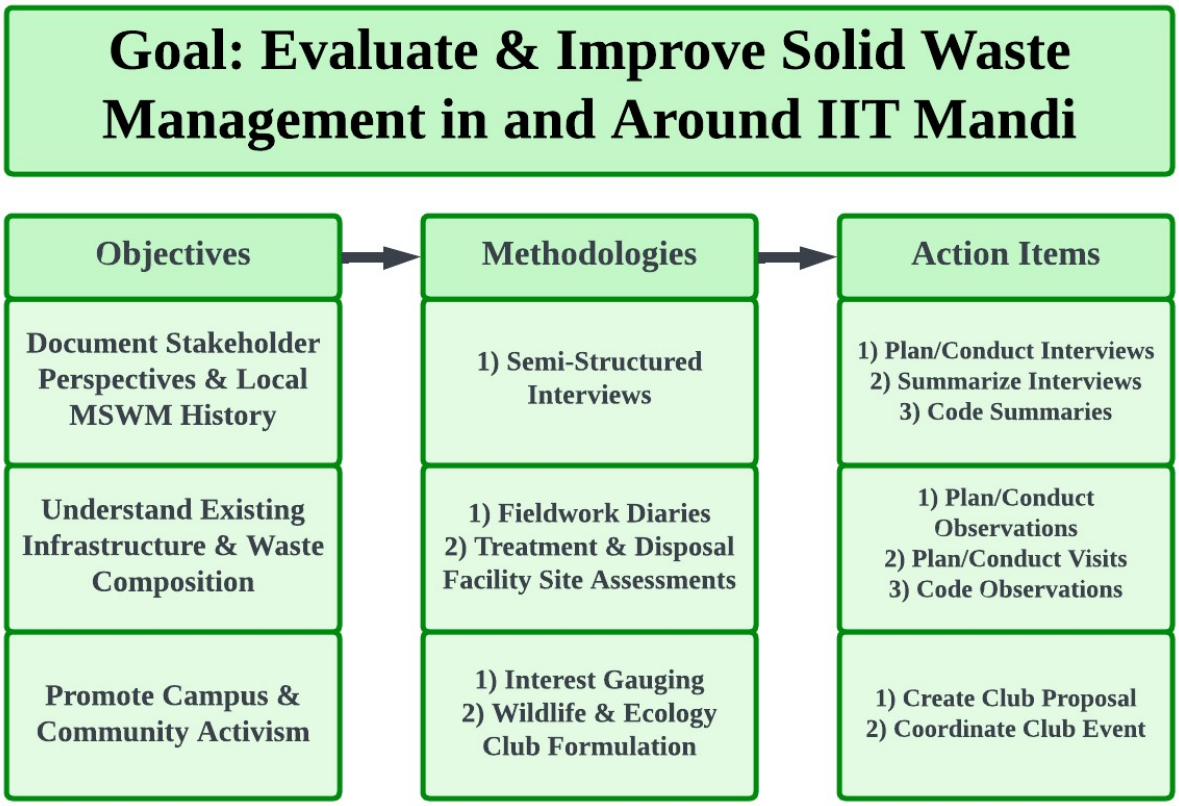

Figure 4: A breakdown of the project's objectives, methodologies, and action items.

Objective 1: Document Stakeholder Perspectives & Local MSWM History

Our primary objective was to document the perspectives of MSWM stakeholders to understand the sources of MSWM success and challenges, along with comprehending the evolution of MSWM in the region, particularly following IIT Mandi's establishment. To achieve this objective, we conducted semi-structured interviews to document waste generation and disposal practices, including quantity, composition, and sources. We also explored attitudes and traditions regarding MSWM, perceptions of past and existing systems and policies, and changes observed in the region over the years, including the impact of different waste streams on local communities.

Our interviewing processed involved:

- Simultaneous interviews by team members, adapting to the number of interviewees.
- Consent-based (see ***Appendix A***) recording for future analysis.
- Use of a standardized questionnaire (see ***Appendix B***) to guide the interview while allowing open-ended dialogue.

Field visits were planned, and interviews were conducted, with their recordings used for summarizing discussions for coding to identify patterns and quantify commonalities. Interviews involved various MSWM stakeholder groups, including IIT Mandi affiliates, Panchayats, shopkeepers, and waste management workers. An initial observation from interviews, applicable to our next objective, highlighted the increased plastic waste influx due to IIT Mandi, posing challenges in MSWM for nearby communities despite their historical MSWM success.

Objective 2: Determine Waste Composition and Infrastructure

An understanding of the local waste composition and the capacity of the local infrastructure is essential for making accurate and effective recommendations to improve local MSWM systems. Using fieldwork diaries, we documented our observations of the local MSWM systems by observing, photographing, and recording how each of the different communities and facilities we visited collected and disposed of MSW, noting common types of visible waste.

We scheduled visits to local treatment and disposal facilities to conduct site assessments of the waste management capabilities within the region and evaluate the success of segregation at the source. Additionally, we gathered information on the maintenance and history of these facilities, working to document any changes over time, particularly regarding waste segregation and plastic waste, as its impact was highlighted in our first objective.

