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Sanitation, Water and
Solid Waste for Development

Planning For Zero-Waste At Schools

- A toolkit

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Planning For Zero-Waste At Schools

- A toolkit

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Introduction

Solid waste management (SWM) is a universal issue affecting every single person in the world: everywhere, tremendous challenges are faced to cope with the growing amounts of waste produced daily, as a result of population and urbanization growth. While sound waste management is key to protect the environment and human health, nowadays 2 billion people still lack access to solid waste collection service, while 3 billion people lack access to controlled disposal facilities [9]. This results in tremendous amounts of waste being littered, dumped or openly burnt, contaminating water, groundwater and the world's oceans. Such practices are causing floods by clogging drainage systems, attracting pests, rodents and other disease vectors, increasing respiratory problem, greenhouse gas emissions, enhancing climate change, while impacting negatively on biodiversity and increasing resources depletion.

Sustainable SWM is key to achieve the Agenda 2030 for Sustainable Development. Indeed, among the 17 Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015, 4 are directly linked to waste management (Goal 1, 6, 11, 12) and 8 indirectly (Goal 2, 3, 7, 8, 9, 13, 14, 17), as shown in Figure 1 with stroke and dotted line respectively.

Figure 1: SWM-related SDGs [4]

Urgent actions are needed at all levels of the society [5, 10], to tackle what can be considered as "one of the biggest challenge of the urban world" [11]. As SWM is closely linked to people and people's behavior, a shift of paradigm is needed to consider solid waste as potential resource and not as trash. Such a shift in the society requires awareness raising, pragmatic approaches and concrete actions that, we believe, can be best transmitted through education.

Education has long been recognized as a critical factor to address environmental and sustainability issues and ensuring human and nature well-being [12]. Following the recommendation of UNESCO for Education for Sustainable Development (EDS), education should aim at "empowering and equip current and future generations to meet their needs using a balanced and integrated approach to the economic, social and environmental dimensions of sustainable development" [12]. These are the very same precepts of this toolkit, which aims at developing innovative solutions, which maximize on the synergies between water, sanitation, waste management, food production, health, environment and energy generation in schools. By using schools as model unit, it targets learning, application and practice so that students become agents of change and ambassadors for sustainable behaviour and a cleaner world under a circular economy.

We are all in this together, so it is up to each one of us to be more responsible with what we throw away and how our waste is managed.

How to use this toolkit

This toolkit aims at providing step-by-step guidance accompanied by tools to develop and implement "Action Plans" to close the loops of material and resources at any school level, considering a system approach and focusing on low-tech options that could be applied in any low- and middle-income settings.

This toolkit was built on existing proven methodologies from the sanitation and solid waste management sector (see Part 1 - Key concepts). They were used and adapted in schools in Nepal and Peru between 2018 and 2022 through pilot projects.

Scope and target audience

This toolkit is for individuals or organizations, such as:

— **School community members** (teachers, students, non-teaching staff, etc.) who want to improve SWM in their own institution;

— **Non-Governmental Organizations (NGOs) and civil society organization** who want to support educational institutions in implementing a Zero-Waste approach.

Navigation through this guide

This toolkit is structured as follows:

Part 1: Introduces the key concepts and guiding principles of the developed methodology presented in the toolkit.

Part 2: Describes each steps of the planning approach towards Zero-Waste at schools, with detailed activities:

Step 1: Mobilize

Step 2: Baseline

Step 3: Planning priorities

Step 4: Identify and evaluate options

Step 5: Develop an Action Plan

Step 6: Implement the Action Plan

Step 7: Monitor and evaluate

Part 3: Presents technical resources covering all the aspects of solid waste management.

Part 4: Contains summary briefs for each tool.

Part 5: Contains technical factsheets.

Additional resources and references are listed at the end of the document.

Throughout the text, you will come across the following icons, which indicate milestones, tools, technical resources and factsheets as well as access to further resources.

Milestones

Key stakeholders

Tools

Technical resource & Factsheets

Additional literature

Video resources

Webpage resources

Key issues and concepts are highlighted in numbered colored boxes.

Part 1 -

Key concepts

Zero-Waste approach at school

Zero-Waste is an approach based on two key principles:

- **Waste management hierarchy,** as it aims at reducing the amount of waste produced and send to final disposal (see Box 1) ;
- **Circular economy principle,** as it aims at closing the loops of material and resources as close as possible to the production source (See Box 2);

Implemented at school level, a Zero-Waste approach will thus allow to plan and implement efficient strategies to reduce, reuse, recycle and recover waste, while at the same time raise awareness and good practices of the school community members; it targets learning, application and practice, so that students become agents of change and ambassadors for sustainable behavior and a cleaner world under a circular economy.

Figure 2 visually represents the Zero-Waste concept, where all materials and substances generated inside the school compounds, such as solid waste, water, wastewater, grey water or faecal sludge, are reused and materials exiting the school compound are reduced to a minimum, while all of this is embedded in an environmental education component.

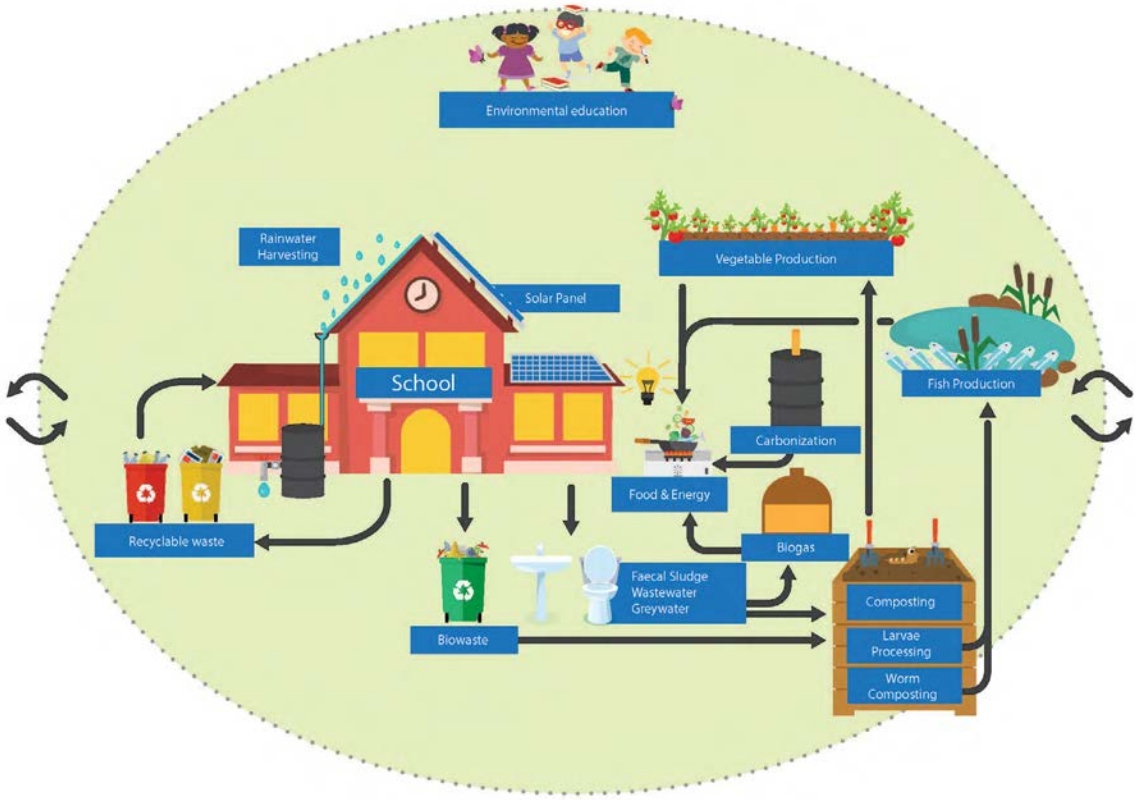


Figure 2: Zero-Waste approach - Schematic overview

Box 1: Waste management hierarchy

The waste management hierarchy provides a generalized priority order for waste management options and technical approaches. Highest priorities should be set on preventing waste and thereafter "encouraging treatment options that deliver the best overall environmental outcome, taking into account life-cycle thinking" [5].

Applying this concept at school level, this translates into innovative school policies regarding use and consumption of materials at the school (e.g. by limiting/prohibiting the use of single-use items, reducing food waste, etc.), making sure to stop harmful practices for the environment (e.g. stop littering, stop open burning of waste, uncontrolled dumping, etc.), while fostering recycling practices.

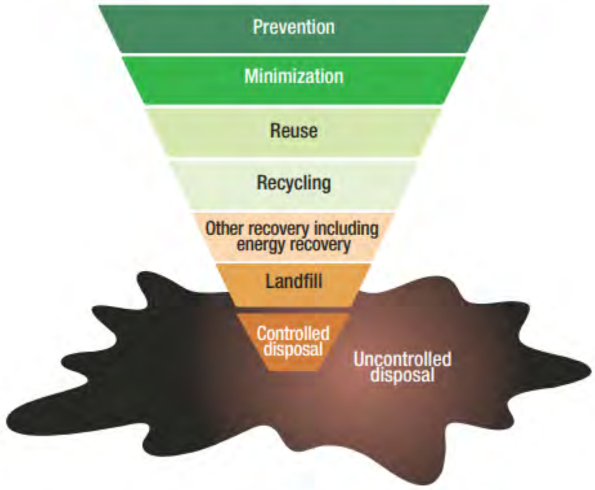


Figure 3: Waste management hierarchy [5]

Wilson, D.C., 2015. Global Waste Management Outlook [5].

Box 2: Circular economy principle

Since the industrial revolution, our economies have followed a linear growth in the use of natural resources, consisting of take – make – use – discard, based on the false premise that resources are infinitely available and accessible. Such a model simply cannot be sustained by the earth system: sources of materials are limited, and there are limits to the resilience of terrestrial ecosystems due to habitat degradation and pollution by various hazardous chemicals.

Nature, on the other hand, follows a circular logic, where each element produced/created serves the next. Circular economy envisages a similar system, where after the make and use stages, materials are recovered and transferred to a new production and use cycle.

Applying this concept at school level, this would emphasize the need of managing waste as resources and enhancing recycling activities inside and outside the school.

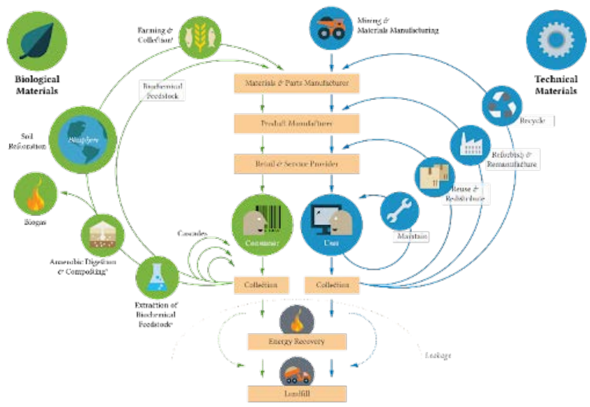


Figure 4: Circular economy principle [3]

Wilson, D.C., 2015. Global Waste Management Outlook [5].

Youtube video – [Explaining Circular Economy and How Society Can Re-Think Progress](#) (Ellen MacArthur Foundation)

[Ellen MacArthur Foundation](#)

Strategic planning – Data-driven decisions & Participatory approaches

This toolkit follows the principle of data-driven decisions and participatory approaches, which are two fundaments of strategic planning. Its structure is inspired by the CLUES participatory planning approach [13] and the seven steps of City Strategic Plan mentioned in the online course of UN-habitat "From Data to Tangible Impact: Achieving Waste SDGs by 2030" [4].

Strategic planning serves to improve the efficiency and effectiveness of services by taking a broader view and addressing the problems based on setting priority. Plans are usually best if they are "evidence" led, meaning where data has been used to take decisions. A structured step-by-step approach, allows to understand the current situation, generate key data and information and plan improvement options accordingly.

Ensuring stakeholders participation throughout the strategic planning process ensures that the planning reflects priorities and interests of the stakeholders, as well as building trust and ownership, which in turn foster their commitment, role and responsibility in translating planning into actions.

Evidence-based decision making and participation principles are already well established in sanitation and solid waste management planning and were adapted for the school context in the present toolkit.

Box 3: Planning steps – Towards Zero-Waste at schools (adapted from [4])

The planning steps suggested in this toolkit are:

1) **Mobilize** → Assemble your team, agree on principles and process, confirm school commitment, identify stakeholders;

2) **Baseline** → Establish a baseline on the current situation, identify key issues and validate the baseline;

3) **Planning priorities and principles** → Agree on principles priority order, set goals and targets, identify priorities based on key issues;

4) **Identify and evaluate options** → Identify and evaluate options, discuss and agree on options, revisit goals and targets;

5) **Develop an Action Plan** → Develop an Action Plan, identify roles, responsibilities and set targets;

6) **Implement the Action Plan** → Start the implementation process, communicate priorities, objectives and targets to all stakeholders;

7) **Monitor and evaluate** → Monitor and evaluate progress against targets set, identify opportunities for improvement, updates the Action Plan accordingly

During each of these steps, engaging stakeholders is a high priority task.

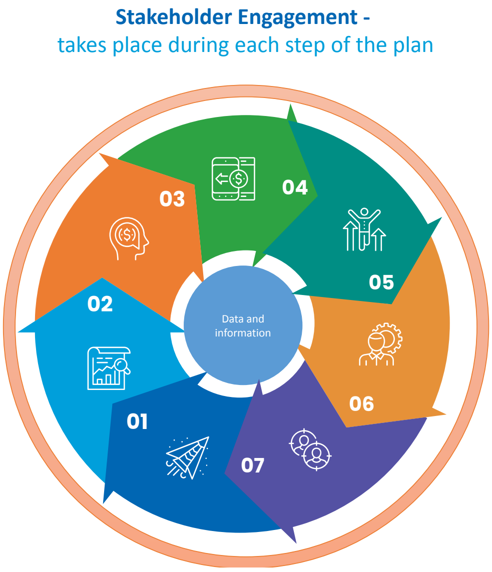


Figure 5: Planning steps - Towards Zero-Waste at school, adapted from [4]

Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES [13]

Wilson et al., 2001. Strategic Planning Guide for Municipal Solid Waste Management [14]

Online course – [From Data to Tangible Impact: Achieving Waste SDGs by 2030] (UN-Habitat) [4]

Behavior change

Most solid waste management improvements require a change of practices by different stakeholders; the waste generators, that must stop littering, start segregating waste at source, or use a collection service, and also the waste handlers, that must increase efficiency of the service delivered, or the local authority that need to prioritize waste management issues and allocate sufficient human and financial resources towards waste management improvements. Yet, it is important to remember that even if it might sound trivial on paper, asking for changing a current practices is to ask for a behavior change.

Various methods exist to incite and promote behavior change. Rather than promoting one method or another, this guide hopes to raise awareness about the multitude of factors affecting behavior and behavior change. It uses the RANAS Systematic Behavior Change approach developed at Eawag (see Box 4) to outline the possible behavior-steering factors

Box 4: RANAS behavior-steering factors

The RANAS behavior-steering factors are [15]:

- **Risk:** Person's understanding and awareness of health risk
- **Attitude:** Person's positive or negative stance towards a behavior
- **Norms:** Perceived social pressure towards a behavior
- **Ability:** Person's confidence in her or his ability to practice a behavior
- **Self-regulation:** Person's attempts to plan and self-monitor a behavior and to manage conflicting goals and distracting signals

Different behavior change techniques can used to trigger specifically the factor of concern. The RANAS factors and related behavior change techniques are presented in Figure 6.

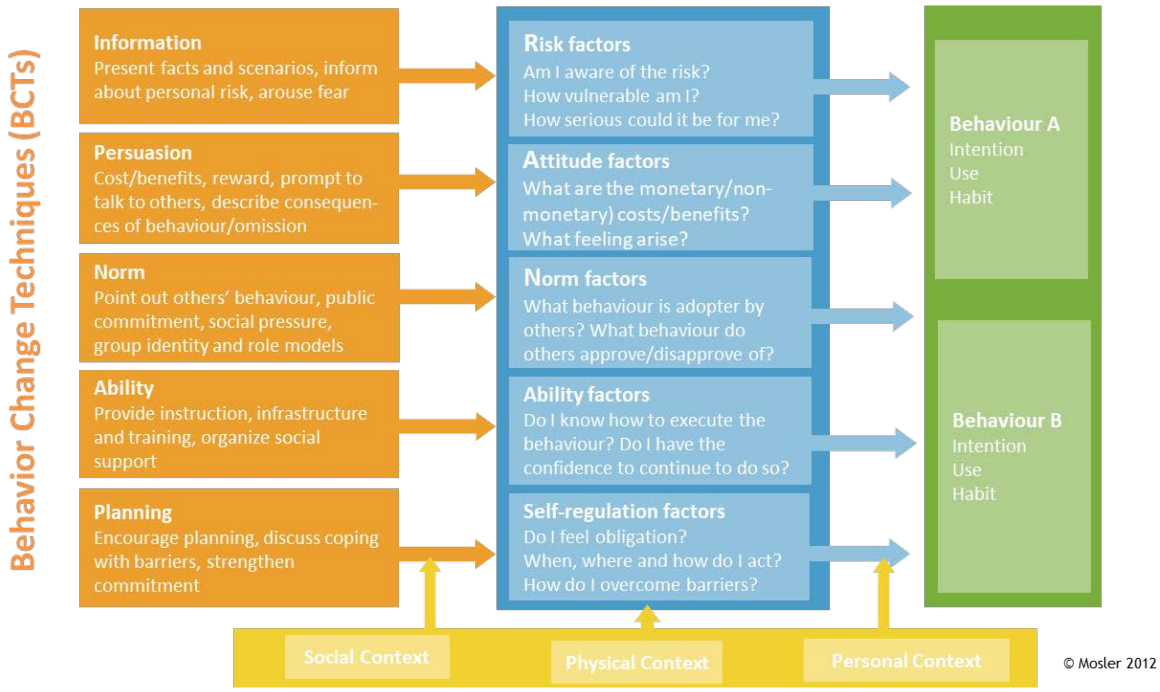


Figure 6: Behavior Change Steering Factors (RANAS, [16])

While typical behavior change interventions related to SWM often target the risk factor (providing information on why doing a certain behavior is good or bad for the environment) it is important to realize that alternative and innovative behavior change techniques, which target other behavior-steering factors, could be more effective.