Objective 3: Promote Campus & Community Activism

Our final objective centered on fostering community involvement within IIT Mandi. Establishing an environmental group on campus is essential for ensuring that students have a platform to uphold the environmental standards initially set by the institution. To kickstart the club, we accomplished the following two action tasks:

- Created a club proposal outlining goals derived from data collected in our previous objectives in collaboration with IIT Mandi students and faculty.
- Organized and facilitated a community clean-up before our departure.

Chapter 4: Results & Discussion

In this chapter, we present the outcomes of our fieldwork, where we gathered and analyzed data from semi-structured interviews, fieldwork diaries, and site assessments. Our goal was to gain insights into various practices and perspectives regarding MSWM across different settings. To achieve this, we aimed for diversity by choosing IIT Mandi (an institute), Salgi (a low population rural village), Kataula (a higher population rural village), Mandi (an urban city), and Shimla (a high population tourist city) to compare the MSWM practices, successes, and challenges across different settings.

Stakeholder Perspectives & Local MSWM History

While we inevitability faced convenience sampling issues due to our limited access to Hindi translators and transportation, we still aimed to interview as diverse a range of MSWM stakeholders as possible. Through this approach, we wanted to identify potential patterns among the diverse locations and gain an understanding of the MSWM outlook in the region.

IIT Mandi Infrastructure & Services Interviews

Upon discovering that IIT Mandi's MSWM fell under the Office of Infrastructure and Services, we interviewed the Dean of Infrastructure and his team. These officials became key contacts for the project, providing valuable insights and support throughout. Major insights include:

- Waste Types: IIT Mandi focuses on dry and wet waste, with efforts made for source segregation of plastic, metals, and e-waste. Plastic waste is especially associated with yellow. However, there are no plastic, metal, or e-waste processing facilities on campus.
- Dry Waste: Collected daily from households and hostels, managed by an outsourced company, and is supposed to be transported to a landfill site in Mandi, about 30 minutes away.
- Wet Waste: Collected from messes and proceeded at the South Campus biogas plant, converting wet waste into natural gas used for cooking.
- Waste Segregation: Each household receives two dustbins for wet and dry waste, while hostels have three for wet, dry, and plastic waste. Initial segregation is encouraged, but the outsourced company handles final separation.

Following discussions with these officials, we identified a significant disconnect between their perspectives, those of the outsourced company, faculty, and students regarding MSWM. For instance, while the officials stated that dry waste should be disposed of in Mandi's landfill, as we will discuss later, we observed the company dumping it at an unregulated site near IIT Mandi's North Campus. Furthermore, when asked about waste color coding, the Dean of Infrastructure and Services provided no clear answer and seemed confused about additional colored bins on campus. Additionally, the discrepancy between households receiving two dustbins and hostels three dustbins highlighted a lack of uniform MSWM policy across campus.

Salgi Interviews

In Salgi, we conducted six interviews with residents, shopkeepers, and representatives from the Enabling Women of Kamand Valley (EWOK) nonprofit organization. These interviews centered around the interviewee's interactions with MSW and how their community handled MSWM. Furthermore, the effect of plastic waste on Salgi often became the focus of interviews. Key findings include:

- Wet Waste: Traditionally immediately fed to animals, composting is seen as cumbersome.
- Waste Collection & Disposal: Lacks a formal collection system. Although dustbins were once provided by local bodies, they were never properly collected.
- Dry Waste Pits: Efforts to collect dry waste in designated locations, typically pits, results in burning or burial.
- Mountain Slopes: Downhill terrain is frequently used as a convenient dumping ground, with residents considering it an "out of sight, out of mind" solution.
- Plastic Waste: Increased plastic waste, often attributed to the establishment of IIT Mandi, has disrupted effective MSWM in Salgi. The widespread adoption of plastic over traditional sustainable alternatives, like leaf plates, has left residents struggling with safe disposal methods.
- Government Influence: The absence of Mandi Municipal Corporation in the region limits the impact of government policies. However, the notable ban on plastic bags has been widely implemented, with most stores providing non-plastic alternatives for customers.

Through our interviews, we found it challenging to foster community involvement when external entities, particularly businesses, entered. These outsiders often lacked sensitivity and awareness about MSWM, resorting to careless disposal methods like open burning and dumping. This complicates efforts to raise environmental awareness. However, conversations with EWOK revealed an interest in collaborating with and mentoring an environmental club, such as organizing a clothing thrift drive, at IIT Mandi. By going beyond campus boundaries, a club mentored by a community leader like EWOK could bridge gaps between communities.

Figure 5: Salgi shopkeeper interviews (March 19).

Kataula Interviews

In Kataula, we conducted three hour-long interviews with shopkeepers and Panchayat officials to understand the village's waste management practices and opinions on local leader interventions for MSWM. From these discussions, the following significant findings emerged:

- Traditional Waste Management: Kataula employs sustainable methods for easy-to-handle waste, like composting food waste by feeding cows and repurposing cloth into bedding.
- Plastic Waste: Residents struggle with plastic that cannot be repurposed, like chip bags, resorting to burning or river dumping. Plastic interrupted a period of a circular economy, where Kataula would also recycle and reuse all their waste.
- Waste Collection & Disposal: Lacks a formal collection system and the funding for one.

From these interviews, we were impressed by Kataula residents' understanding of waste disposal, especially with wet waste. However, the introduction of plastic waste posed challenges, leading residents to resort to improper disposal methods. While our project does not focus on technological improvements, Kataula's struggle highlights the urgent need for a dedicated study to manage plastic waste. These communities lack government support, infrastructure, and access to plastic processing facilities. Despite these challenges, Kataula's primary school presents an opportunity for collaboration with IIT Mandi, such as organizing a cleanup drive with local children. Witnessing such an event may prompt residents to reconsider their plastic disposal practices in the long run.

Mandi Interview with Municipal Corporation Officials

In Mandi, we held a 90-minute interview with Municipal Corporation officials and the mayor. This interview focused on city policies, technologies, and social aspects of MSWM. Significant findings from this interview include:

- Waste Collection & Disposal: Mandi operates a central waste landfill and material recovery facility, requiring collection vehicles across fifteen districts. Dry waste is shredded and compacted, while wet waste is directed to separate composting pits. Households pay 30 Rs monthly for collection.
- Public Dustbins: Prohibited in Mandi, residents are encouraged to carry waste home due to a lack of manpower and the cost associated with collecting dustbins scattered throughout the city.
- Waste Segregation: While households are provided with green (for wet waste) and blue (for dry waste) dustbins for sorting, residents frequently mix waste, requiring manual sorting at the material recovery facility. This process is slowed by limited manpower, leading to delays of up to three to five days for separating mixed materials like plastic and food.
- Waste Processing Decentralization: Officials plan to decentralize processing facilities, constructing them for individual districts to reduce the main facility's workload.

During our discussions with the Mandi Municipal Corporation, we gained insight into the critical role of waste segregation at its source. The lack of this practice significantly complicates Mandi's MSWM treatment processes, despite the city's access to MSWM processing technology. Mixed waste often hampers treatment efforts, leading to doubts about the value of waste treatment. This interview highlighted the significance of grassroots initiatives and the importance of community activism. Despite Mandi's resources and infrastructure for MSWM, the core issue persists at the grassroots level, where residents struggle to grasp the importance of waste segregation and proper disposal.

Figure 6: Mandi Municipal Corporation officials and mayor interview (March 26).

Shimla Interview with the Deputy Commissioner & Municipal Project Coordinator

During our hour-long interview in Shimla, we discussed the city's MSWM systems and each phase comprehensively. We also explored social dimensions and future enhancements. Key insights include:

- Waste Collection: Daily collection from households and businesses, with segregation of wet and dry waste.
- Source Segregation: Pre-COVID, achieved an 80% success rate. Pandemic disruptions prompted a restart.
- Dry Waste: Utilized to produce electricity through a gasification process.
- Wet Waste: Despite plans for a biogas plant, current management struggles to manage wet waste.
- Future Priority: The foremost concern is to enhance awareness and encourage resident cooperation, with a specific emphasis on engaging school eco-clubs to lead educational initiatives.

Our Shimla interview reaffirmed our previous findings from Mandi. The official we spoke to, with a PhD in solid waste management and twenty-five years of experience in the field, provided invaluable advice regarding school clubs, further shaping the direction of our project.

Existing Infrastructure & Waste Composition

Throughout our fieldwork phase, we recorded key MSWM moments through field diaries and photography. During our time at IIT Mandi, we actively engaged with the campus' MSWM system and documented our interactions with waste generation, collection, and disposal. Targeted observations were conducted at key project sites, including hostel dustbins and drainage systems, where we closely monitored changes. Additionally, visits to Salgi and Kataula were documented with photographs from observational walks. Furthermore, our visit to a waste-to-energy facility in Shimla provided valuable insights.

IIT Mandi Observations

Our observations on IIT Mandi's campus focused primarily on dustbins, where two types of communal dustbins were primarily used: colored plastic bins indoors and metal bins outdoors. While indoor bins occasionally had lids to deter animals and insects, they lacked uniformity and clear labeling. On our hostel floor, we observed inconsistency in dustbin access. Initially, three separate bins were present, with only one having a lid. However, over time, the number, colors, and availability of lids varied drastically, as seen in ***Figure 7***.

Figure 7: Dustbin variation on the third floor of an IIT Mandi hostel over a month (March 12, March 16, and April 4).

The inconsistent arrangement of hostel dustbins explains why the Dean of Infrastructure and Services was perplexed when questioned about dustbin color-coding at IIT Mandi. This lack of labeling and color-coding significantly contributes to student difficulties in waste segregation, worsened by deviation from the standard green-blue color scheme for wet and dry waste. The surplus of unlabeled indoor bins, especially in hostels, complicates MSWM at IIT Mandi, evident in instances like the waste pile show in ***Figure 8*** on the hostel's second floor.