If time and resources allows, researching on key driving behavioral factor before implementing a behavior change intervention would be best, so that a targeted campaign could be performed. For more information on RANAS please consider the resources listed hereafter.

- *Mosler Contzen, 2016. Systematic behavior change in water, sanitation and hygiene. A practical guide using the RANAS approach [15]*
- *Cavin, 2017. Behavior Change Manual [17]*
- *Ranasmosler.com*
- *MOOC module – Triggering Community Participation with the RANAS approach (Eawag/Sandec)*

Learning by doing - Education for Sustainable Development

As mentioned in the introduction, thistoolkit is in line with the Education for Sustainable Development (ESD) principle of UNESCO, which is commonly understood as "education that encourages changes in knowledge, skills, values and attitudes to enable a more sustainable and just society for all" [12].

As such, ESD is recognized by UNESCO at the heart of the 2030 agenda for sustainable development. According to UNESCO, schools should "see themselves as experiential places of learning for sustainable development" and the "institution itself [should] function as a role model for the learners" [1]. Following the moto "living what we learn", UNESCO promotes the so-called "whole-institution approach" (see Figure 7), where governance, policy & capacity building, together with community, partnership & relationships, curriculum, teaching & learning and facilities, school operation all converge towards sustainable development. The key elements of the "whole-institution approach" are summarized in Box 5.

According to UNESCO, ESD is about "empowering and motivating learners to become more active and critical" and as such, action-oriented transformative pedagogy is required. The key pedagogical approaches in ESD promoting "learning by doing" are summarized in Box 6.

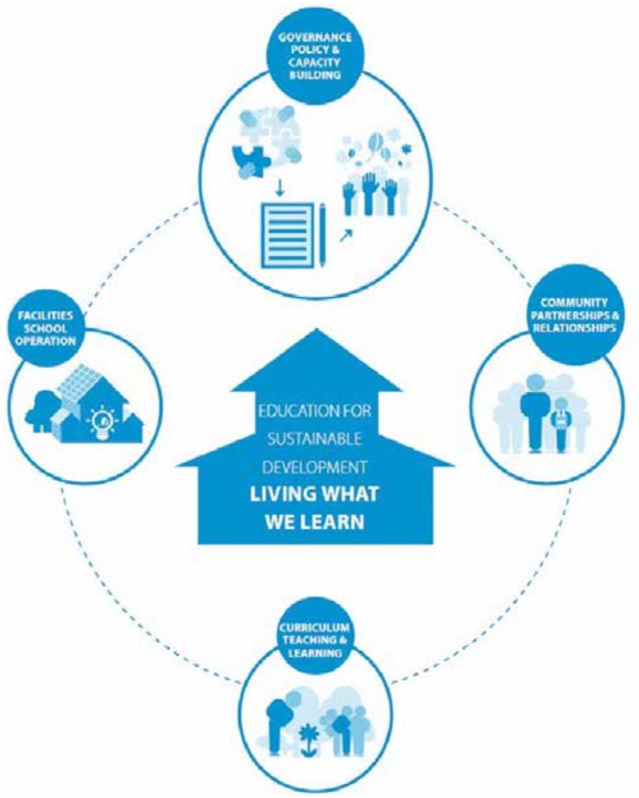


Figure 7: The whole-institution approach [1]

Box 5: Key elements for whole-institution approaches [12]

1. Institution-wide process is organized in a manner that enables all stakeholders – leadership, teachers, learners, administration – to jointly develop a vision and plan to implement ESD in the whole institution.
2. Technical and, where possible and appropriate, financial support is provided to the institution to support its reorientation. This can include the provision of relevant good practice examples, training for leadership and administration, the development of guidelines, as well as associated research.
3. Existing relevant inter-institutional networks are mobilized and enhanced in order to facilitate mutual support such as peer-to-peer learning on a whole-institution approach, and to increase the visibility of the approach to promote it as a model for adaptation.

Box 6 : Key pedagogical approaches in ESD [12]

A learner-centered approach

Learner-centered pedagogy sees students as autonomous learners and emphasizes the active development of knowledge rather than its mere transfer and/or passive learning experiences. The learners' prior knowledge as well as their experiences in the social context are the starting points for stimulating learning processes in which the learners construct their own knowledge base. Learner-centered approaches require learners to reflect on their own knowledge and learning processes in order to manage and monitor them. Educators should stimulate and support those reflections. Learner-centered approaches change the role of an educator from that of an expert who transfers structured knowledge to that of a facilitator of learning processes [18].

Action-oriented learning

In action-oriented learning, learners engage in action and reflect on their experiences in relation to the intended learning process and personal development. The experience might come from a project (e.g. in-service learning), an internship, facilitation of a workshop, implementation of a campaign and so on. Action-learning draws on Kolb's learning cycle of experimental learning, which has the following stages: (i) having a concrete experience, (ii) observation and reflection, (iii) formation of abstract concepts for generalization and (iv) application in new situations [19]. Action-learning increases knowledge acquisition, competency development and values clarification by linking rather abstract concepts to personal experience and the learners' life. The role of the educator is to create a learning environment that prompts learners' experiences and reflexive thought processes.

Transformative learning

Transformative learning can be defined primarily by its aims and principles, not by a concrete teaching or learning strategy. It aims to empower learners to question and change their ways of seeing and thinking about the world, in order to further develop their understanding of it [20, 21]. The educator acts as a facilitator who empowers and challenges learners to change their worldviews. The related concept of transgressive learning [22] goes one step further – it states that learning in ESD has to overcome the status quo and prepare the learner for disruptive thinking and the co-creation of new knowledge.

UNESCO, 2014. Shaping the Future We Want [1]

UNESCO, 2018. Issues and trends in Education for Sustainable Development [12]

Integrated Sustainable Waste Management (ISWM)

The Integrated Sustainable Waste Management (ISWM) framework is a framework that helps visualizing and understanding all the important elements for sustainable and integrated solid waste management.

As shown in Figure 8, the ISWM framework is composed of two main elements:

— **Physical components:** Linked to the waste management chain, such as waste generation, collection, treatment and disposal and the 3Rs of Reduce, Reuse, Recycle, by describing what happens to the waste;

— **Governance aspects:** Linked to the software aspect of waste management such as stakeholder inclusivity, financial sustainability and institutions and policies, addressing how things are done at governance level.

Considering all these elements is key for a sustainable and prosper waste management system decreasing environmental and health threats.

Knowing how each of these elements perform or to which degree they are included in SWM can be assessed using the "Wasteaware benchmark indicators" (WABIs). The WABIs comprise quantitative and qualitative indicators used to evaluate the physical components and governance aspects of a solid waste management system.

This guide adapts the WABIs for school settings. These can be found in Step 2 (A) and in T 2.A2

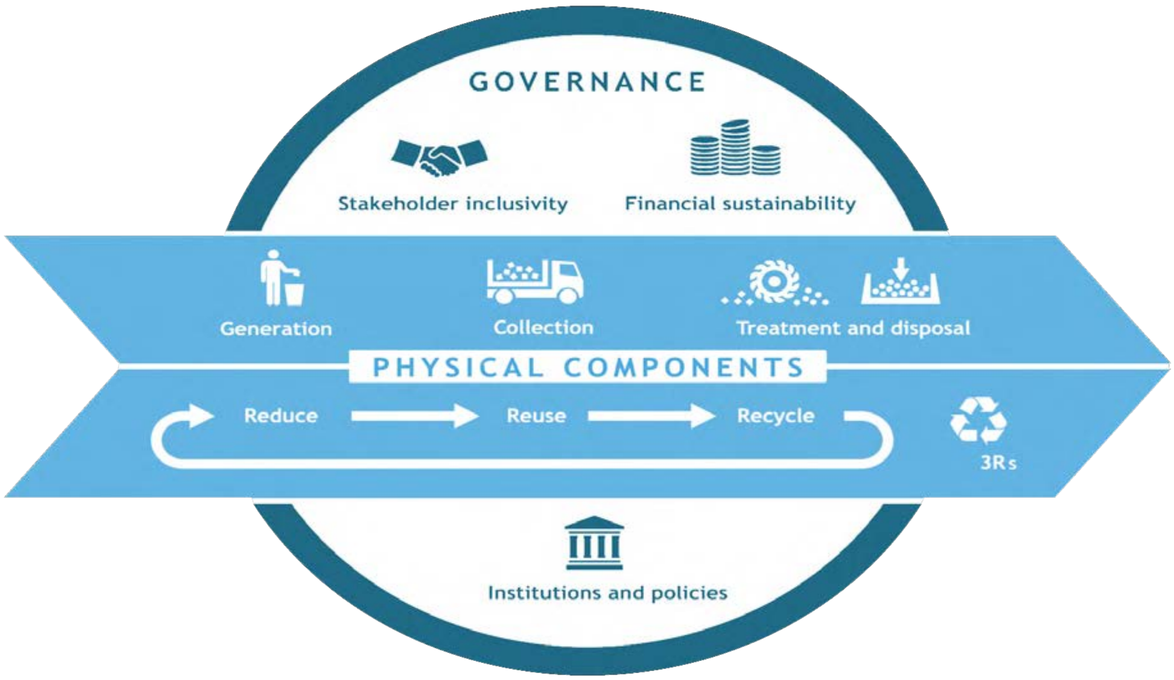


Figure 8: Integrated Sustainable Waste Management Framework (ISWM) (adapted from [23]

Wilson, et al., 2015 "'Wasteaware' benchmark indicators for integrated sustainable waste management in cities" [24]

MOOC module – [Comparing cities' performance](#) (Eawag/Sandec)

Part 2 -

Planning steps – Towards Zero-Waste at Schools

Overview of the seven steps

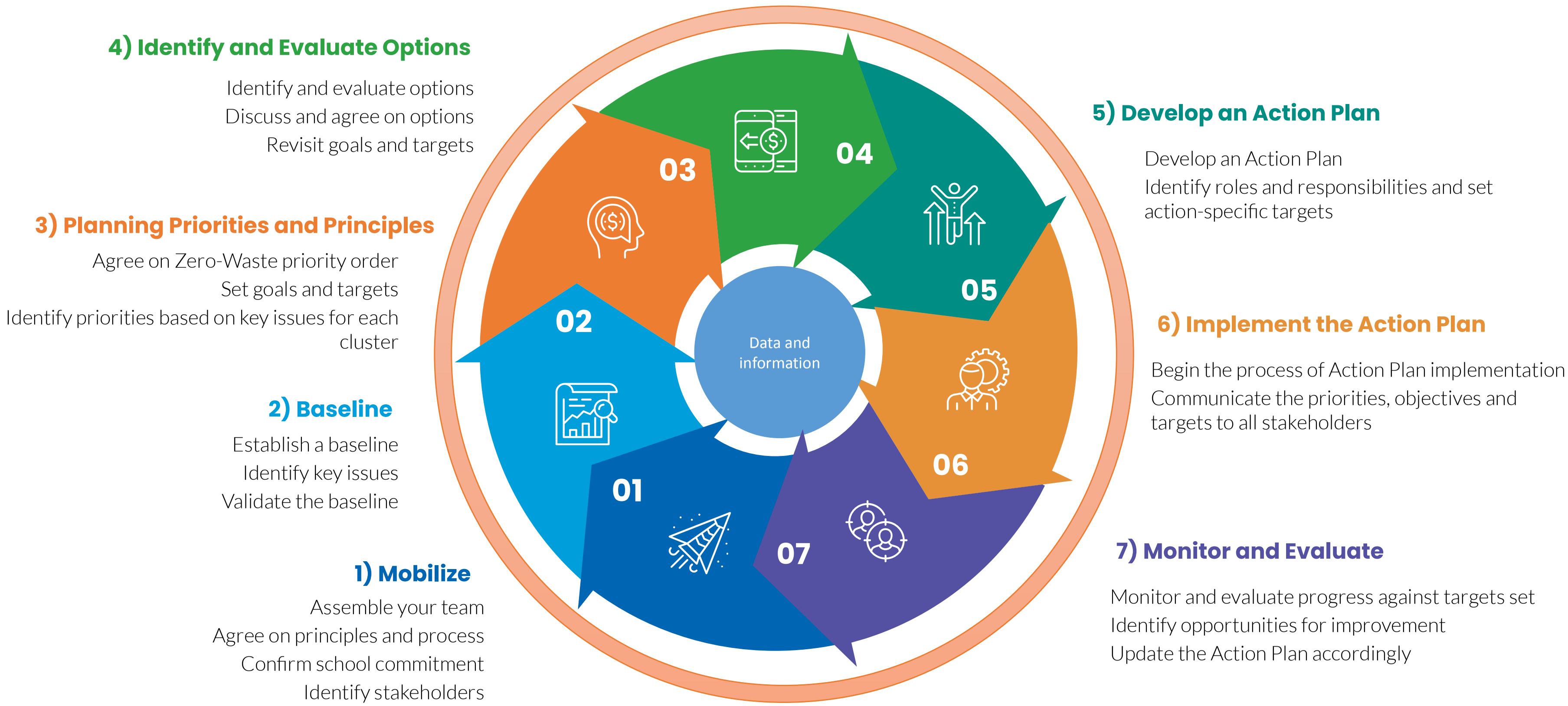


Figure 9: Planning steps - Overview (adapted from [4])

Milestones	Key stakeholders	Tools & Resources
A. Assemble your team B. Agree on principles & process C. Confirm school commitment D. Identify stakeholders	• Zero-Waste committee (ZWC) • School officials	• T 1.B – Zero-Waste principles & process • Technical resources on SWM

(A) Assemble your team

First, assemble your team, which will be referred to as "Zero-Waste Committee" (ZWC) throughout this toolkit. To ensure a broader acceptation among the school community, we recommend to include a large variety of school stakeholders and to have a representative of each school stakeholder group/constituency.

As the success of projects often relies on "champions" [25], it is important to make sure to have highly motivated and committed people in the team.

Typical school stakeholder groups and potential interested members are:

— Teachers (e.g. science teachers)

— Non-teaching staff (e.g. administrative staff, cleaning staff, kitchen staff)

— Students (e.g. environmental/green club members, representative of students)

— School officials (e.g. representative of headmaster)

— Parents of students (e.g. representative of student's parents association)

The interest and participation of school stakeholders can be triggered through posters, social media posts and concretized in a start-up meeting.

(B) Agree on principles and process

As presented in Part 1 - Key concepts, the main principles behind the Zero-Waste approach in schools are:

Waste hierarchy, where the focus is on preventing waste generation in the school compound to reduce the amount of waste generated;

Circular economy, where the aim is to close the loops of material and resources as close as possible to the production source so that more material and resources can be recycled inside and/or outside the school;

Behavior change and learning by doing, where the aim is that the whole school community can experience sustainable practices and that students are encouraged to adopt such practices in their daily lives;

[1] Champions are defined as specific individuals highly committed, well-linked to the other stakeholders, usually having good expertise on the subject and respect by other stakeholders25. Zurbrügg, C., Assessment methods for methods for waste management decision-support in developing countries, F.d.I. Università degli Studi die Brescia, Editor. 2013.

Participatory strategic planning, where the aim is to involve a broad variety of school stakeholders to come up with an Action Plan towards Zero-Waste tailored to the school context, and which follows a structured approach allowing to take data-driven decisions.

These principles should be explained to the ZWC and the main projects steps and activities presented. You can use the resources of T 1.B as supporting material.

T 1.B – Zero-Waste principles & process

(C) Confirm school commitment

For any project to be successful at school level, political support from school headmaster and school commitment is essential, as this will permit to run the process smoothly and access school financial and human resources.

Experiences showed that projects run at school level are usually more sustainable if own school funding is used, as this signals a stronger commitment from school stakeholders and ownership over the project. Also, it ensures that investments remain reasonable for the school and do not compromise the long-term benefits once installations and/or equipment need to be repaired or replaced.

Conducting "fact-finding" and trying to understand what are the key issues related to SWM felt by the entire school community can help increasing school commitment. Also, you can check if there is any national strategy, policy or target on SWM set by the Ministry of Environment, or any environmental education strategy developed by the Ministry of Education which could support the implementation of the Zero-Waste approach. You can also use the global facts and figures on SWM available in Part 3 - Technical resources to highlight the importance of tackling solid waste issues.

Presenting the resources of T 1.B to the school headmaster is recommended at this stage, so that the key principles and main steps can be agreed on.

T 1.B – Zero-Waste principles & process

Technical resources Solid waste management – Facts and Figures

(D) Identify stakeholders

Together with the ZWC, make a list of all the stakeholders inside and outside the school that are linked directly or indirectly with solid waste management. This will allow you to have more clarity on key stakeholder to be included later on (see Step 2 (A.5)).

A non-exhaustive list of potential stakeholders can be found in Box 7.

Box 7: List of potential stakeholders

Milestones	Key stakeholders	Tools & Resources
— Students — Teachers — Administration — Kitchen staff	— Cleaning staff — Kitchen staff — Municipal collection service (if any) — (In)formal waste recyclers* (if any)	— School officials — School administration — Students associations — Parents of students

**See Part 3 - Technical resources Existing recycling system*

STEP 2. Baseline

Milestones	Key stakeholders	Tools & Resources
A. Establish a baseline B. Identify key issues C. Validate the baseline	• ZWC in collaboration with: • Waste generators • Cleaning staff • School officials • Public/private SWM company (if any) • + External support (if any)	• *T 2.A1 – Waste audit* • *T 2.A2 – WABIs for school* • *T 2.A3 – Water, sanitation & energy assessment* • *T 2.A4 – Curricula review* • *T 2.A5 – Stakeholder analysis* • *T 2.B1 – Problem tree analysis*

The second step is about establishing a baseline and identifying key issues. It is a very important step, most of the time overlooked, but crucial to ensure that meaningful decisions are going to be taken. If we want to change the system in place, we need to understand it!

(A) Establish a baseline

Establishing a baseline will require some time and efforts. It will be done in five stages:

1. Determining waste quantities and composition
2. Reviewing waste management operations
3. Reviewing water, sanitation and energy operations
4. Reviewing curricula
5. Conducting a stakeholder analysis

Each of these activities are described hereafter

A.1) Determining waste quantities and composition

Knowing how much waste, what type of waste and where it is produced is key to improve SWM. This will be determined by doing a so-called "waste audit".