Figure 8: A waste pile on a hostel floor lacking consistent dustbins (April 22).

Furthermore, during our dustbin observations, we witnessed stray dogs interacting with indoor dustbins, particularly near canteens. They would often knock over bins to access wet waste when lids were missing. Additionally, we witnessed a stray dog entering a hostel, retrieving trash from an open dustbin, and dropping it on the ground outside as litter. ***Figure 9*** depicts some of these incidents.

Figure 9: Stray dogs interacting with IIT Mandi dustbins and wet waste (March 13, March 15, and March 20).

The accessibility of food waste to stray dogs poses both aesthetic and and health concerns. Frequently, this waste contains harmful materials like plastics and metals, which dogs may ingest. Our observations revealed that dogs typically rummage through bins without lids, likely attracted by the smell of waste. Therefore, ensuring that indoor dustbins have lids, particularly on ground floors, could prevent dogs from accessing waste and causing further mess.

Salgi & Kataula Observations

In addition to our observations at IIT Mandi, we conducted walks in Salgi and Kataula, noting MSWM observations. Waste often accumulated in open drains and on river rocks, following natural water pathways. Disposal frequently occurred downhill from slopes, in collection pits, or openly burned on streets. ***Figures 10 and 11*** display these findings:

Figure 10: Photos of an open burning pile, a waste collection pit, and drainage buildup in Salgi (March 17 and March 19).

Figure 11: Photos of waste in rivers and off slopes in Kataula (March 14).

Considering how waste consistently accumulates in specific locations within these villages, establishing regular cleanup drives could go a long way. Given the lack of external resources in these villages, IIT Mandi could play a pivotal role in implementing a systematic collection system through scheduled cleanup drives. These drives would involve removing waste from identified locations, potentially segregating it, and handing dry waste to IIT Mandi's third-party company for proper disposal. This initiative not only aids in community cleanup but also strengthens bonds with local communities, enhancing IIT Mandi's reputation in the region.

Shimla Waste-To-Energy Facility Visit

Additionally, alongside our observations in IIT Mandi, Salgi, and Kataula, we visited a waste-to-energy facility in Shimla. Here, we observed the conversion of dry waste into fuel for producing electricity and cement. Despite being in its early stages, the facility processed a significant volume of waste, contrary to our initial assumption of waste accumulation at the adjacent landfill.

Figure 12: Waste-to-energy facility outside Shimla (April 4).

Observing the dry waste treatment process further highlighted the critical importance of source segregation. Despite the machines' ability to segregate waste with laborers' assistance mixed waste significantly impeded the entire process, echoing our discussions with the Mandi Municipal Corporation officials.

Overall, our observations reinforce the 2016 report's emphasis on waste segregation at the source, and they echo our interview findings. This commonality highlights the necessity for clearer guidelines at IIT Mandi, as the current collection system lacks clarity on bin usage, leading to mixed waste and dog intrusion attributable in part to inconsistent bin lids. Additionally, waste dumped from mountain slopes and in rivers reflected the "out of sight, out of mind" mentality often mentioned in interviews.

Campus & Community Environmental Activism

After weeks of conducting fieldwork, we recognized the potential for a student and faculty-driven environmental initiative to create lasting change at IIT Mandi and its surrounding communities. With this in mind, we launched an environmental club at IIT Mandi in coordination with passionate students and faculty. Municipal officials and local leaders have repeatedly emphasized the importance of school-based education in waste management, reinforcing our initiative.

To kickstart our initiative, we collaborated closely with Jeet Lahiri, a dedicated PhD student at IIT Mandi, who was already developing a proposal aligned with our vision. Together, we refined his ideas, addressed our concerns regarding campus MSWM, and enlisted interested students to bolster the club's potential for student engagement. Thus, the *Wildlife and Ecology Club* was born, aiming to address wildlife and environmental issues, including MSWM. The finalized proposal, included in ***Appendix C***, was submitted for official approval.

While awaiting the club's approval process, we organized a waste cleanup drive in collaboration with the Office of Infrastructure and Services. The cleanup drive proved advantageous for

several reasons. Firstly, it served as a test of the club's operational framework, allowing us to refine the approach to future drives. Additionally, the participation of the Office of Infrastructure and Services officials was invaluable; they provided equipment, such as gloves, trash bags, and a waste collection vehicle, and supervised the cleanup efforts. By engaging with them early in the club's activities, we facilitated future collaboration for club members even after our departure. The third and arguably most significant benefit of the drive was the substantial amount of MSW collected from the road behind IIT Mandi's North Campus. In just two hours, noticeable improvement was achieved in the area's cleanliness, demonstrating that with minimal effort and passionate community members, maintaining a litter-free environment in and around IIT Mandi is entirely feasible.