A waste audit consists in collecting waste on a daily basis, over a week, and each day: weigh the waste, characterize the waste (i.e. separate the collected waste in different waste fractions, weigh each fraction separately), and report the gathered information on a document. At the end of the week, an average of waste production per day can be obtained. By using the number of people at the school an average waste production per capita can also be calculated.

Depending on the goal you want to achieve and what you want to use the data for, the waste audit can be performed at different level (from general to specific):

1. If you want to just know the overall amounts and types of waste generated, you can collect all the trash bins together, weigh and characterize them;
2. If you want to come up with concrete actions to be taken by the different waste generators, you can cluster the school waste generators by their activity and characterize them separately (e.g. school canteen/kitchen; classrooms; offices; etc.);

3. If you want to create a "group awareness" and allow foster "competition" inside the school to motivate students to adopt better waste management practices, you can conduct waste characterization studies per classroom.
4. If you want to raise awareness of students regarding their own waste generation, you could ask them to put all their waste in a specific bag and ask them to conduct a waste characterization study based on their own waste.

Box 8 summarizes the different options mentioned above, what needs to be done as well as pros and cons of each.

T 2.A1 explains how to perform a waste audit step-by-step. Don't forget to consider seasonal variation in the type and amounts of waste generated!

Box 8: Summary of waste audit option

Purpose	What to do	Pros and Cons
1) Overall amounts – To design infrastructure (composting site, bins, disposal site, etc.)	Collect all the trash bins, weigh and characterized the waste into different fractions	+ Requires less logistic - Don't give information regarding generation source
2) Cluster by generation source – To come up with concrete actions to be taken at different locations of the school	Collect all the waste from the same generation source (e.g. classrooms, admin. offices, cafeteria, etc.), weigh and characterized the waste into different fractions for each generation source separately.	+ Allows to plan specific actions for each school waste generation source - Requires a bit of logistic
3) Cluster by classrooms – To create "group awareness" and make "competition" inside the school to motivate classrooms to take collective efforts to reduce waste generation	Collect the waste from each classrooms separately, weight and characterized the waste into different fractions for each classroom separately.	+ Motivates collective efforts from each classroom - Requires more logistic and support from each classroom
4) Amounts per students - To raise awareness of students regarding their own waste generation	Ask each student to put all their waste in a specific bag and then ask them to conduct the waste characterization study.	+ Raise awareness of students at individual level - Less relevant to plan concrete actions at school level

We recommend Option 2 if you want to develop an Action Plan specific for each waste generation source. Option 3 and 4 can be used by teachers for teaching and awareness raising purposes.

T 2.A1 – Waste audit

Additional resources:

UN-Habitat, 2021. Waste Wise Cities Tool (Step 2) [4]

Wasteaid, 2017. Making waste work: A toolkit – How to measure your waste [26]

MOOC module – Conducting a Waste Generation and Characterization Study (Eawag/Sandec)

A.2) Reviewing waste management operations

Planning towards a Zero-Waste school requires a good knowledge about the current SWM system, its physical components as well as the governance aspects (see Part 1 - Key concepts).

To help you assess all the relevant aspects of the SWM system, we adapted the Wasteaware benchmark indicators (WABIs), a set of indicators developed by experts to benchmark SWM services of different cities across the globe, for schools. It uses a set of quantitative and qualitative indicators covering the aspects of:

Waste collection – Percentage of waste collected and quality of waste collection

Waste treatment and disposal – Percentage of waste treated and disposed of on site and quality of environmental protection from treatment and disposal methods

- **Resource management –** Recycling rates and quality of the 3Rs – Reduce, Reuse, Recycle
- **Stakeholder inclusivity –** To which extend are stakeholder involved in SWM
- **Financial sustainability –** To which extend SWM is financially sustainable
- **Sound institutions and policies –** School institutional capacity for appropriate SWM

The full list of indicators can be found in Box 9.

You can gather the information through observation, estimation and interviews. Each indicator is scored on a scale of 1 to 5, from very low, to very high. By a "traffic light" color system, allows you to visualize where improvements are needed. An example for a fictitious school is shown in page 33.

Guidelines on how to assess and score each indicator are provided in T 2.A2.

Box 9: Wasteaware benchmark indicators [24] adapted for a school compound

#	Indicator's name	Description
1C	**Collection**	
1.1	Waste captured by the solid waste management system (%)	Percentage of waste generated at the school that is actually handled by the waste management and recycling system, and not "lost" through illegal ("wild") burning, burying or dumping in unofficial areas.
1C	**Quality of waste collection**	
1C.1	Appearance of waste collection points	Presence of accumulated waste around collection points/ containers. It focuses on locations where large amounts of waste is collected (e.g. containers or collection points where all the waste from the school is gathered).
1C.2	Appearance of waste bins	Presence of litter and of overflowing litter bins.
1C.3	Effectiveness of sweeping	Presence of littering inside the school compound
1C.4	Regularity of collection service and monitoring	Presence of documentary evidence of appropriate service planning, service delivery, monitoring procedures and tools.
1C.5	Health and safety of collection workers	Use of appropriate personal protection equipment & supporting procedures

#	Indicator's name	Description
2E	**Onsite waste treatment and disposal**	
2.1	Amount of waste managed onsite (%)	Percentage of waste managed in the school compound and not given outside for further disposal
2.2	Amount of waste burnt on school compound (%)	Percentage of waste burnt in the school compound.
2.3	Controlled treatment or disposal (%)	Of the waste managed onsite, percentage managed in a controlled way
2E	**Quality of environmental protection of waste treatment and disposal**	
2E.1	Control over onsite waste disposal	Assessment of the degree of control over waste disposal reception and disposal operation
2E.2	Control over organic waste treatment (composting or anaerobic digestion)	Assessment of the degree of control over the organic waste treatment in terms of infrastructure and operating procedures for their proper use.
2E.3	Know-how of the responsible person	Assessment of the level of technical competence of the responsible person for waste treatment and disposal.
2E.4	Occupational health and safety	Use of appropriate personal protection equipment & supporting procedures
3R	**Resource Management – 3Rs**	
3	Recycling rate (%)	Percentage of total solid waste generated at the school which is recycled (inside or off-site)
3R	**Quality of resource management**	
3R.1	Source separation of waste	Assessment of how much of the total waste amount is separated at source and how well it is done.
3R.2	Focus on 3Rs in school policy and curricula	Assessment of the degree of both school policy and pedagogical focus on promoting '3Rs'
3R.3	Integration of the informal recycling sector (IRS)	Assessment of the integration of the IRS with the school waste management.
3R.4	Occupational health and safety for waste sorting	Use of appropriate personal protection equipment & supporting procedures

#	Indicator's name	Description
4U	**Inclusivity of school stakeholders**	
4U.1	Level involvement	Evidence of actual involvement at appropriate stages of the SWM decision-making, planning and implementation process.
4U.2	Feedback mechanisms	Existence and use of feedback mechanisms on SWM services.
4U.3	Education & Awareness	Implementation of comprehensive, culturally appropriate education, and/or awareness raising programs.
4U.4	Behavior in waste management	Assessment of good SWM practices, such as: not littering, applying 3Rs principles, waste separation at source.
5F	**Financial sustainability**	
5F.1	Cost accounting	Extent to which the solid waste management accounts reflect accurately the costs of providing the service.
5F.2	Planning for necessary capital for investment	Extend to which capital investment are available to purchase necessary infrastructure.
6L	**School institutional capacity for appropriate SWM**	
6L.1	Organizational structure	Responsibility at management level
6L.2	Institutional capacity	Institutional capacity and know-how
6L.3	School SWM strategy & plan	Recent strategy or plan in place and implemented at the school level for SWM
6L.4	SWM data	Availability and quality of SWM data

T 2.A2 – WABIs for schools

Wilson, et al., 2015 "'Wasteaware' benchmark indicators for integrated sustainable waste management in cities" [24]

A.3) Reviewing water, sanitation and energy operations

Moving towards a Zero-Waste school goes beyond waste management only. In order to close the loop of all resources and materials, you should also assess the water supply, sanitation and energy system (sources and consumption) of the school. This will help identify improvement possibilities and show potential synergies regarding material recovery options.

The main information of interest for each of these elements are summarized in Box 10[2].

[2] Note that the assessment provided here focuses on flows of material and resources but do not tackle water, sanitation and hygiene (WASH) aspects that need to be considered in a school setting to meet the WHO minimum standards. For a thorough WASH assessment at school level, the Facility Evaluation Tool for WASH in Institution (FACET) can be used. FACET was developed with support from the UNICEF/WHO Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP). More information on FACET can be found here: https://www.eawag.ch/en/department/sandec/projects/sesp/facet/

Box 10: Information needed on water, sanitation and energy

Water	Sanitation

– How much water is consumed at the school
– What are the main sources of water supply
– Is drinking water always accessible or not
– Is there any water treatment
– Does the water quality meet WHO guideline values for presence of residual chlorine, E.Coli, Arsenic, Lead
– Is there any storage system for water and how well is it maintained
– 3Rs:
    – Which efforts are done to reduce water consumption
    – Where are potentials for water reduction
    – Is rainwater collected
    – Could rainwater be harvested to substitute some water source
	– What kind of toilet type is used
	– What is the collection and storage /treatment system used
	– Is there any wastewater treatment system in place at the school or is it connected to a sewer
	– Is greywater (wastewater from showers, sinks, etc.) mixed with blackwater (from toilets)
	– How many toilets are there
	– In which state are these toilets
	– Does the sanitation system works properly or is there any issues of smell, overflow, etc.

Energy

– How much energy is consumed at the school
– What are the main electricity/energy sources
– Is energy always available or not
– 3Rs:
    – Which efforts are done to reduce energy consumption
    – Where are potentials for energy consumption reduction
    – What could be possible options to substitute energy by renewable energy source (e.g. solar panels, biogas, etc.)

Questionnaires to assess water, sanitation and energy system at school are provided in T 2.A3 .

A.4) Reviewing curricula

The Zero-Waste approach in schools targets learning, application and practice so that strategies to reduce, reuse, recycle and recover waste can be experienced by students inside and outside the classrooms. For SWM issues to be effectively tackled in schools, it is important that SWM is considered a topic of high importance for the school community and that education strategies are in place to give guidance to school teachers on how to tackle such issues. SWM education cuts across multiple thematic areas and should ideally be incorporated into different subjects of the school curricula, going beyond sciences subjects. Following the recommendation from UNESCO on ESD (see Part 1 - Key concepts), practical teaching should be preferred over theoretical teaching only.

Box 11 gives an overview of key steps to review curricula. T 2.A4 provides you guidelines on how to assess the current school curricula in more details.

Box 11: Curricula assessment

1. **Check national strategies and policies from ministries of Education and of Environment** to see if any education strategy is in place which could support the implementation of the Zero-Waste approach;
2. **Check the current school curricula** to see if environmental and/or SWM topics are covered or not and how;
3. **Discuss with teachers and headmaster** to see if there would be any ideas on how to integrate Zero-Waste concept in classroom teaching and what would be the main challenges to be overcome to do so.

T 2.A4 – Curricula review

An interesting example of national education strategy guiding schools on how to tackle environmental education in their teaching and operations was found in Peru as described in Box 12.

Box 12: National education strategy – Example from Peru

In Peru, since 2003 emphasis is given to environmental education (including SWM) with different regulatory frameworks developed accordingly. One is the National Environmental Education Plan (PLANEA, 2016) set in motion by the Ministries of the Environment and Education. This plan gives guidance on how to "mainstream the environmental focus" in schools following two main components as described in the Table 1.

Table 1: Environmental focus summary - Peru

Components	Specification	Description
Management components	Institutional	Environmental approach has to be part of the Educational Institutional Project (PEI), Annual Working Plan (PAT) and Internal Rules (RI) lead by the school headmaster.
	Pedagogical	Environmental approach has to be part of the School Curriculum Project (PCI) and Integrated Environmental Education Project (PEAI)
Thematic components	Climate change	Mitigation, adaptation and resilience towards climate change
	Eco-efficiency	Biodiversity, energy, water, solid waste management, air and soil quality, responsible consumption
	Health	Personal hygiene, environmental conservation and cleanliness, healthy nutrition, diseases prevention, sexual health
	Risk and disaster management	Prevention, adaptation and resilience towards natural disasters.

A.5) Conduct a stakeholder analysis

Identifying your stakeholders and understand their needs and position towards changes in the SWM system will help the planning process. This can be done through mapping stakeholder impact, influence, priority, contribution, opposition and engagement options in a so-called stakeholder matrix (see Box 13). As situations and relationships evolve over time, it is advised to update the stakeholder matrix from time to time.

Box 13: Stakeholder matrix

Role in SWM	Impact	Influence	Priority	Contribution	Opposition	Engaging
In which step of the SWM chain do they play a role?	How would a Zero-Waste Action Plan impact them?	How much influence they have on the implementation success?	What is important to this stakeholder?	How can they contribute to the Zero-Waste implementation success?	How could they block the implementation success?	How will they be engaged in the Action Plan dev. & implementation?
[Generation, collection, transport, recycle, disposal and/or treatment]	[low – high]	[low – high]	[Explanation on priority]	[Explanation on contribution]	[Explanation on possible blocking]	[Explanation on how engagement should be strengthened]

Adapted from UN-Habitat [4], Module 1.3

Typical stakeholder groups: students, teachers, school officials, non-teaching staff, parents of students, SWM company (if any), formal/informal waste recyclers (if any).

Additional resources:

- *Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES, Tool T5 [13]*
- *Wilson et al., 2001. Strategic Planning Guide for Municipal Solid Waste Management, Annex 1.1 [14]*
- *JICA, 2019. Guidebook for Environmental Education on Solid Waste Management in Africa, Chapter 2.2, (2) [2]*
- *Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 , Module 1.3 (UN-Habitat) [4]*

(B) Identify key issues

Understanding what are core-issues that need to be solved is always a challenging task. We recommended to bring together different school stakeholders and analyze the issues by answering the following questions:

- **Who –** Who are the people who influence/ will be influenced by a specific issue
- **What –** What is the problem
- **When –** When does the problem occur
- **Where –** Where does the problem occur
- **Why –** Why does the problem occur
- **How –** How does the problem occur

Remember: the process of enabling and achieving participation by the different stakeholders to draw out an output is just as important as the output itself!

B.1) Problem tree analysis

A useful tool for structuring the problem and identify what impacts it, is the so-called "Problem tree" and the cause-effect relationship (see Box 14).

Box 14: Problem tree analysis

Problem tree analysis, also called situational analysis or problem analysis, is a method to "identify and understand the main issues around a specific local situation and to visualize cause-effect relationships in a problem tree" [13]. It helps to define in a schematic way the core-problem and related causes and effect.

The different parts of the tree symbolizes the following elements (see Figure 10):

- Trunk: Core problem
- Roots: Causes
- Branches: Consequences, effects

For each cause (root) of the problem it is important to try to break down the problem to its root problem. Always ask yourself: Why do we have this problem?

Remember that there may be many causes for one specific problem.

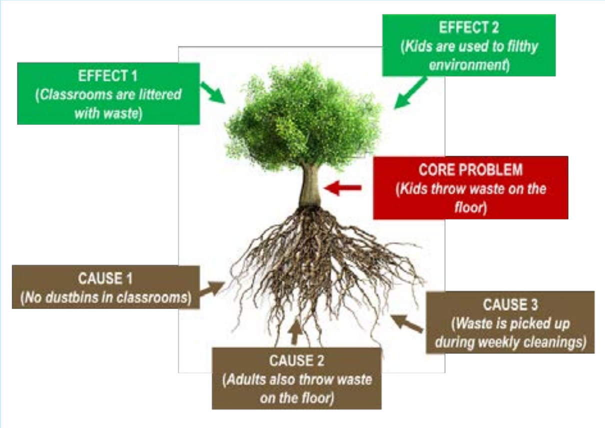


Figure 10: Examples of Problem Tree for elementary school [2]

T 2.B1 – Problem tree analysis

Additional resources:

Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES, Tool T8 [13]

JICA, 2019. Guidebook for Environmental Education on Solid Waste Management in Africa, Chapter 2.2, (2) [2]

(C) Validate the baseline

Once you have completed your baseline assessment and identified your key issues, you should present your results to all the school stakeholders. This will help you to validate the data and information gathered, as well as ensure that key issues faced by the different school stakeholders are considered. This can be done via a so-called validation workshop.

C.1) Organize a validation workshop

A validation workshop is the premises of the Action Plan development. It aims at [4]:

- Engaging with all stakeholders to reassure that they have been and are listened to, build trust and confidence
- Clarifying terminology and definitions
- Reporting back and presenting the baseline information to the stakeholders
- Discussing and resolve "hot" issues of disagreement regarding the baseline data
- Validating the facts and figures of the baseline
- Validating the identification of problems and priorities in the baseline
- Starting a first discussion on planning priorities and principles
- Identifying and agreeing with stakeholders on next steps in the planning process and scheduling

For such workshop, it is important to prepare the workshop agenda and related technical content well in advance. Also, try as much as possible to use visualization tools to communicate your results (see Box 15).

Box 15: Data visualization

An assessment always generates a lot of data. Yet, tools exist to visualize your data and help you transform data into valuable information.

The way you present your data depends on:

— **Who** your audience is, as presentation style and visuals must be neat, clear and tailored to the needs of your audience

— **What** information you want to highlight, as different tools exist to convey different type of information

Among the many visualization tools available, the most useful to present waste related data include:

Pie, Bar and Stacked bar charts : Helps representing percentages and frequency of a given answer (e.g. waste composition, level of satisfaction, etc.)

Material flow charts and Sankey diagram : Helps representing what happens to the waste

Traffic light systems : Helps identifying what works well and what does not work so well

Examples of visualization tools are shown in Figure 11, Figure 12 and Figure 13

Additional resources:

Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 , Module 5.5 (UN-Habitat) [4]

Figure 11 and Figure 12 show examples, visualizing results from waste audits and assessments done in schools. Mass flow charts show how the waste is handled, using a Sankey diagram, where the line thickness is proportional to the amounts.