Figure 13: Waste cleanup drive group photos (April 27).

Although the club's official recognition may not occur during our time in India due to the lengthy approval process, we are confident in Jeet's leadership and passion. To demonstrate the club's potential, the community cleanup drive around the misused landfill with IIT Mandi's Deanery of Infrastructure and Services on April 27th was documented for club promotion.

Unintended Success: IIT Mandi Waste Dump Cleanup

During our IQP's first week, cohort members shared findings from an interview in Salgi, revealing a nearby waste dump killing local animals eating from it. Witnessing animal's eating from it firsthand, as seen in ***Figure 14***, we confirmed the dump's existence, noting its mixture of dry and wet MSW. To trace the source of the waste, we examined packaging addresses and traced some waste back to IIT Mandi.

Figure 1414: Local animals eating waste at the landfill (March 16 and March 22).

After identifying IIT Mandi as a source of the waste, we met with the Dean of Infrastructure and Services, facilitated by Rinki Sarkar. The Dean acknowledged our concerns and explained that the institute's MSWM processes are handled by a third-party company. He expressed surprise and concern about the nearby waste dump. Following up with additional evidence, we prompted the department to act. Consequently, the department assured us that they financially penalized the company and initiated a cleanup operation. Within a day, clearance efforts began, and within a week, most dry waste was removed. We were informed that only wet waste would be dumped at the landfill moving forward; however, if the waste is not segregated, dry waste is still dumped there, bringing the challenge of MSWM back to source segregation on campus.

Figure 1515: Clearance progress of the waste dump (March 16, March 23, and March 28).

Our team's success at the waste dump highlights the importance of establishing the *Wildlife and Ecology Club* on campus. The proactive intervention of a few students, voicing their concerns to administrators, led to swift and positive environmental changes.

Chapter 5: Recommendations & Conclusions

With the completion of fieldwork, involving data collection and analysis, we have developed practical recommendations for immediate implementation in MSWM for IIT Mandi. Furthermore, we have outlined suggestions for future research in this field and region. Finally, reflecting on our project, we have drawn overall conclusions and valuable lessons from our experience as we conclude our project.

Recommendations

Based on our research and fieldwork, we have prepared a series of recommendations to improve MSWM in and around IIT Mandi. These recommendations are targeted towards two main bodies: the Office of Infrastructure and Services, since they oversee MSWM on campus and provide the resources, and the Wildlife and Ecology Club that we are aiming to establish. Additionally, we would like the Office of Infrastructure and Services to inform the third-party company about our recommendations, given they play a pivotal role in MSW collection and disposal on campus.

Recommendation 1: Streamline Waste Segregation on Campus

This recommendation targets the Office of Infrastructure and Services to address the complex MSWM system at IIT Mandi. Despite efforts to segregate waste, confusion persists among students and campus services due to inconsistent practices and mixed-color bins. To streamline the process, we propose adopting a simplified approach like methods observed in other Indian cities we researched.

The suggested approach involves categorizing waste into wet and dry types, aligning with regional practices. Clear bin colors, green for wet waste and blue for dry waste, along with simple labeling, will enable easy identification and adherence. Special attention should be given to training mess hall and canteen staff to prevent mixing of waste types, improving efficiency in collection, and reducing manpower requirements.

To promote awareness and understanding, posters and emails can be utilized initially, with potential involvement from the Wildlife and Ecology Club. Ultimately, the goal of this recommendation is to make waste disposal effortless for students and waste workers, emphasizing simplicity and convenience while conserving resources.

Recommendation 2: Actively Monitor Third-Party Company & Disposal Practices

This recommendation is for the Office of Infrastructure and Services, given their direct involvement with the third-party company responsible for campus MSWM. Our interactions with infrastructure officials revealed a disconnect regarding the actions of this company, particularly concerning improper waste disposal at the nearby landfill. To address this, we propose implementing active monitoring of the third-party company's activities.

Active monitoring involves conducting surprise visits to waste collection sites and the nearby landfill to ensure adherence to proper disposal procedures. We recommend scheduling surprise visits by officials at least once every two weeks to inspect operations firsthand. During these visits, officials can assess MSWM practices and address any mistakes immediately.

In instances of non-compliance, officials should have the authority to issue fines or provide retraining to waste management workers, as demonstrated with the landfill incident. Additionally, establishing a communication channel, such as an email, for students to report issues related to waste collection or disposal would enhance monitoring efforts. This system would enable systems to conveniently report any observations, fostering transparency and accountability in waste management practices.

Furthermore, we recommend that the Office of Infrastructure and Services make efforts to formalize the wet waste dump off campus via the utilization of fencing and signage. Fencing will help keep out domesticated animals, such as dogs, cattle, and goats, while official signage will clarify that the dump site is only for wet waste, discouraging residents and waste management employees from throwing household and dry waste in the site.