Such mass flows representation typically highlights the waste generation rate at the school from each source as well as the fate of the waste. The added pie chart in Figure 12 shows the waste composition and thereby visually highlights the potential for waste segregation, as almost 60% of the waste generated is either organic or recyclable.

Figure 13 shows an example of WABIs traffic light system results for a fictitious school. This example shows a good collection system at the school, but a rather poor disposal method and a weak resource management. It also highlights room for improvement regarding governance aspects such as stakeholder's inclusivity and financial sustainability.

[3] A simple way to create such graphic where lines thickness are proportional to waste amount generated is to use Power Point and define width of the line proportionally to the amount of waste generated.

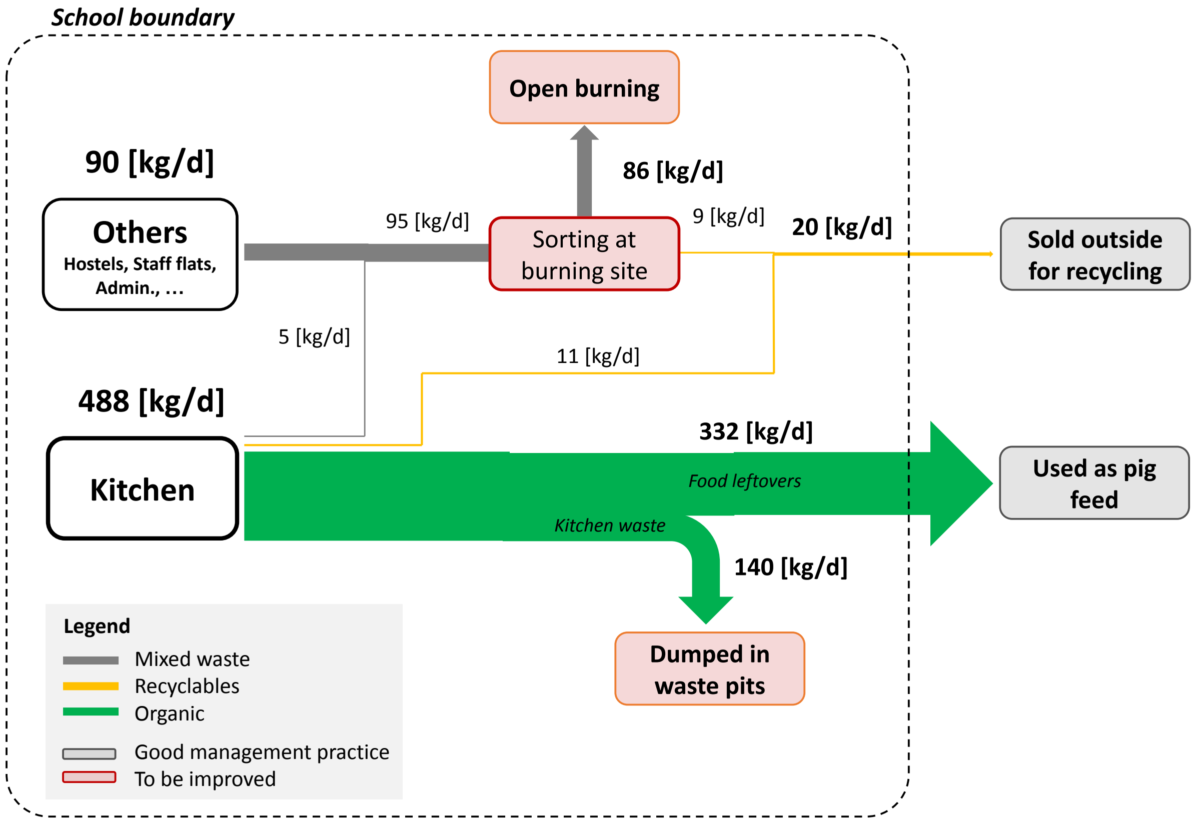


Figure 11: Example of mass flow chart for waste audit visualization [7]

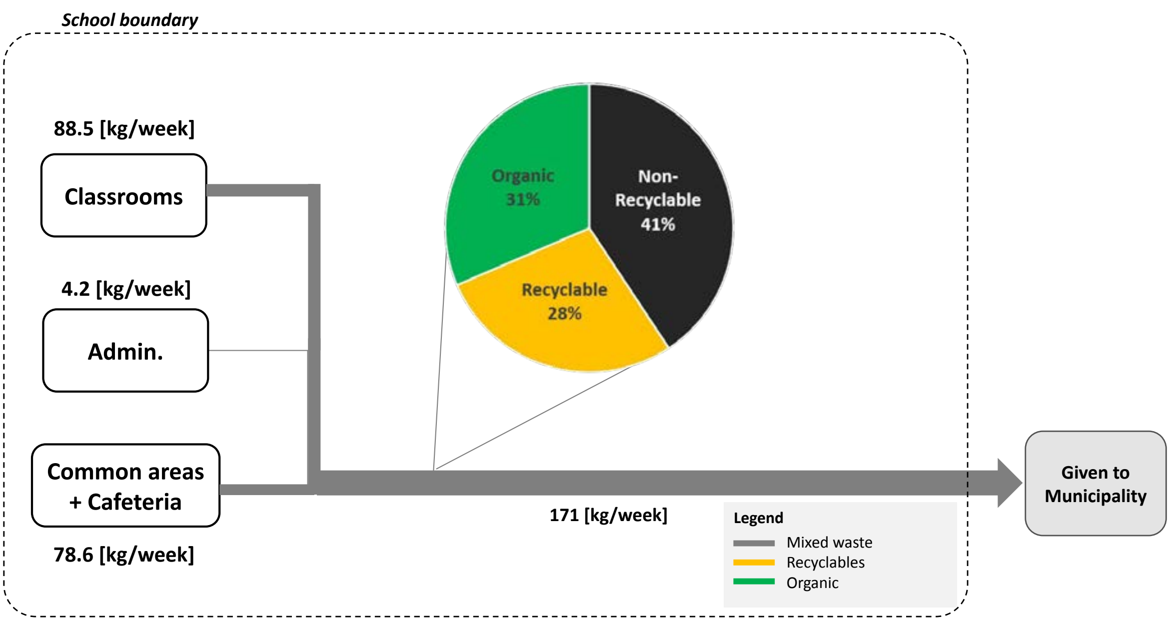


Figure 12: Example of mass flow chart for waste audit visualization combined with pie chart [27]

1. Background information on the school							
School name		**Happy School**					
Municipality, Country		Happy land					
Date since previous application of indicators:				-			
B1	General information	School type		Boarding school			
		# Meals served		4			
B2	Population of school	Total population of the school		**1,286**			
		Students		1,070			
		Staff (teaching and non-teaching)		216			
B3	Waste generation	Total municipal solid waste generation (kg/week)		**4,080**			
No	**Category**	**Data/ Benchmark Indicator**		**Results**	**Code**		**Progress**
Key Waste-related data		***Data***			-	-	-
W1	Waste per capita	MSW per capita	kg per week	3.17	-	-	
			kg per day	0.45	-	-	
W2	Waste composition:	Summary composition of MSW for 3 key fractions – all as % wt. of total waste generated			-	-	-
W2.1	Organic	Organics (food and green wastes) %		86	-	-	-
W2.2	Paper	Paper %		5	-	-	-
W2.3	Plastics	Plastics %		3	-	-	-
W2.4	Metals	Metals %		0.3	-	-	-
Physical Components		***Benchmark Indicator***		-	-	-	-
1	Public health – waste collection	Waste captured by the solid waste management system (%)		99			
1C		Quality of waste collection service		90			
2.1	Environmental control – waste treatment and disposal	Amount of waste managed onsite (%)		40			
2.2		Amount of waste burnt on school compound (%)		14			
2.3		Controlled treatment or disposal (%)		0			
2E		Quality of environmental protection of waste treatment and disposal		6			
3	Resource Management – Reduce, Reuse, Recycle	Recycling rate (%)		60			
3R		Quality of 3Rs – Reduce, reuse, recycle		38			
Governance Factors		***Benchmark Indicator***		-	-	-	-
4U	Inclusivity	Inclusivity of school stakeholders		19			
5F	Financial sustainability	Financial sustainability		25			
6L	Sound institutions, proactive policies	Local institutional coherence		38			

Key for color coding:

Low: Red ; **Low/Medium:** Red/Orange ; **Medium:** Orange ; **Medium/High:** Orange/Green ; **High:** Green

Figure 13: Example of WABIs results summary

Milestones	Key stakeholders	Tools & Resources
A. Agree on Zero-Waste priorities B. Set goals and targets towards Zero-Waste C. Identify priorities for each cluster	• ZWC • School officials	• *T 3.C1 – Priority identification per cluster*

The third step in the process is to define the planning priorities and principles and setting goals and targets towards Zero-Waste.

(A) Agree on Zero-Waste priority order

Once the baseline is validated and the core-issues agreed on, we can start defining the Zero-Waste priority order as presented in Box 16.

Box 16: Zero-Waste priority order

Going towards Zero-Waste at schools goes hand-in-hand with a general SWM improvement. Following the waste hierarchy and circular economy principles (see Box 1 and Box 2), the priority order towards Zero-Waste should therefore be on: 1) waste reduction, 2) waste segregation, 3) improving waste collection, 4) enhancing reuse/recycling, 5) improving waste disposal (inside school compound), while considering cross-cutting and underlying elements such as infrastructure needed, stakeholder involvement, behavior change and education, institutional policies and financial sustainability, as shown in Figure 14.

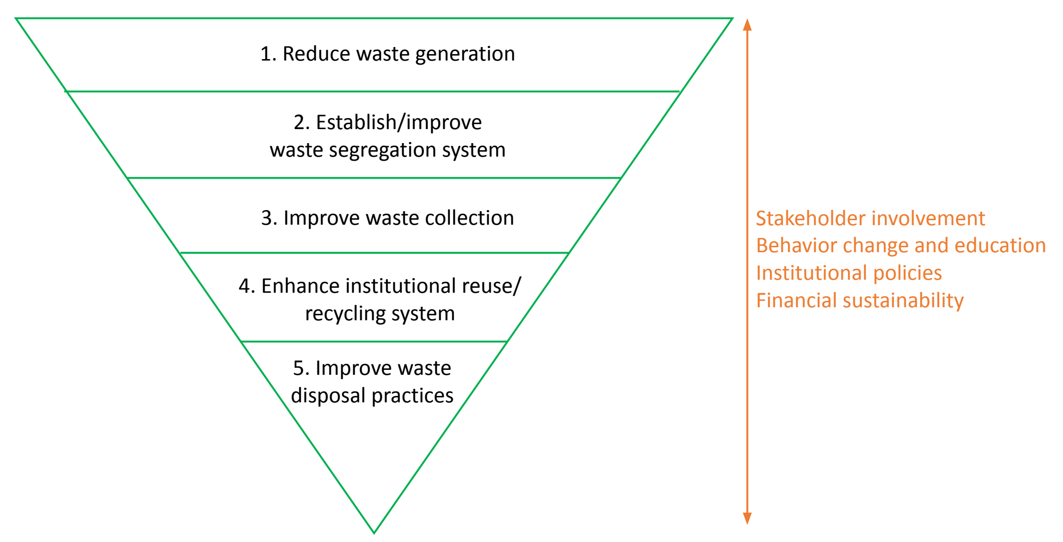


Figure 14: Zero-Waste priority order

Based on the baseline assessment results and problem tree analysis, this priority order should be discussed, contexualized and agreed upon together with school officials.

(B) Set goals and targets

Once the priority order is agreed on, we can start settings goals and targets towards Zero-Waste.

At this stage, national as well as local policies on SWM at school and in the surrounding communities should be reviewed to check if there are already goals and targets set at national or local level that could be referred to, to support the school's decisions.

Such goals and target could include for example:

– Reduce by X% the amount of waste generated
– Increase to X% the amount of waste segregated at source
– Increase to X% the amount of waste collected on the school compound
– Increase by X% the waste recycling/reuse rate at the school
– Increase to X% the amount of waste disposed/treated in a controlled manner
– Reduce to 0% the amount of waste burnt on school compound

Note that these goals and targets will help you define priorities for each school waste generation source but targets will be revised once the final decisions on actions to be taken are defined (see Step 4 (C)).

(C) Identify priorities based on key issues for each cluster

Once the general goals and targets towards Zero-Waste are defined, it is time to dig into the priorities and define what needs to be fixed urgently for each school waste generation source referred hereafter as "cluster". Filling out the cluster priority matrix will help.

Box 17: Cluster priority matrix

The cluster priority matrix helps you to define the priorities for each area of the school, based on the results of the baselines assessment. By using a scale from "no specific improvement required" to "major improvements required", it visualizes focus points as shown in the example below of a boarding school in Table 2. In his case the table suggests: "There is a big potential for reducing waste from the kitchen; waste segregation should be improved primarily in classrooms, administration offices, open spaces and dormitories; and in general disposal practices need to be improved."

Table 2: Example of cluster priority matrix

	General SWM	Classrooms	Kitchen/ Canteen	Offices/ Admin	Open spaces	Dormitories*
Reduce waste generation	-	*	***	**	-	*
Establish/improve waste segregation	-	***	*	***	***	***
Improve waste collection	*	-	-	-	*	-
Enhance institu. reuse/ recycling system	***	-	-	-	-	-
Improve waste disposal practices	***	-	-	-	-	-

*** To be considered in case of boarding schools Where:**
- : no specific improvement required; *** :** minor improvement required; **** :** some improvements required;
***** :** major improvements required

T 3.C1 – Priority identification per cluster

STEP 4. Identify and Evaluate options

Milestones	Key stakeholders	Tools & Resources
A. Identify & evaluate options B. Discuss and agree on options C. Revisit goals and targets	• ZWC ⊕ External support from SWM expert (optional)	• *T 4.A1 – Improvement options evaluation* • *T 4.A2 – Recycling market assessment* • *Technical Resources on SWM* • *Factsheets on Organics (O.1 – O.4)* • *Factsheet on MRF (R.1)* • *Factsheets on Plastic (P.1 – P.4)* • *Factsheet on Handicraft (HC.1)* • *Factsheet on Disposal (D.1)*

Once you have established your baseline and understand school community priorities it is time to think about options for the future – What can you do to achieve a Zero-Waste school?

In Step 4, the ZWC, who can also ask support from an external SWM expert, will identify options that are feasible at the school level.

The selection of options should be based on a system approach, i.e. considering all components required for the adequate management of the different waste fractions, from generation source to disposal. The main outcome of Step 4 is a consensus agreement of what should be done.

(A) Agree on Zero-Waste priority order

Based on Zero-Waste priority order (see Box 16), two categories of options can be defined:

1. **General SWM improvements**
2. **Specific improvements per waste fraction**

Options for both categories are described in the following subchapters. Each option should be evaluated considering the 5A principles (see Box 18).

Box 18: Evaluating options – 5A principles

In order for an option to be suitable for a given context, the 5A principles can be used [4]:

- **Applicable –** Is this option feasible in the given context?
- **Appropriate –** Does it fit the purpose?
- **Achievable –** Are adequate resources (capacity, know-how, infrastructure, etc.) available to implement that option?
- **Acceptable –** Does it receive enough support from the entire school community?
- **Affordable –** Can the school afford the cost related to that option?

For each option, the resources needed (i.e manpower, materials, infrastructure, funds, space, time and expertise), the level of stakeholder involvement, the need for institutional policy to support that option, as well as the required behavior change and possible education strategy to support it should be considered. The templates provided in Too 4.A1.2 can be used to evaluate the different options and corresponding needs.

T 4.A1 – Improvement options evaluation

Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 , Module 5.4 (UN-Habitat) [4]

A.1) General SWM improvements

Improvement on SWM can be divided into 4 categories. For each of these categories, the following questions should be answered:

— **Waste segregation:** Can you improve/put in place a waste segregation system?
— **Improving waste collection:** Can you improve collection coverage and/or collection frequency?
— **Enhancing recycling:** Is there any (in)formal recycling market in the nearby community the school could link to? (e.g. (in)formal businesses or individuals buying or collecting recyclables)
— **Improving waste disposal:** If the waste is disposed of at the school, can you improve waste disposal practices?

To answer these questions, you can use the resources available in Part 3 - Technical resources.

Technical resources – Waste segregation

Technical resources – Waste recovery

Technical resources – Waste collection

Technical resources – Waste disposal

T 4.A2 will guide on how to perform a recycling market assessment.

T 4.A2 - Recycling market assessment

A.2) Specific improvements per waste fraction

For each waste fraction generated at the school compound, the following questions should be answered:

Reduce: Which type of waste could be avoided? (e.g. single-use items, foodwaste, etc.)

Reuse: Is there any way that the reuse of certain material can be institutionalized? (e.g. books, cloths, etc.)

Recycle: Is it possible to sell/give it for recycling outside the school? If not, can the waste be recycled at the school compound?

Safe disposal: For waste which cannot be reduce/reuse/recycled and should be managed on the school compound, what would be a safe disposal option?

To help you answer these questions, we prepared tables summarizing options to reduce, reuse, recycle and safely dispose the different waste fractions. These options should be revised and contextualized for each school.

Technical information for options requiring a certain level of knowledge can be found in the factsheets presented in Part 3 - Technical resources.