Recommendation 3: Feed Stray Dogs Food Waste

In addressing the issue of stray dogs on campus, it is crucial to consider not only the impact on the MSWM system but also the welfare of these animals. Observations have revealed a worrying presence of starving dogs scavenging for food scraps around mess halls and canteens, often resorting to knocking over dustbins in their desperation. While this behavior temporarily alleviates their hunger, it poses risks to their health as they consume potentially harmful substances, including plastics mixed with food waste.

To mitigate this challenge, we recommend that the Wildlife and Ecology Club establish a method of feeding food scraps to these stray dogs. Given the significant amount of food waste generated daily on campus, diverting a portion of it to these animals could alleviate their hunger and reduce their reliance on scavenging. However, caution must be exercised to ensure that the provided food is safe for consumption, as certain ingredients, like onions and garlic, may be harmful to dogs. Further research into suitable food options is advisable to ensure the well-being of the animals. We recommend contacting staff at the Higher Taste canteen located on North Campus to discuss this recommendation, as they do not utilize garlic or onions in their cooking, making most of their food safe for dogs to consume.

If implemented safely, this initiative could yield multiple benefits. Not only would it improve the welfare of the stray dogs, but it could also contribute to a reduction in aggressive behavior and a cleaner campus environment.

Recommendation 4: Conduct Further Cleanup Drives with Passionate Students

The Wildlife and Ecology Club possesses an ability to unite enthusiastic and passionate students to address environmental issues. Given this potential, we recommend the organization of regular cleanup drives on and around campus, specifically at high generation regions, like those seen in Salgi and Kataula around natural water pathways. These events should be integrated into the club's ongoing activities, with a minimum of two per semester.

It is crucial to recognize that cleanup drives should not be isolated occurrences but rather sustainable efforts within the campus culture. IIT Mandi holds a significant influence as a role model for surrounding communities and bears a responsibility for its environmental impact. By establishing a consistent presence of students engaging in active waste cleanup, the institution can serve as a catalyst for heightened local awareness and sensitivity to environmental issues.

Recommendation 5: Communicate with EWOK for Running a Thrift Drive

During our fieldwork in Salgi, we had the opportunity to speak with passionate members of EWOK. In our discussions, the idea of establishing a Wildlife and Ecology Club on campus emerged, sparking particular interest from Sandya, the founder of EWOK. Sandya expressed eagerness to mentor and collaborate with the club if it were to be established.

We discussed the possibility of organizing a thrift drive on campus, aimed at collecting clothing and other items for resale or repurposing within nearby communities. Sandya highlighted the challenges her organization faces due to limited manpower, indicating that the involvement of a club could significantly enhance the success of the drive.

As our project shifted towards community activism, we see strong potential in fostering collaboration of the Wildlife and Ecology Club with EWOK. This collaboration could serve as a foundation for community-building between IIT Mandi and its surrounding communities, particularly dealing with environmental activism. By using the expertise and resources and EWOK and the enthusiasm of the club members, we envision impactful initiatives that contribute positively to both campus life and the broader community.

Future Work & Final Conclusions

This project has evolved from a longitudinal study into a platform for environmental activism at IIT Mandi and its surrounding communities. While our initial focus was on recommending technological improvements for MSWM, we recognize the potential for student activism to drive meaningful change in the region. We discovered a need for a platform where environmentally conscious members of the IIT Community can connect and advocate for their concerns. As we pass the torch to student leaders, we urge them to continue fostering this passion for environmental activism and to transform it into a powerful student organization. With its talented students and access to resources, IIT Mandi has the potential to serve as a catalyst for positive change in its community.

Looking ahead, we recommend expanding MSWM projects at IIT Mandi to address the diverse aspects of MSWM. By engaging new students in these projects, we can raise awareness and sensitivity to environmental issues. One potential project could focus plastic waste, which poses significant challenges to local communities. Another area of exploration could involve the collection and disposal of e-waste generated by labs and facilities on campus. Managing e-waste early can mitigate future environmental risks. While IIT does not currently mismanage e-waste, it is important to stay vigilant as the university continues to grow, given how fast growing the e-waste stream is. Additionally, collaborating with the Wildlife and Ecology Club to integrate environmental awareness into the curriculum and marketing initiatives can prove to be another project.

Universally, MSWM is a deeper social problem at the grassroots level than initially anticipated, prompting a significant shift in our project's focus. While technology is relevant, particularly at the municipality level, the infrastructure in the areas we visited generally has the capacity to handle its waste volumes, except for plastic waste, which demands further attention. Despite lacking formal collection systems, these communities previously maintained a circular economy before the introduction of plastic. Another significant issue, notably at IIT Mandi, is waste segregation at the source, which complicates disposal efforts when waste types are mixed. We concluded that source segregation primarily stems from social factors, despite adequate resources being available.

This project and the 2016 report should serve as a foundation for future initiatives in the field of MSWM. By fostering innovation and student engagement, IIT Mandi can play a vital role in addressing environmental challenges within its region.

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Appendix

Appendix A: Informed Consent Form

We are a group of students from Worcester Polytechnic Institute (WPI) in the United States. We are conducting interviews to learn more about the experience and perceptions of waste management in Mandi District. Your participation is voluntary. You can refuse to answer any of the questions and leave at any time.

Do we have your permission to record this interview?

Yes ☐ | No ☐

Do we have your permission to possibly include quotes from you in public materials?

Yes ☐ | No ☐

Will you allow us to include your name and other identifying information?

Yes ☐ | No ☐

Appendix B: Stakeholder Interview Questionnaire

Stakeholder Question Sheet

Municipal Stakeholder Categories:

- **Homestead**
  - Includes any household.
  - Questions will be focused on household waste management, and individual practices.
- **Local Business**
  - Includes any business focused on consumerism.
    - Restaurants, retail, etc.
  - Questions will be centered around business waste practices and increased waste generation from businesses.
- **Educational**
  - Includes IIT Mandi and any other school.
  - Questions will be centered around the waste management practices of the entire institution, as well as individual students and faculty members.
- **Local Representative**
  - Includes any local elected official but does not include Panchayats.
  - Questions will be centered around local policy and the politics behind waste management in the community.
- **Panchayat**
  - Includes any Panchayat in the Mandi District.
  - Questions will be centered around local cultural norms and how to best represent the general population since most Panchayats have a deep understanding of their communities.

Stakeholder General Questions

These are questions we will ask every level of stakeholder we interview, regardless of position. These are meant to best represent the general thoughts of the entire population.

1. ***General Questions***
    a. **What's the general waste life cycle?**
        i. When you're done with waste, how do you dispose of it?
        ii. What do you do with your food leftovers?
        iii. Does anyone collect your waste?
            1. If so, who collects it, and how often?
        iv. Is there a place in your community where people put their waste?
            1. If so, how easily accessible is it for you?
            2. If not, where does communal waste generally end up?
            3. If not, how would a communal waste dumping facility improve SWM in your community?
    b. **What are areas of high waste generation?**
        i. In your community, what are common sources of high waste production?
        ii. Are there times during the year when you produce more or less waste than normal?
            1. If so, what factors affect this change?
    c. **What are the general waste categories in communities?**
        i. On a day-to-day basis, what types of waste are you generating?
        ii. Do you separate your waste?
            1. If so, how often do you separate?
            2. If so, do you know if your separated waste remains separated upon collection?
            3. If not, how can the community help people better separate their waste?
    d. **What is the general perception of SWM in the Mandi District?**
        i. How well do you manage your waste?
        ii. How well does your community manage waste?
        iii. How would you like to see waste management practices improve?
        iv. What technologies exist within your community that make SWM easier?
        v. Are problems within SWM a result of technological or social difficulties?
            1. Do you have the necessary resources provided to make effective SWM accessible?
            2. Are there any specific areas of the community that make it more difficult to manage waste effectively?

Stakeholder Specific Questions

These are questions we will ask specific levels of stakeholders. These are meant to best represent data points within the community that not everyone will be able to contribute to.

1) ***Local Business***
    a. In your profession, how does waste management compare to managing waste at home?
        i. Is your waste collected in the same manner as household waste?
    b. Are you provided with adequate resources to manage your business waste?
        i. If so, do these differ from what you're provided at home?
        ii. If not, what would help your business dispose of waste effectively?
    c. Are you aware of policies that encourage businesses to dispose of waste properly?
    d. Do your local representatives treat businesses the same way, or are there different waste management policies depending on the industry?
2) ***Educational***
    a. ***Students***
        i. Have you been taught about different types of waste and how to separate them effectively?
        ii. Does your school make it easy to practice good waste management techniques?
    b. ***Faculty and staff***
        i. Are students taught about different types of waste and how to separate effectively?
        ii. Is there a national standard for how schools teach waste management practices? (i.e. reduce, reuse, recycle)
            1. If not, would your local representatives support standard community waste management practices that become part of curriculum for students?
        iii. Even if your school does a good job at waste segregation, do you believe your waste collection services continue that cycle?
3) ***Local Representatives***
    a. What polices exist within your community to assist with waste management?
        i. Are these policies unique?
    b. Are the concerns of the public within the scope of the local government to fix?
        i. If so, what plans exist to improve SWM practices?
        ii. If not, how effective would further help from the state or national governments be?
    c. What issues within SWM exist that regular citizens may not be aware of?
4) ***Panchayats***
    a. Are there any cultural practices within your community that help or hurt the ability of the community to manage their waste in the traditional sense?
    b. Does the local government best represent the needs of the people?
    c. Would your community be open to any amount of social change if it meant improving SWM practices?

Appendix C: The Official Wildlife & Ecology Club Proposal

WILDLIFE AND ECOLOGY CLUB, IIT MANDI - PROPOSAL

Our institute, nestled amidst the serene foothills of the Himalayas, is not just a center for academic excellence but also a custodian of the delicate ecological balance of the region. Recognizing the need for concerted efforts towards environmental conservation and wildlife protection, we propose the establishment of a ***Wildlife and Ecology Club***. This club aims to sensitize members of our institute community to ecological issues, promote conservation efforts, and foster a sense of responsibility towards our environment.