Factsheet O.1 – Direct animal feed

Factsheet O.2 – Composting

Factsheet O.3 – Vermicomposting

Factsheet O.4 – Biogas production

Factsheet R.1 – Material Recovery Facility (MRF)

Factsheet P.1 – Ecobricks

Factsheet P.2 – Paving tiles

Factsheet P.3 – Shredding

Factsheet P.4 – Extrusion

Factsheet HC.1 – Plastic film crochet

Factsheet D.1 – Waste pit

Box 19: Specific improvement options per main waste fraction

Organic waste	Reduce	Reuse/ Recycle
Food leftovers served	Change the serving system so that less waste is generated;	Direct animal feed [O.1] Composting [O.2] Vermicomposting [O.3] Biogas production [O.4]
Food leftovers unserved	Implement a system to know how many people eat every day; Adjust the ratio of food cooked per person; Invest in cold storage system;	
Other organics (e.g. garden waste, vegetable/fruit waste)		

Plastic waste	Reduce	Reuse/ Recycle	Safe disposal
Plastic - dense (e.g. PET, hard plastic (HDPE), etc.)	Buy things in bulk	Sell/give recyclable plastic to (in)formal entity collecting recyclables*	Waste pit [D.1] Ecobricks [P.1]
Plastic – film (e.g. food wrappers, PP, LDPE, etc.)	Stop using/ban single-use plastic Buy things in bulk	Ecobricks [P.1] Paving tiles [P.2] Extrusion [P.4] Handicraft [HC.1]	

Paper/cardboard	Reduce/ Reuse	Recycle	Safe disposal
Paper	Optimize paper use	Sell/give paper/cardboard to (in)formal entity collecting recyclables* Handicraft	Waste pit [D.1]
Books	Re-use school books		
Cardboard (e.g. egg crates, etc.)	Re-use cardboard		

Glass, metal, textiles & shoes,	Reduce/ Reuse	Recycle	Safe disposal
Textiles & shoes	Re-use glass	Sell/give materials to (in)formal entity collecting recyclables*	Waste pit [D.1]
Glass	Re-use glass		
Metal	Re-use metal		
E-waste	Fix and repair e-waste		

Other	Reduce/ Reuse	Safe disposal
Inert	Reuse in construction	Waste pit [D.1]
Sanitary waste	Use reusable sanitary pads Use menstrual cup	
Medical waste	-	
Paints, solvents	-	

** Check T 4.A2 on how to perform market recycling assessment*

These lists of options can be found in Tool 4.A1.1. They should be revised considering the 5A principles (Box 18).

T 4.A1 – Improvement options evaluation

(B) Discuss and agree on options

Once the different options were identified and evaluated, it is time to take decision on what should be implemented at the school. For that, it is very important to be transparent with the financial consequences in terms of capital cost and operational cost, as well as the level of stakeholder involvement required of each option.

Typical questions to be answered at this stage are:

- **Capital cost**
  - How costly is the infrastructure needed?
  - What is the lifetime of the infrastructure and equipment? How often does it need to be replaced?
- **Operational cost**
  - Does it require electricity, water and/or fuel?
  - How frequently does it require management and maintenance (e.g. daily, weekly, monthly)?
- **Level of stakeholder involvement**
  - Does it require dedicated staff for operation and maintenance?

The selected options should be discussed and a consensus agreement should be found among the different school stakeholders.

At this stage, approval from school officials and support from the entire school community should be confirmed.

(C) Revisit goals and targets

Once the decision is taken on what will be implemented at the school the specific goals and targets defined in Step 3 (B) can be revised to represent more realistically the potential achievements.

STEP 5. Develop an Action Plan

Milestones	Key stakeholders	Tools & Resources
A. Develop an Action Plan B. Identify roles and responsibilities and set action-specific targets	• ZWC + External support from SWM expert (optional)	• *T 5.A1 – Action Plan content*

The objective of step 5 is to develop a so-called Action Plan, a plan describing what needs to be done and by whom in order to achieve a Zero-Waste school. The Action Plan does not have to address every detail but should rather serve as a guiding document. It should be realistic in terms of cost, include a timeline for implementation and address institutional and human resources issues.

If financial support allows, you can ask support from an external SWM expert to help you in that step.

(A) Develop an Action Plan

Once decisions are taken on what will be done at the school, the next step is to formulate a concrete Action Plan. For that, you need to:

1. Define the timeframe for the Action Plan implementation (e.g. 1 or 2 school year(s), X semester(s), etc.);
2. Make a list of activities to be undertaken to fulfil the goals and targets set in Step 4 (C).
3. For each activity, define the following elements (see Figure 15):
   - **What** the actions are – **Activity**
   - **Who** should take the action – **Owner**
   - **When** it should be taken – **Timeframe**
   - **Monitoring** of action implementation – **Progress**

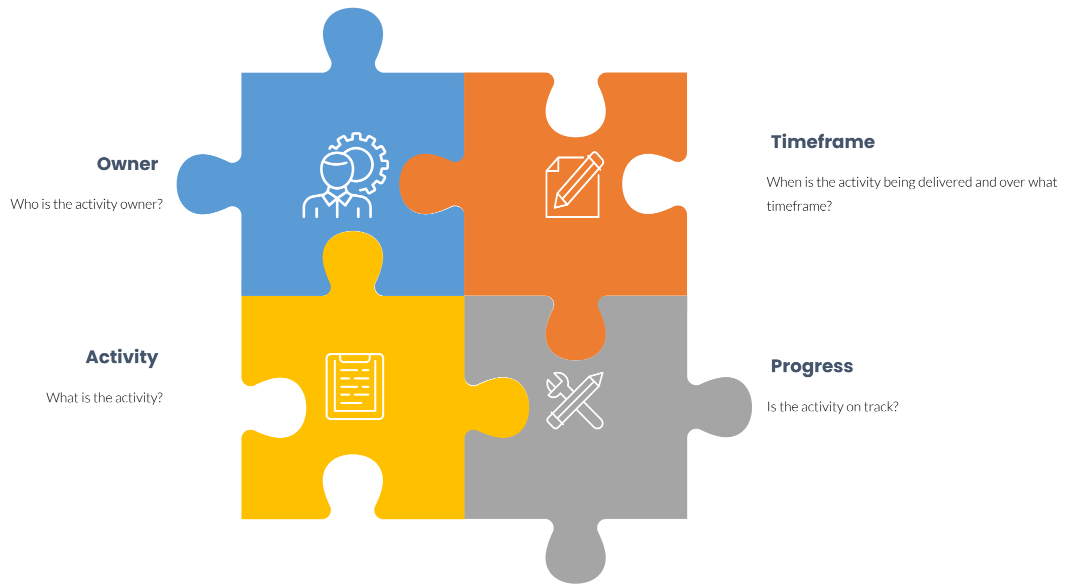


Figure 15: Key components of an Action Plan, adapted from [4]

It is important to remember that although it may be that other stakeholders such as an external SWM expert support the school in developing the Action Plan, the school must have overall responsibility and accountability for it. The Action Plan should be a "live" document that is updated regularly, as such it will detail activities which are on track and those that have been delayed for any number of reasons.

Examples of Action Plan table of content and Action Plan activity timeline are presented in the Tools 5.A1.1 and 5.A1.2.

Box 20 gives an overview of possible activities or actions, as well as key steps to be undertaken for each. For any activity to be performed, always assess the available and needed resources (manpower, materials, funds, space, time and expertise).

Box 20: Type of activities & actions

Procurement of goods or services	Awareness raising and behavior change activities
– Identify the requirements for goods and services – Identify and evaluate a list of suppliers (ask for offer, qualify offers, etc.) – Negotiate contracts with selected suppliers	– Identify key behavior to target – Consider the RANAS factors to see which factor(s) you want to trigger* – Consult RANAS Behavior Change Techniques (BCTs) catalog – Design innovative campaign – Optional: Assess impact of the activity of awareness raising
Initiating and operating a new technology (e.g. biogas reactor, composting, etc.)	**Educational activities**
– Assess end-product market demand – Conduct a feasibility study / Hire a consultant to make a feasibility study – Launching of the initiative/technology – Training of school staff – Set up of monitoring protocol (who, how, what, when, resource needed, etc)	– Evaluate rooms for improvement in current (extra-)curricula activities – Set objectives appropriate for each age and stage of development – Get inspire by existing educational resources (see Resources for schools) – Prioritize experiential learning over theoretical learning (see chapter Learning by doing - Education for Sustainable Development)

** See Behavior change chapter for more information*

T 5.A1 – Action Plan content

Additional resources:

Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES, Tool 23 [13]

Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 , Module 6.5 (UN-Habitat) [4]

[4] The RANAS Behavior Change Techniques (BCTs) can be found here, and the catalog of BCTs here

[5] The Bloom Taxonomy for teaching, learning and assessment can help defining aims and goals. https://www.bloomstaxonomy.net/

When developing the Action Plan, it is important to consider typical barriers for long-term success of waste initiatives in schools and plan ahead coping and mitigation measures. Box 21 highlights typical barriers encountered in many school projects worldwide as well as possible mitigation measures.

Box 21: Typical barriers for long-term success & mitigation measures

— **Lack of school political support**

- Align with National strategy
- Make sure to get written political support
- Put in place a mitigation strategy in case of changes in school officials

— **Lack of financial resources**

- In case of donation for infrastructure, make sure to build some reserves to replace infrastructure at the end of its life-time;
- Be realistic when defining potential revenue from recyclable sale or other end-product (e.g. compost, biogas, handicraft, etc.);
- Create a basket fund with revenues from sales

— **Lack of capacity and know-how**

- Make sure to have someone inside or outside the school who can give trainings and can ensure a follow-up to answer questions, doubts and troubleshooting after few months of implementation
- Make sure to train permanent school staff for proper operation and maintenance
- Ensure knowledge transfer in case of staff turnover

— **Lack of time**

- Be realistic when defining time required as well as time availability of school staff
- Divide responsibilities to make it less time intensive
- Involve students clubs in activities
- Integrate activities in (extra-)curricula activities depending on which option works best in your school setting

(B) Identify roles and responsibilities and set action-specific targets

Once the Action Plan is drafted and the list of activities to be undertaken more clearly defined, it is time to determine roles and responsibilities and set targets.

Having clear roles and responsibilities will allow you to smoothen the Action Plan implementation process and to reach a better commitment from the different stakeholders. In addition to that, it will also allow to distribute tasks among the different stakeholders and decrease the potential burden from Action Plan implementation. Setting targets will help monitoring the progress of the Action Plan implementation. Targets should be set using SMART indicators (see Box 22).

Box 22: SMART indicators

SMART indicators stands for:

Specific – Indicator should be as specific as possible

Measurable – Indicator should be easy to track, monitor and measure

Achievable – Indicator should be realistic and attainable

Relevant – Indicator should support the achievement of the overall goal and target

Time-bound – Indicator should have a time-frame in which it should be achieved

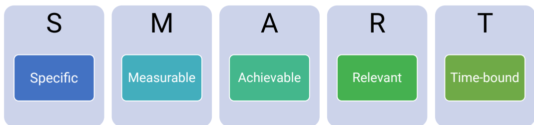


Figure 16: SMART indicators definition, adapted from [4]

STEP 6. Implement the Action Plan

Milestones	Key stakeholders	Tools & Resources
A. Begin the implementation process B. Communicate the priorities objectives and targets to all stakeholders	• Action Plan leader • Activity owners • ZWC • School officials	–

An Action Plan is not an end in itself; developing an Action Plan would be completely useless without its implementation in practice. The aim of the Action Plan is to provide a practical plan which makes a difference when it is implemented. So let's start implementing it and see where it brings us!

(A) Begin the process of Action Plan implementation

To implement an Action Plan smoothly and effectively, it is important to [14]:

– **Have an Action Plan "leader"**, a designated person who can guide the Action Plan both through approval process and initial stages of implementation

– **Obtain necessary approvals and budgets** when decisions taken have financial consequences

– **Continue consensus building**, particularly if significant organizational changes are being proposed

– **Build capacity** among school stakeholders on SWM issues to ensure skills transfer to and capacity building within the school

(B) Communicate the priorities, objectives and targets to all stakeholders

It is important to communicate the priorities, objectives and targets to the whole school community so that everyone is informed and can support the implementation process. Ideally, this should be embedded into one of the first step of the public awareness and education strategy of the school.

Milestones	Key stakeholders	Tools & Resources
A. Monitor and evaluate progress against target B. Identify opportunities for improvement C. Update the Action Plan accordingly	• Action Plan leader • Activity owners • ZWC • School officials	–

The Action Plan will include a number of milestones and indicators, but is however not written in stone. It is important that progress is reviewed by key stakeholders at regular intervals so that necessary amendments and adjustment of the plan can be made as appropriate.

(A) Monitor and evaluate progress against targets set

Action Plan follows the so-called PDCA cycle, which consists in planning, doing, checking and acting (see Figure 17). As such, progress against targets set should be monitored and evaluated regularly throughout the implementation of the Action Plan.

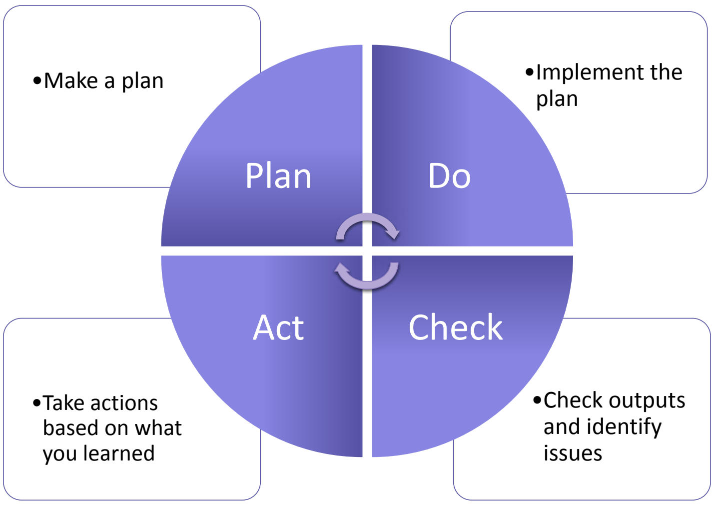


Figure 17: PDCA cycle, adapted from [2]

(B) Identify opportunities for improvement

Based on the monitoring results, opportunities for improvement can be identified. It can be for adapting slightly the strategy, or adding/deleting activities whenever it is appropriate.

(C) Update the Action Plan accordingly

Once the changes are agreed upon the main school stakeholders, the Action Plan can be updated accordingly.

Remember that is it very important that the progress, success and/or changes are communicated to all school stakeholders. Transparency on performance can help building confidence and can also be an opportunity to gain further feedback from different school stakeholders.

Part 3 -

Technical resources on Solid Waste Management

Contents

(A) Solid waste management – Facts and Figures

Solid waste definition

Waste is a generic term that refers to something which is no longer used and is discarded. Solid waste is waste generated in homes, restaurants, shopping centers, school, etc. when we consume a product and want to get rid of it.

Solid waste management as a global challenge

It is estimated that the world population now generates around 2 billion tons of solid waste each year of which 30% remains uncollected and is mostly openly burned or dumped somewhere. For the collected fraction, 70% is disposed in landfills and dumpsites [6]. If we look at numbers worldwide, 2 billion people are still lacking access to waste collection service, and 3 billion people do not have access to controlled waste disposal site. Current SWM practices are responsible for 8 to 10% of greenhouse gas (GHG) emissions worldwide [5].

Figure 18: SWM key figures

Yearly, 8 tons of plastic end up in the ocean which is equivalent to one garbage truck full of plastic dumping waste into the ocean every minutes, as shown in Figure 19.

Figure 19: Plastic key figures

Impact of waste mismanagement

Burning and dumping mixed waste are common practices that have a huge impact on human health and the environment.

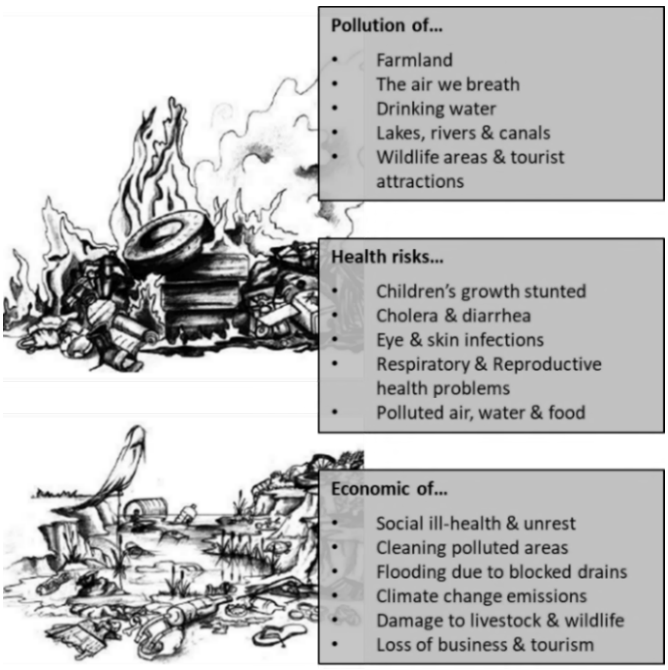


Figure 20: Impact of waste mismanagement [6] adapted from [8]

Burning threat: Even if sometimes not visible, the smoke from burning waste can enter lungs through nose and mouth and the tiny particles can poison the blood, cause respiratory diseases and cancer. Burning waste exacerbate soil pollution, water pollution and food contamination. It also pollutes the air by releasing toxic emissions (dioxin, furans, etc.) and contributes to climate change by emitting greenhouse gases (GHG) as well as short-lived climate pollutants such as black carbon (BC), or soot, which is 460 to 1'500 more harmful than CO2 (see Box 23 for more information on BC)[28]. Note that open burning of waste is prohibited by law in most countries worldwide.

Dumping threat: Dumping waste leads to visible plastic accumulation in nature, environmental pollution of soil and water. It is responsible for flooding due to drainage system blocking, spreading of diseases as it encourages breeding of mosquitoes among others disease vectors and GHG emissions (see Table 5 for organic waste specific issues). When waste is washed by the rain, it contaminated water supplies, harming crops, livestock and people. Plastic waste eventually reaches streams, rivers and the sea causing ecological and public health problems [8].

Box 23: Black Carbon [28]

Black carbon (BC), also called soot, is a fine particulate air pollutant (PM2.5), which is formed by the incomplete combustion of fossil fuels, wood and other fuels [28]. BC is a short-lived climate pollutant with a lifetime of 4 to 12 days only, yet with a great climate warming potential 460 to 1'500 times stronger than CO2 per unit of mass [28].

According to CCAC [28] and as shown in Figure 21, BC impacts on :

- **Health,** by increasing the risk of heart diseases, stroke, as well as lung diseases and cancer;
- **Climate,** by absorbing sunlight and converting it into heat;
- **Weather,** by preventing clouds formation and altering regional weather patterns and rainfall;
- **Snow and ice,** by accelerating the melting of ice and snow;
- **Agriculture & ecosystems,** by reducing sunlight and affecting plant health and its productivity

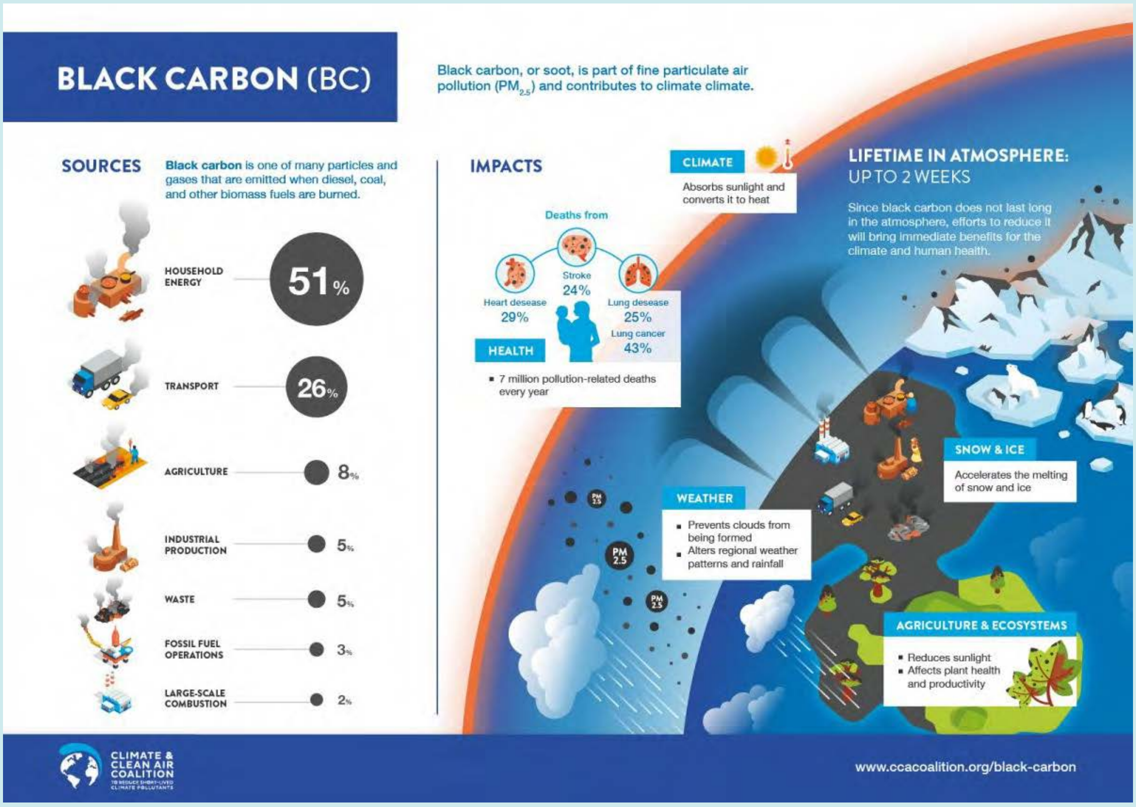


Figure 21: Black carbon key features [28]

As BC does not stay long in the atmosphere, efforts to reduce it will immediately bring benefits for climate and human health.

Additional resources:

Bond, T.C. et al., 2013. Bounding the role of black carbon in the climate system: A scientific assessment [29]

Reyna-Bensusan, N., 2020. The Impact of Black Carbon Emissions from Open Burning of Solid Waste [30]

CCAC - Black carbon [28]

Waste generation and composition worldwide

Waste generation and composition are key elements to be able to plan appropriate waste management systems at any scale. Waste generation refers to the amount of waste produced over a certain period of time, usually expressed in terms of kg per person per day, while waste composition refers to the type of material present in the waste, usually expressed in terms of percentage of a specific waste fraction amount over the total waste amount of waste generated (see Table 3).

Table 3: Waste generation and composition definition

	Definition	Typical units
Waste generation	Amount of waste generated/ produced over a time period	Kg/pers/day Kg/pers/year
Waste composition	Categorization of types of waste materials (e.g. organics, paper, glass, plastics, etc.)	% wet weight over total weight

Such data will for example influence:

- Waste prevention and reduction strategies,
- Help determine the capacity and number of collection vehicles or infrastructure needed to store the waste,
- Assess the feasibility and scale of treatment option,
- Identify recycling opportunities,
- Estimate lifespan of landfill and disposal sites, and
- Estimate trends to plans for the future.

On a global scale, waste generation rates varies from countries to countries and is highly influenced by the income levels, as shown in Figure 22. Low-income countries usually generated around 0.4-0.5 kg of waste per capita per day, whereas high-income countries generate up to 2 kg of waste per capita per day.

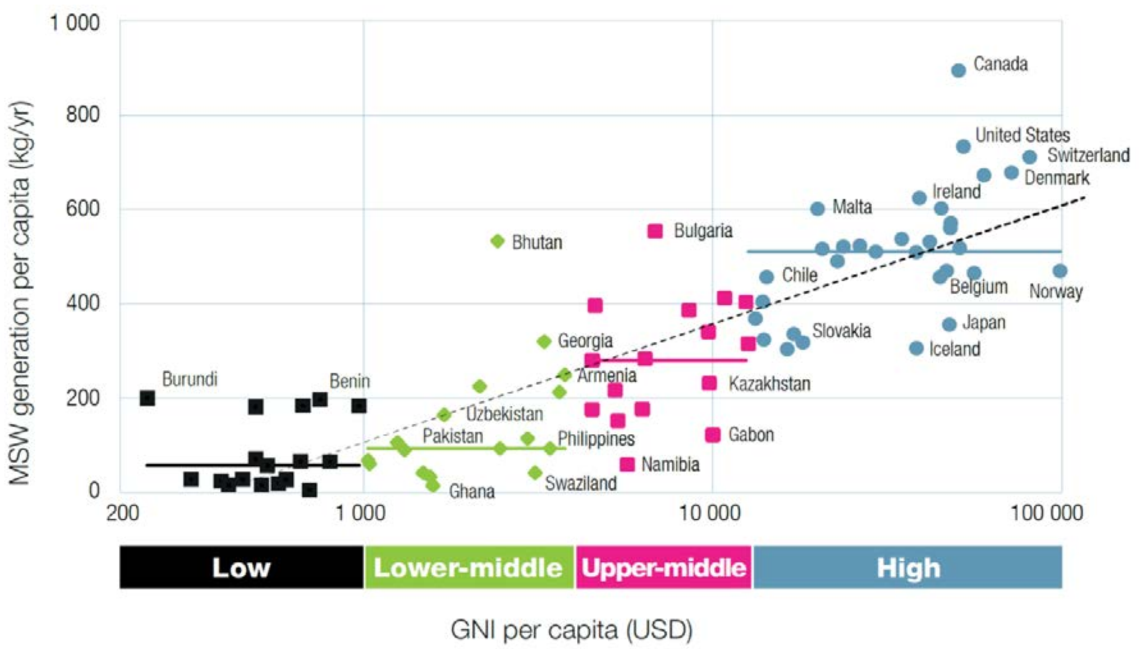


Figure 22: Waste generations rates and income levels [5]

The income level also influences the composition of the waste, as shown in Figure 23. Generally speaking, most of the waste produced in low-income settings is organic waste (typically 50-70% of total waste generated). Other waste fractions such as paper, plastic and glass have a higher percentage in high income settings than in low income settings.

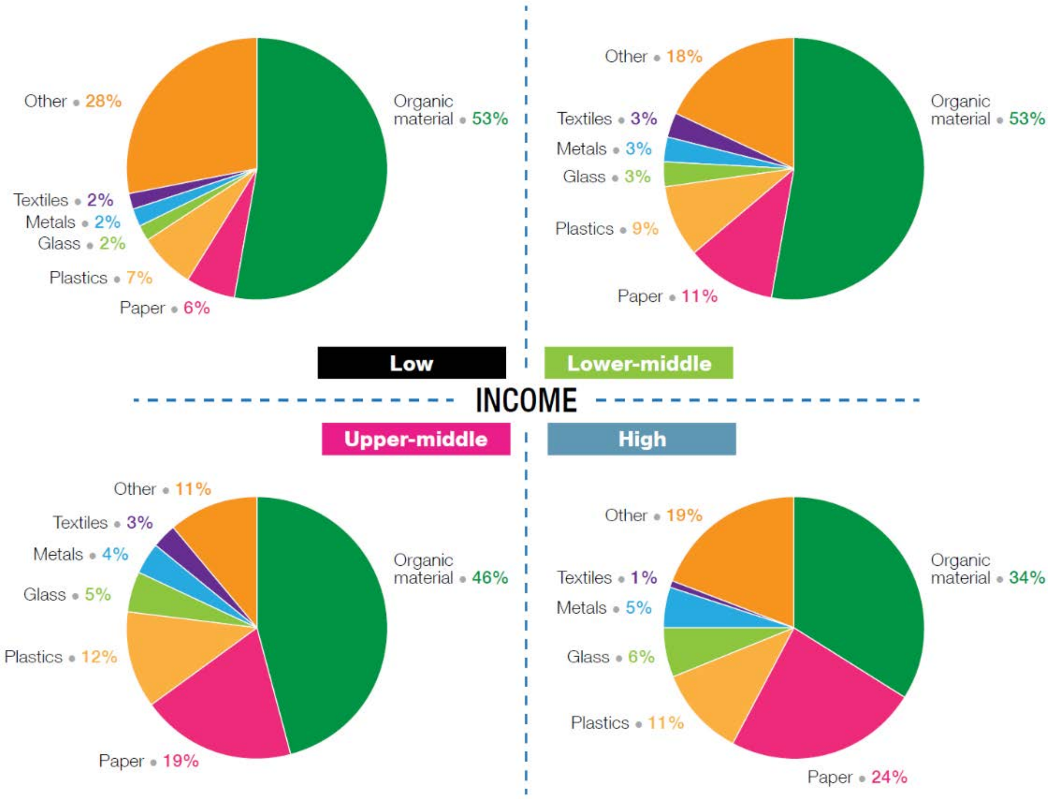


Figure 23: Waste composition patterns per income level (wet weight) [5]

Data on specific waste generation rate and waste composition per country can be found in the online database of the World Bank as well as in the "What A Waste 2.0" publication [10].

Besides general tendency, waste generation and composition may vary significantly from one location to another and is generally influenced by:

- Lifestyle
- Degree of urbanization
- Income levels
- Seasons (crops, tourism, festivities, etc.)

It is therefore recommended to rely on a local waste characterization study rather than national or regional data, and check for seasonal patterns. Information on how to perform a waste characterizations study can be found in T 2.A1.

Additional resources:

Wilson, 2015. Global Waste Management Outlook [5]

Kaza et al., 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050 [10]

(B) Solid waste fractions

Solid waste is not homogenous and is composed of a broad variety of materials. According to UN-Habitat, solid waste can be divided into the following categories [9]:

Organic

- Kitchen/ canteen waste – Cooked or uncooked food, organic waste from food preparation
- Garden/ park waste – Non-food biodegradable materials resulting from landscaping
- Paper & cardboard – Paper and cardboard packaging and products

Non Organic

- Plastics - film – Thins plastic used in packaging and for other purposes
- Plastic - dense – Hard plastic used in packaging and for other purposes
- Metal – Ferrous and non-ferrous metals packaging and products
- Glass – Glass packaging and products
- Textiles & shoes – Clothes and other textiles as well as shoes
- Wood (processed) – Untreated and treated processed wood
- Special waste – Waste electric and electronic equipment (anything with a cable), batteries / accumulators, other hazardous waste
- Composite products – Products that are made of more than one of the above
- Other – Anything that cannot be classified in one of the above categories

In Table 4, each category defined by UN-Habitat is further described with examples. Key properties are highlighted on the left side.

Table 4: Solid waste category - Adapted from UN-Habitat [9], pictures from [9]

Kitchen/ canteen waste	Examples	Key properties
	Bread, coffee grinds, cooked or uncooked food items, food leftovers, fruit and vegetables, meat and fish, pet foods, tea bags, peels, skins, shells, pips and stones, etc.	Degrade naturally over time; Rich in nitrogen; See subchapter Focus on organic waste (B) for more information on organic waste and recovery option in Organic waste (F)
Garden/ park waste	**Examples**	**Key properties**
	Flowers; Fruit and vegetable garden waste; Grass Cuttings; Hedge trimmings; Leaves; Pruning; Tree branches; Weeds, etc.	Degrade naturally over time; Rich in carbon; See subchapter Focus on organic waste (B) for more information on organic waste and recovery option in Organic waste (F)

[6] https://datacatalog.worldbank.org/dataset/what-waste-global-database

[7] Note that there is to date no unified waste categories across the globe and official waste sorting categories can be defined at national level. It is therefore important to check on national regulations to see if the proposed waste category list provided in T 2.A1 should be adapted to your local context when performing a waste audit.

Paper & cardboard	Examples	Key properties
	Brochures, magazines, news-papers; cereal packets, noodle boxes; Food Paper bags/ wrapping ; Cards, books, wall-papers; Paper bags, tissue boxes, wrapping paper, tissue paper, Writing paper, printouts, envelopes, etc.	Degrade naturally over time but issues with ink; Easy to recycle; Low to middle recycling market value
Plastic – film	**Examples**	**Key properties**
	Biscuit wrappers; Cling film; Frozen food bags; Packaging plastic film; Cellotape; Garden sheets; Non-packaging film; Plastic bags; waste liner bags; etc.	Do not degrade over time; Low to no recycling market value; Heterogeneous plastic type (mix of polymers, PP, LDPE, etc.)
Plastic - dense	**Examples**	**Key properties**
	All plastic bottles/ jars; Appliance packaging; Egg boxes; Food packaging trays; Plastic lids; Ready meal trays; Bank/credit cards; Buttons; CDs; music cassettes; Cosmetic/ glue/paint applicators; lighters; pens; etc.	Do not degrade over time; Middle recycling market value; Less heterogeneous plastic type than plastic film (PET, HDPE, etc.)
Metals	**Examples**	**Key properties**
	Packaging for carbonated drinks; Shoe polish cans; Tinned food; Aerosols (deodorant, perfume, hairspray); Aluminium foil sheets; Bike parts; Cutlery; Keys; Metal shelves; Nails; Paper clips; Ring pulls; Safety pins; Screws; Tools; Locks; etc.	Do not degrade over time; Easy to recycle; High recycling market value
Glass	**Examples**	**Key properties**
	Alcoholic and non-alcoholic drinks bottles/jars; Food jars; Medicine bottles; Cookware; Flat glass (e.g. table top, window, mirrors, reinforced, windscreens); Mixed broken glass; etc.	Do not degrade over time; Easy to recycle; Usually high recycling market value (unless long transport distances)

Textiles & shoes	Examples	Key properties
	Clothes; Balls of wool; Blankets; Carpets; Cloths; Cords; Curtains; Household soft furnishings and upholstery; Mats; Pillow cases; Rags; Ropes; Rugs; Sheets; Threads; Towels; Shoes (incl. flip-flops); etc.	Cotton textiles and other natural fibers degrade over time however synthetic fibers, plastic components do not degrade. Easy to reuse
Wood (processed)	**Examples**	**Key properties**
	Bottle corks, Cork packaging,: Pallets; Solid timber and timber fragments; Particle board (e.g. chipboard, plywood, mdf); Wood fencing; Wooden furniture; Wood work tops; etc.	Untreated wood naturally degrade over time; Can be used to produce heat. Easy to reuse
E-waste	**Examples**	**Key properties**
	All Electric and Electronic Equipment, such as clocks, electric tools, phones, laptops, PCs, printers, screens, etc; Batteries/ Accumulators; Other Hazardous Waste such as fire extinguishers; chemicals; glues and solvents; medicines; paint products, etc.	Do not degrade over time; Composite mix; Hazardous substances; need special care when managing and disposing!
Composite products	**Examples**	**Key properties**
	Composite Packaging, such as "tetrapack" ; Products made out of different materials, e.g. Scissors, knifes, razors, umbrellas, etc.	Do not degrade over time; Difficult to recycle due to composite materials
E-waste	**Examples**	**Key properties**
	e.g. inert (Boulders; Bricks; Gravel; Pebbles; Sand; Soil; Stones; Ceramics, Clay plant pots; Crockery; Stone/ceramic floor and wall tiles; Vases); Nappies/diapers; Rubber; Light bulbs (all kinds)	Inert materials can easily be used for other purposes (crushed to gravel for inert filler). Nappies, diapers, sanitary pads light bulbs will require special treatment as they are potentially harmful

Waste degradation rates

As highlighted in Table 4, not all the waste can naturally and easily fully degrade over time. Figure 24 shows typical waste and their respective degradation rates.