Objectives:

- *Awareness and Sensitization:* The club will conduct educational workshops, seminars, and awareness campaigns to educate students, faculty, and staff about the importance of preserving local wildlife and ecosystems.
- *Species Protection and Nurturing:* Focus will be placed on protecting and nurturing species abundant in our campus environment, such as dogs (it has been found some of them try to eat from garbage bins containing hazardous items like plastic). This will include initiatives to promote responsible pet ownership, feeding the dogs in campus from the food waste, vaccination drives, and fostering a harmonious coexistence between humans and animals.
- *Cleanliness Drives:* Organizing regular cleanliness drives within the campus and surrounding areas to mitigate environmental degradation and maintain the ecological integrity of the region. A cleanliness drive would be organizing students to collectively pick up waste and undo the damage of problematic solid waste management.
- *Habitat Restoration:* Undertaking projects aimed at restoring and enhancing natural habitats within the campus, including tree planting drives, creating birdhouses, and establishing butterfly gardens.
- *Research and Documentation:* Encouraging students and faculty to engage in research projects related to local biodiversity, ecology, and conservation efforts. This will involve conducting surveys, documenting species diversity, and studying ecosystem dynamics. –
- *Helpline number:* A communication channel for anyone in the institute to register complaints/grievances etc. in context to the track of WEC club.
- *Waste segregation:* Maintaining hostels waste segregation bins, which are so far managed very poorly. The scope of the same can be extended beyond hostels where emphasis should be given to the segregation of regular waste from food waste to enable efficient waste collection and disposal. There is an urgent need to address the labelling and bin colors that should be continually monitored to ensure that students understand what waste goes where.
- *Collaboration and Outreach:* Collaborating with local conservation organizations, wildlife experts, and government agencies to leverage resources and expertise for effective conservation initiatives. Additionally, the club will engage in community outreach programs to involve residents of nearby villages in conservation efforts.
- *Policy Advocacy:* Advocating for policies and regulations that support wildlife conservation, habitat preservation, and sustainable development in the region.

Activities:

- Educational Workshops: Regular workshops on topics such as wildlife conservation, sustainable living practices, and biodiversity hotspots.
- Field Trips and Nature Walks: Organizing Hield trips and nature walks to explore the rich biodiversity of the surrounding hills and learn about local flora and fauna.
- Guest Lectures: Inviting experts from academia, conservation organizations, and government agencies to deliver lectures on various ecological and wildlife conservation topics.
- Volunteer Programs: Providing opportunities for students and faculty to participate in volunteer programs focused on wildlife rescue, habitat restoration, and environmental cleanup.
- Awareness Campaigns: Launching awareness campaigns through social media, posters, and interactive sessions to engage the broader institute community in conservation efforts.
- Green Initiatives: Implementing eco-friendly practices within the institute, such as waste reduction, recycling programs, and promoting energy efficiency.

Members interested:

Currently, there are around 20 very enthusiastic members (that includes 3 students from the USA) immediately interested in being a part of this club, however, we look forward to more participation in the coming future.

Note: The USA students are particularly interested in proposing such a club based on their research through ISTP and concern for the local region's environment based on their findings.

Core members:

1. Jeet B. Lahiri (Ph.D. Scholar, IIT Mandi)
2. Vinay Paliwal (Ph.D. Scholar, IIT Mandi)
3. Priyanka Mittal (UG Student, IIT Mandi)
4. Suryansh Rathore (UG Student, IIT Mandi)
5. Avisha Singh (UG Student, IIT Mandi)
6. Aditya Anurag (UG Student, IIT Mandi)
7. John Clendenin (UG Student, WPI, USA)
8. Hayden O'Connell (UG Student, WPI, USA)
9. Liam Jennings (UG Student, WPI, USA)

Faculty Advisors:

1. Dr. Sreelakshmi Manjunath (SCEE, IIT Mandi)
2. Dr. Srikanth Suvugaman (SCEE, IIT Mandi)

Estimated budget:
We have a rough estimate that around Rs. 10,000 would be required to start off the activities of the club at full scale, that include advertisements and conducting meetings. Additionally, roughly about Rs. 50,000/year would be required considering the future activities that include but is not restricted to educational materials, medications for treatment of animals, field trip expenses, volunteer program expenses, awareness campaign materials, training workshops, research and documentation, habitat restoration projects, community outreach programs, and administrative expenses.

Conclusion:
The establishment of a Wildlife and Ecology Club at our institute signifies our commitment to environmental stewardship and sustainable development. By fostering a culture of environmental consciousness and active participation in conservation efforts, we aim to contribute towards the preservation of our precious natural heritage for future generations. We seek support and collaboration from all members of our institute community to make this initiative a success. Thank you for considering our proposal. We look forward to your support in establishing the Wildlife and Ecology Club at our institute.

Appendix D: Satellite Imagery of Prominent Project Locations