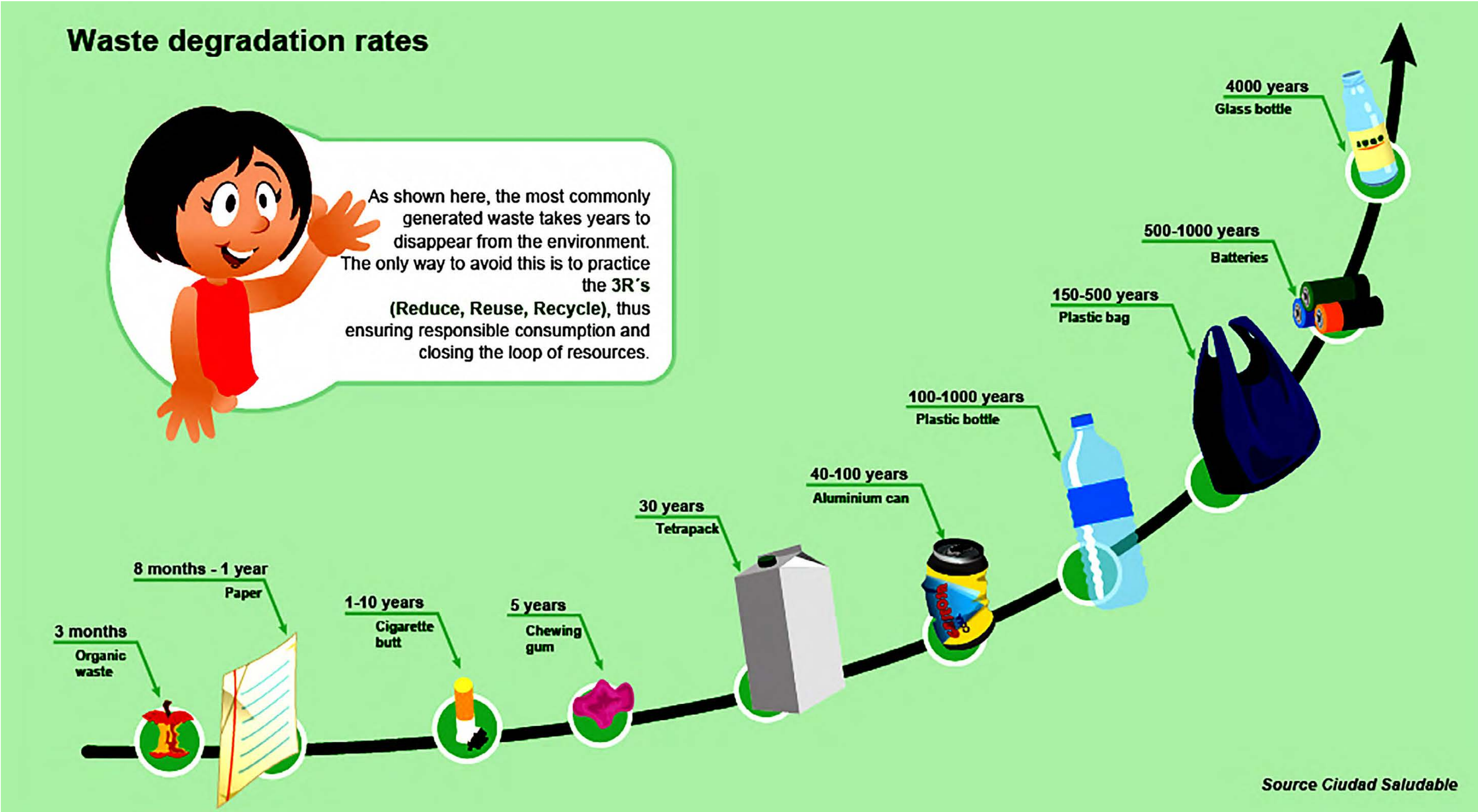


Figure 24: Waste degradation rates ©Ciudad Saludable

Focus on organic waste

Organic waste, also known as biodegradable waste, or biowaste refers to any waste that is capable of undergoing anaerobic (without oxygen) or aerobic (with oxygen) decomposition such as food, garden waste, agricultural waste, animal waste, etc. [31].

Most of the solid waste generated in low- and middle-income countries consists of organic waste, which typically represents 50 to 70% of the total amount of waste generated [5].

In school settings, organic waste is typically produced in kitchen, kiosk or canteen area when food is provided onsite, as well as from garden and green areas.

Even if organic waste does degrade naturally over time, it is necessary to manage it adequately to prevent harmful environmental and health impacts as highlighted in Box 24. More information on organic waste recovery options are presented in chapter (F) Waste recovery.

Box 24: Impacts of uncontrolled organic waste degradation

Uncontrolled organic waste degradation in large amounts may generate harmful environmental and health impacts as summarized in Table 5.

Table 5: Potential impacts of unmanaged organic waste, adapted from [31]

	Negative impact	Consequence
Soil	Contamination of soil through leachate Devaluation of the fields	Deterioration of public and environmental health Economic costs
Water	Contamination of groundwater through leachate Need for water treatment downstream	Deterioration of public and environmental health Economic costs
Air	Release of greenhouse gases such as methane (28 CO_2eq at 100y [32]) and N_2O (265 CO_2eq at 100y [32]) Bad smell	Global warming Deterioration of comfort and public health
Other	Promoting/attracting carrying diseases vectors (flies, rodents) Esthetical contamination	Deterioration of public health Deterioration of landscape impacting on tourism

Additional resources:

Zurbrügg, 2017. Biowaste management: the key to sustainable municipal solid waste management [33]

MOOC module – Overview of biowaste treatment technologies (Eawag/Sandec)

Focus on plastic waste

The mass production of plastic only started in the 1950's. Until today, around 6'300 million tons of plastics have been produced globally, of which only 9% has been recycled, 12% incinerated and the remaining 79% discarded and therefore accumulated in stocks, landfill and in the environment [34].

Plastic is a synthetic material made from organic polymers. Plastics are usually classified in 7 categories as explained in Box 25.

In school settings, plastic waste is typically under the form of food packaging (LDPE, PP), single-use plastic cutlery (PP, PS), plastic bags (LDPE), drinking bottles (PET) and plastic furniture (HDPE).

Box 25: Plastic type and specificities

Plastics can be divided in 7 main categories based on their polymer, as shown in Figure 25. This composition influences their melting and decomposition temperature as well as the general quality of the final product.

— **PET** (or PETE) is often used in plastic drinking bottles. They are often collected and recycled in large scale facilities. However, at small scale, their recycling is difficult as PET is highly hygroscopic (it absorbs moisture from the atmosphere) and lead to brittle result when moisture is present in the melting phase [35].

— **HDPE** (or PE-HD) are typically found in households as milk, shampoo or detergent bottles. This polymer is also often collected and is easy to recycle.

— **PVC** is used for a broad range of items, from plumbing to food packaging. Yet **PVC should never be attempted to be recycled in an uncontrolled environment** as this polymer is leading to a risk of production of toxic hydrochloric acid, dioxins, other polychlorinated biphenyls and furans [36].

— **LDPE** (or PE-LD) are light plastic wrappers, sandwich bags, squeezable bottles, and plastic grocery bags. Usually, LDPE is usually not recycled in large scale industry, but small scale recycling could be possible as it is quite easy to melt and mould.

— **PP** is one of the most commonly used plastic and is widely used for food packaging. It is strong and can withstand high temperatures. PP is often not recycled in large industry and often contains layers of various materials (e.g. silver coat, etc.).

— **PS** also known as Styrofoam is used for disposable coffee cups, plastic food boxes, plastic cutlery. PS is rarely recycled in large scale industry.

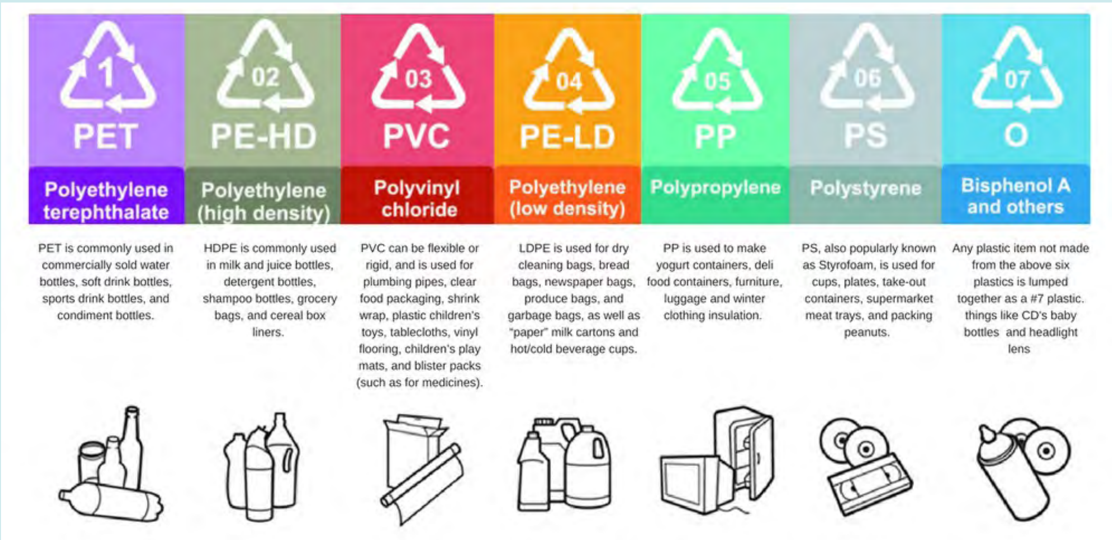
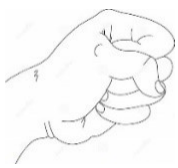
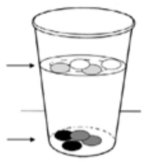


Figure 25: Plastic types ©Green Peace in https://plasticoceans.org/7-types-of-plastic/

Plastic recovery options are presented in chapter (F) Waste recovery. Note that melting different plastics together should be avoided as this reduces the end-product quality [37] or may not even be impossible because of immiscibility [36], and make it impossible to recycle the polymers again [38]. A compilation of methods for plastic identification are presented in Box 26.

Box 26: Methods for plastic identification

Method	Explanations
Polymer identification number 	The easiest way to identify polymer is to look for SPI code (see Figure 25).
Source investigation	Investigate what the plastic was used for (food wrapper, bottle seal, grocery bag,…) and formulate an hypothesis using the information provided in Box 25.
"Feeling" (breaking and listening) 	When touching the plastic you can also feel some difference: – PP wrappers feel "greasy", they can be extended a little – PET wrappers "sound loud", like a thin aluminum foil. – Multiple polymer film: By trying to stretch a film, one might see two different layers. More information on that can be found in Precious Plastic Manual [38]
Floating test 	Cut out a flat piece of plastic and put it in fresh water. Look if it floats or sinks. – Float: LDPE, HDPE, PP and PS – Sinks: PET, PVC Floating test in other liquids can be performed to identify other polymers, as described in the "Floating properties" in Precious Plastic Manual [38]
Flame test (unsafe)  ! DO NOT BURN PVC!	Take a small piece of plastic, go outside and light it using a long stick or match. Observe the color of the flame: – Blue flame with yellow tip: LDPE, HDPE and PP – Yellow flame and dark smoke: PET and PS – Yellow flame with green tip: PVC More information on that can be found in Wasteaid toolkitl [39]
Melting trial	By trying to melt a plastic at different temperature, one can find what polymer this item is made of. More information on that can be found in Precious Plastic Manual [38]
Other methods	Other methods are applied at the industrial level: – Fourrier Transform Infrared identification (FTIR) – Sorting by using fluorescent lamps – Optical automated sorting

As plastic pollution has become one of the most pressing environmental issues due to rapidly increasing production of disposable and single-use plastic products and low recycling rates, new alternatives to conventional plastics have now entered the market under the name of "bio-based plastic", "biodegradable plastic" and "oxo(bio)degradable plastics".

Yet, there is a widespread confusion among people about the sustainability and environmental impacts of these different alternatives and their name can be quite misleading, as explained in Box 27.

Box 27: Biodegradable plastic, biobased plastic, oxo-degradable plastics

The terms "bio-based", "biodegradable" and "oxo(bio)degradable are nowadays largely used for alternatives to conventional plastic. Yet these terms can be misleading regarding the environmental impacts of such alternatives. Here below some definitions taken from the European Commission [40] and from European Bioplastics [41, 42]:

— Biodegradable: Biodegrade in certain conditions and may be made from fossil-fuel based materials. Biodegradation is a chemical process during which microorganisms convert materials into water, carbon dioxide and compost without artificial additives. The process of biodegradation depends on the surrounding environmental conditions (e.g. temperature, location), on the material and on the application [41].

— Bio-based plastics: Plastics that are fully or partially made from biological resources rather than fossil raw materials. They are not necessarily compostable or biodegradable [40].

— Oxo(bio)degradable: Oxo(bio)degradable plastics are made from conventional plastics and supplemented with specific additives in order to mimic biodegrdation [42]. As such, it fragments the plastic into very small particles that remains in the environment (i.e. so-called micro-plastics). Oxo(bio)degradable plastics are not biodegradable. There is to date no internationally established and acknowledged standard or certification on oxo-degradable plastic and is therefore "just an appealing marketing term" [42] that is currently widely used and often misleads consumers. Also note that in some countries, oxo(bio)degradable plastic are often simply called "biodegradable plastic", even if they are not biodegradable.

As shown in Figure 26 conventional plastic, as well as bio-based PE, PET, PA, PTT are not biodegradable. The only one being biodegradable are: PBAT, PCL, PLA, PHA, PBS and starch blends.

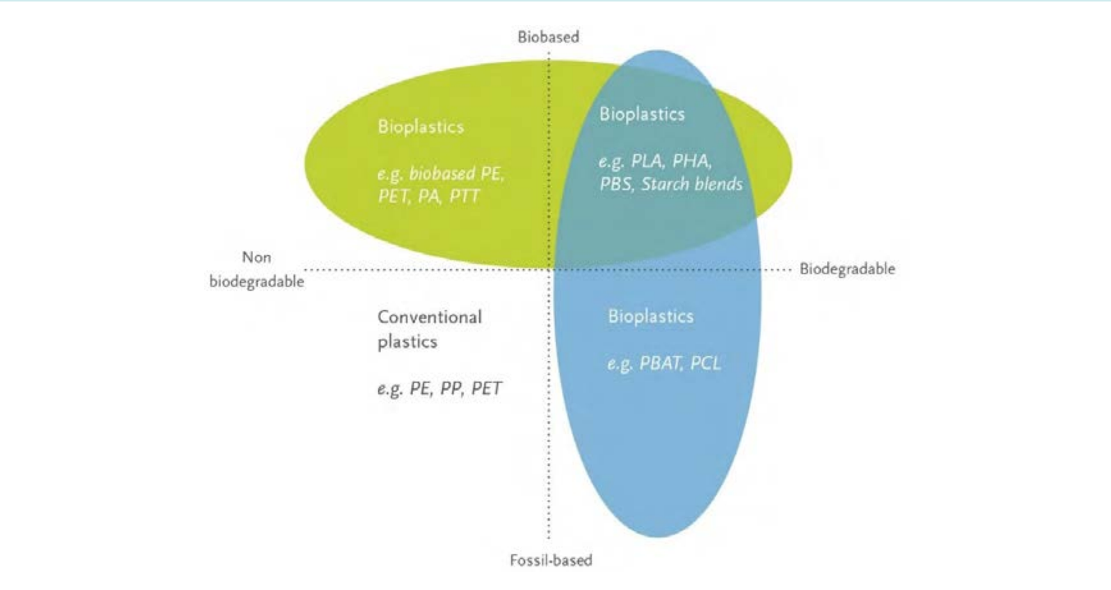


Figure 26: Plastic origin and biodegradability [41]

Additional resources:

- *Wasteaid, 2017. Making Waste Work: A toolkit – How to prepare plastics to sell to market [39]*
- *Precious Plastic, 2017. Manual 1.0 [38]*
- *EuropeanBioplastics, 2021 – Bioplastic materials [41]*
- *MOOC module – Plastic waste management - Theory (Eawag/Sandec)*

(C) Waste reduction & reuse

The best way to manage waste is to not produce it at the very first place. Therefore, efforts should always be put on reducing the amount of waste by:

1. Avoiding consumption of goods generating high amounts of waste;
2. Adapting the procurement of goods to the actual needs for it;
3. Systematically reusing material and item before it becomes a waste.

Here below a list of key elements to consider to reduce typical waste generated at school:

Kitchen/ canteen waste

— Change the serving system to avoid food leftover served

— Implement a system to know how many people eat every day

— Adjust the ratio of food cooked per person

— Invest in cold storage system

Plastic waste

— Buy things in bulk to avoid small plastic packages

— Stop using single-use plastics and replace with reusable items (e.g. cutlery, beverages container, etc.)

Paper & cardboard

— Optimize paper use

— Re-use school books and cardboard

Sanitary waste

— Promote reusable hygienic alternatives (reusable sanitary pads, menstrual cup, etc.)! If reusable alternatives are promoted, make sure to provide necessary infrastructure and trainings to ensure a safe and hygienic reuse of sanitary products!

See Tool 4.A1.2 for waste-specific reduction strategies.

(D) Waste segregation

Separating the waste into different fractions allows to consider it as potential resources and not as trash anymore. Waste can be separated at different moments along the SWM chain. Usually, when done at the generation point, it is called "waste segregation", and when it is first mixed together and then separated, it is called "waste sorting".

Waste segregation at source is preferable over waste sorting as it allows a higher quality of the material. Table 6 gives a definition of waste segregation and waste sorting and summarizes the main pros and cons.

Table 6: Waste segregation and waste sorting

	Definition	Pros and Cons
Waste segregation	Waste separated at source, when the waste is put thrown away, i.e. put into a bin	➕ Quality of the material (waste = resource) ➖ Require a change of practice and therefore a behavior change
Waste sorting	Waste first mixed together in a bin and then separated into different fractions	➕ Don't require a change of practice ➖ Materials are soiled and more difficult to recycle

Different waste segregation systems can be put in place:

- **2-bins system:** organic + other (i.e wet and dry)
- **3-bins system:** organic + recyclables + other
- **4-bins system:** organic + paper + other recyclables + other
- ...

It is advised to put in place at least a 2-bins system to make sure that organic waste does not soil the rest of the recyclables.

Note that the bins do not have to be plastic bins. It can also be made out of cardboard boxes or other materials (see Figure 27), PET bottles, etc.

Figure 27: Examples of cardboard bins ©Ciudad Saludable

Box 28: Waste segregation & behavior change

Remember that asking people to segregate their waste, is actually asking for a behavior change from people. As such, it goes beyond bringing solely the adequate infrastructure to people; it requires the use of appropriate trainings and behavior change techniques.

See the Behavior change chapter in Part 1 for more information.

Figure 28: Waste segregation ©Ciudad Saludable

Whenever a waste segregation system is put in place, it is important to:

— Ensure a separate collection system for the separated waste fraction;

— Make sure to consider behavior change interventions (software aspect) to complement the infrastructure implementation (hardware aspect).

Additional resources:

Mosler Contzen, 2016. Systematic behavior change in water, sanitation and hygiene. A practical guide using the RANAS approach [15

Cavin, 2017. Behavior Change Manual [17]

Ranasmosler.com

MOOC module – Triggering Community Participation with the RANAS approach (Eawag/Sandec)

(E) Waste collection

Collecting waste means to gather it from where it is produced and transport it, either to an intermediate collection site (e.g. a container located at the entrance of the school, from where an external person is going to come and pick up the waste), or to a final place of recycling or disposal.

It is important to collect waste safely and frequently enough to avoid attracting animals and insects, bad smell and spread of diseases. Recommendations below are taken from Wasteaid [43] and adapted to a school context.

Waste bins and containers

Waste bins and containers are useful to temporarily hold the waste before it is collected for disposal or recycling. The type of container and size may vary from one location to another depending on locally available material (plastic, metal, wood, etc.) and preferences. Sizes can vary from 5L, small bin, to 200L. The number of containers needed depends on the amount of waste produced and the frequency of collection. Do not forget that the weight of the full bin or container needs to match the carrier!

Cleaning equipment

Once the waste is collected, it is important to make sure that the area is clean of any residue. As mentioned by Wasteaid [43], the type of equipment used for cleaning the ground depends on the nature of the waste as well as the floor condition.

Brooms and dustpans can be used to clean out classrooms, whereas litter pickers are useful for picking up small pieces of waste littered. Straw or wooden broom are useful to sweep pavements and streets.

Transporting waste

There are many ways to collect and transport waste depending on the amount and type of material and the distances. As mentioned by Wasteaid [43], waste can be collected by hand in sacks or wooden baskets (a), transported with wheelbarrow or handcart (b) or bicycle trailer (c), for larger amounts, animal drawn-cart (d) or motorized vehicle (e) can be used, as shown in Figure 29.

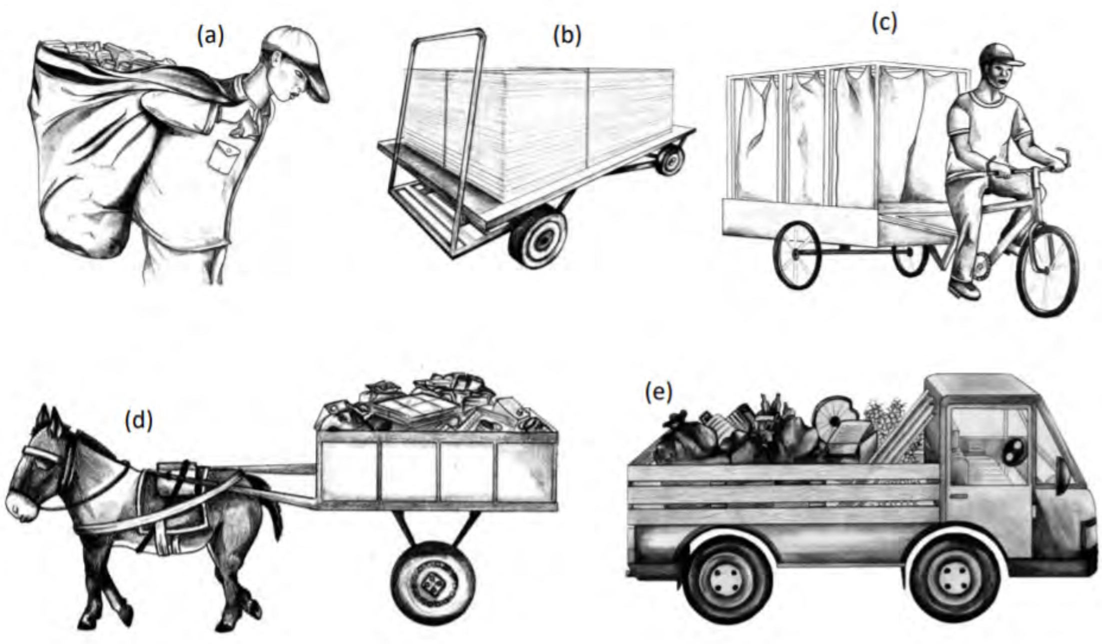


Figure 29: Ways to collect waste – from [43]

Frequency of collection

Solid waste should be collected often enough so that the amounts produced are easily handled and do not produce too many nuisances. This could mean a daily collection, or two-three times a week [43].

The collection frequency is highly influenced by the type of waste collected and the ambient conditions; in warm and wetter climates, organic waste will start rotting quickly, creating bad smell and attracting insects and other pests. Under such conditions, it is advised to collect organic waste every 1-2 days. Dry materials such as paper, plastics, glass and metal can be stored and collected less frequently.

Placement of waste containers and collection routes

Containers and bins should be located in strategic waste-generation spots to avoid littering and easily accessible to the waste collection team. Establishing a collection route is important to save time and effort. An established collection route will encourage a routine of cleanliness in the school. Plan the route so that it is as short as possible. If the school is located in a hilly/sloping area, try to end the route on the lower side of the slope/hill to avoid carrying waste uphill.

Additional resources:

Wasteaid, 2017. Making Waste Work: A toolkit – How to collect waste safely and efficiently [43]

Coffey et al., 2010. Collection of Municipal Solid Waste in Developing Countries [44]

MOOC module – Waste collection and transport (Eawag/Sandec)

(F) Waste recovery

Depending on the type of waste considered, different recovery options exist. We usually cluster the recovery options in two categories:

- **Recovery options for non-organic waste** (metal, glass, plastics, etc.), commonly called recycling options;
- **Recovery options for organic waste** (kitchen/canteen waste, garden and park waste, etc.), commonly called organic waste treatment options.

The recovery options for each waste category are described in the following subchapters.

Key elements to consider for selecting appropriate recovery options are highlighted in Box 29.

Box 29: Key elements for selecting appropriate recovery option

It is important to keep in mind that not every option suits every context, and it is therefore very important to select recovery options which fits the technical, economic and social context of the specific location considered. Typical questions to be answered to select an appropriate recovery option in a given context are summarized in Table 7.

Table 7: Technical, economic, social and legal elements to consider for appropriate recovery option selection

Technical aspect	Economic aspect
– Is the waste characteristic and amounts suitable for the considered recovery option? – Is there access to external expert who can design and build adequate treatment facility if needed? – Is there a sufficient level of knowledge in-house to operate and maintain the facility? If not, is it possible to train school staff on that?	– Is there a market-demand for the end-product (inside or outside the school)? – Is the school budget enough to cover the capital cost (CAPEX) and operational cost (OPEX)?
Social & Educational aspect	**Legal aspect**
– Is it socially appropriate in the given context to use the end-product? (e.g. cook with biogas from waste source, etc.) – Does the school have any past bad/good experience with such a recovery option which could discourage/favor the use of such an option? – Is it possible to link the use of such a recovery option for any educational purpose? (e.g. link composting practices with science courses on plant growth, etc.)	– Is there any legislation/policy preventing the use of such a recovery option? – Is there any legislation/policy preventing the use of the end-product? – Is there any legislation/policy setting standards for process or end-product quality?

Non-organic waste

Recovery options for non-organic waste are often referred to as "recycling". Yet, it is important to distinguish three possible cycles, depending on the quality of the end-product compared to the initial material as presented in Box 30

Box 30: Recycling, upcycling & downcycling definitions

 Recycling, converts a material into something of roughly the same value as it originally was (e.g. using PET bottle to make new PET bottles, using metal scraps to make new metallic items, etc.)	 Upcycling, converts a material into something with a greater value than it originally was (e.g. using plastic pouches to make bags, etc.)	 Downcycling, converts a material into something of less value than it originally was (e.g. making ecobricks with PET bottle and light plastics, etc.)

Usually, the market demand for recycled products is higher than for upcycled or downcycled products. Recycling is thus usually performed by for-profit businesses and often at larger scale than upcycling and downcycling, which is mostly performed by social businesses or non-for-profit organizations at smaller scale.

It is important to mention that when a material is downcycled or when different plastic materials are mixed together, it is no longer possible to recycle them. As a rule of thumb, we recommend to link the recyclable waste produced at the school with the existing (in)formal recycling system as described hereafter.

Existing recycling system

In most cases, when some waste material have a value on the local recycling market, a recycling chain, also called recovery chain, is already in place, being formal or informal [9]:

- Formal recycling system implies registered organizations and businesses buying recyclables and selling them to recycling facility; whereas
- Informal recycling system implies non-registered small businesses and people extracting recyclable materials from the waste stream to support their livelihood and selling the materials into the recovery system.

The recovery chain is explained in the following subchapter.

Typical recyclable materials value, as well as technical complexity, occurrence and scale of recycling processes are presented in Box 31. Examples of recycling processes can be found in the MOOC video provided in the additional resources.

Box 31: Recycling processes overview

Figure 30 gives a comparative indication among the different recycling processes in terms of recyclable value on the market, the complexity of the recycling process, whether the recycling process usually occurs or not and the scale at which the recycling process usually takes place (small scale being individuals or small businesses, and large scale being more at large businesses or industry level).

	Recyclable value [Market value of the material]	**Complexity** [Technical complexity of the recycling process]	**Occurrence** [If recycling process usually exists or not]	**Scale** [Usual size of recycling facility (from small to large scale)]
Paper	•	•	•••	• - •••
Glass[9]	•(••)	••	••	•• - •••
Metal	••(•)	•	•••	• - •••
Dense Plastic[10]	••	•••	•(•)	•••

Where: • low/ small // ••• high/ large (example: paper has a low value on market compared to other, it occurs very often at different scale (from small recycling business to large scale industries)

Figure 30: Recyclables value, technical complexity, occurrence and scale of recycling processes

[9] In remote places, the value of glass is very less due to high transportation cost, whereas in cities, the price of glass goes up quickly.

[10] Typical recycled dense plastic are: PET and HDPE.

Additional resources:

MOOC module – Recycling municipal waste (Eawag/Sandec)

Recycling chain

A recycling chain usually involved several steps from the point where a recyclable material is extracted from the waste stream until it gets recycled.

In many low and low-to-middle income countries, this involves waste pickers, intermediate traders, apex traders and end-of-chain recyclers, as defined by UN-Habitat [9]:

Waste pickers extract recyclable materials from the waste stream to support their livelihood, selling materials into the recovery system.

Intermediate traders receive materials from both formal and informal recyclable collection systems (including waste pickers), store and prepare these materials for onward trading to apex traders.

Apex traders receive materials from intermediate traders or directly from both formal and informal recyclable collection systems (including waste pickers), store and prepare these materials for onward trading to end-of-chain recyclers.

End of chain recycler receives materials from apex traders or direct from both formal and informal MSW collection systems and processes them into materials and products that have value in the economy either through recycling, incineration with energy recovery, or other recovery process

Figure 31: Recycling chain [9]

Considering a school setting, different scenarios are possible to link the school with the existing (in)formal recycling system: A) the recyclables can be collected by waste pickers, or B) the recyclables can be sold to intermediate traders. Both scenarios pros and cons are described in Table 8.

Scenarios	Pros	Cons
A) Recyclables collected by waste pickers	– No additional work for the school (just access to school compound provided) – Improving livelihood of waste pickers	– No revenue for the school from selling recyclables – Limited educational activities linked with this practice
B) Recyclables sold to intermediate traders	– Generating revenue for the school from selling recyclables – High potential for educational activities (e.g. waste sorting, accounting, etc.)	– More work and logistic for the school – Need a designated area to sort and store recyclables – Need a responsible person to manage recyclables selling

Table 8: Scenarios for linking schools with existing (in)formal recycling system pros and cons

More information on how to increase the market value of recyclables for scenario B are provided in the next subchapter.

Additional resources:

UN-Habitat, 2021. Waste Wise Cities Tool (Step 4) [4]

Increasing recyclable's value

The value of recyclables on the recycling market will depend on the quantity and the quality of the material.

Good quality recyclables are defined by Wasteaid [39] as:

- **Clean and dry**, not covered by food waste, dirt or left out the in the rain
- **Very well sorted**, with only the type of recyclable that the buyer wants
- **Compacted and baled** whenever possible, to reduce transport cost.

Table 9 shows some key steps for increasing recyclables values. This table was adapted from Wasteaid focusing mainly on how to prepare plastics to sell to market [39].

Cleaning	Drying	Sorting	Compacting & storing
– Empty any contents of containers – Remove other materials – Manual washing in large drums or containers (you might use soap to remove the oil)	– Sun drying – Use a fan for drying	– Remove all unwanted material (labels, stickers, lid,etc.) – Separate the materials by type and color depending on the buyer request	– Make sure to store the material in the most compacted way (jute bag, metallic boxes, cardboard boxes, etc.)

Table 9: Pre-treatment steps to increase recyclables value, adapted from Wasteaid [39]

Here below a list of recommendations per recyclable material:

- **Glass:** Make sure to avoid breaking glass; Clean & dry glass; Sort by glass color if needed
- **Paper:** Avoid wrinkling the paper; Keep it dry; Sort paper by paper type (newspaper, paper, etc.); Compact paper to reduce volume
- **Cardboard:** Keep it dry; Sort cardboard by cardboard type (cardboard boxes, egg crates, etc.); Compact cardboard to reduce volume
- **Metal:** Clean & dry metal; Sort ferrous and non-ferrous metal
- **Plastic:** Clean & dry plastic; Sort plastic by plastic type according to recycling market needs (see Box 26 for more information on identification methods); Compact plastics to reduce volume

In addition to that, the quantity will affect the price a buyer would give for a certain material. If the quantities are big enough, the buyer might send a vehicle to pick it up, thus reducing the logistics needed for handling the recyclables. We therefore recommend to have a recyclable storage system, commonly referred to as Material Recovery Facility (MRF), so that the different recyclables can be stored for a while before reaching the desired amounts to be picked up by the buyer(s).

More information on MRF can be found in the Factsheet R.1 MRF.

Additional resources:

Wasteaid, 2017. Making Waste Work: A toolkit – How to prepare plastics to sell to market [39]

Plastic recovery options

For plastics which do not have a market value, such as plastic films (LDPE, PP, etc.), options exist to recycle and downcycle them with low-tech solutions easily implementable in a school context.

Among them, we recommend:

- **P.1 Ecobricks –** Building material made of PET bottle filled with plastic film
- **P.2 Paving tiles –** Melting LDPE plastic with sand to produce paving tiles
- **P.3 Shredding –** Breaking down plastic into smaller pieces for further processing or selling
- **P.4 Extrusion –** Extruding plastic waste into filament to create new[12]
- **HC.1 Plastic film crochet –** Handicraft option to crochet plastic film into bags and mats

Table 10 summarizes the main concept as well as advantages and limitations of each of these options.

Detailed information for each option can be found in the Factsheets P.1 Ecobricks, P.2 Paving tiles, P.3 Shredding, P.4 Extrusion, HC.1 Plastic film crochet.

Please consider the questions highlighted in Table 7 to choose an appropriate recovery option in your given context.

Additional resources:

MOOC module – Plastic waste management - Examples (Eawag/Sandec)

[11] In urban area, unbroken glass might be taken back from the supplier.

[12] Shredding and extrusion done with Precious Plastic technologies: https://preciousplastic.com/

Options	Concept / Product	Advantage and limitations	Key additional references
P.1 Ecobricks 	Create building material from PET filled up with light plastic	⊕ Very easy-to-do; Easily replicable at home; Suitable for all type of plastic film (packaging, wrappers,…); Easy way of storing plastic and avoiding waste littering ⊖ Downcycling option; No economic value; Relevance would depend on the amount of PET bottle produced at the school and need for such building material at the school	Wasteaid 2017 [45] Ecobricks.org 2014 [46]
P.2 Paving Tiles 	Re-melting of LDPE (plastic bags,…) to produce paving tiles	⊕ Relatively easy-to-use technology (only barrel, fired and mould); Useful end-product ⊖ Downcycling option; Sand must be available; Melting temperature should be carefully looked at to avoid plastic burning (risk of environmental and health impact)	Wasteaid 2017 [47]
P.3 Shredding 	Breaking down plastic into smaller pieces for further processing or selling	⊕ Important first step for most plastic recycling processes; effective way to granulate plastic and reduce storage volume ⊖ Need machinery; Need careful plastic sorting	Precious Plastic, 2017 [38]; Precious Plastic shredder webpage
P.4 Extrusion 	Extruding specific plastic (typically either HDPE or PP) to produce plastic filament	⊕ Upcycling option; Various types of products could be designed depending on the need of the school ⊖ Need machinery and know-how; Need careful plastic sorting (extrusion can be done with one type of plastic only)	Precious Plastic, 2017 [38]; Precious Plastic extrusion webpage
HC.1 Plastic film crochet 	Crochet plastic film into bags and mats	⊕ Very easy-to-do; Easily replicable at home; Suitable for all type of plastic film (packaging, wrappers,…) ⊖ Low economic value; Limited amounts of film plastic can be upcycled with that process	Wasteaid 2017 [48]

Table 10: Overview of low-tech plastic recovery options for schools

Organic waste

Various organic waste treatment options exist (see additional resources for more information). Among them and considering a school setting, we recommend the following options:

— **O.1 Direct animal feed –** Using organic waste to feed animal such as pigs

— **O.2 Composting –** Aerobic degradation of organic waste to produce compost

— **O.3 Vermicomposting –** Aerobic degradation of organic waste with worms

— **O.4 Biogas production –** Anaerobic degradation of organic waste to produce biogas

Note that for each of these options, it is necessary to have pure organic waste and therefore, waste segregation at source should be implemented and carefully monitored.

Table 11 summarizes the main concept as well as advantages and limitations of each of these options.

Detailed information for each option can be found in the Factsheets O.1 Direct animal feed, O.2 Composting, O.3 Vermicomposting, O.4 Biogas production.

To define which option should be used in your school context, please consider the questions highlighted in Table 7.

Options	Concept / Product	Advantage and limitations	Key additional references
O.1 Direct Animal feed 	Using organic waste to feed animals such as pigs	⊕ Largely practices; Very easy-to-do; No infrastructure required and no associated cost for operation and maintenance ⊖ Limited economic value; Limited link with educational purpose; Using organic waste to feed animals might be restricted by law to avoid diseases transmission	Lohri et al. 2017 [49]
O.2 Composting 	Aerobic degradation of organic waste to produce compost	⊕ Simple and robust technology; Low capital and operating costs; Limited know-how required; Compost can be used in school garden and green area; Easy to link with educational purposes ⊖ Downcycling option; Sand must be available; Melting temperature should be carefully looked at to avoid plastic burning (risk of environmental and health impact)	Wasteaid 2017 [50]; CCAC,2016 [51]; Rothenberger et al. 2006 [52] Blue Schools Kit (8.1-2) [53] Composting MOOC module
O.3 Vermicomposting 	Aerobic degradation of organic waste with worms to produce vermicompost	⊕ Limited infrastructure required; Limited know-how required; Higher quality end-product than composting; Easy to link with educational purposes ⊖ Pre-composting phase recommend; Significant land area required; Worms sensitive to environmental condition and climate variations	Wasteaid 2017 [54]; CCAC,2016 [51];¨ Blue Schools Kit (8.3) [53] Vermicomposting MOOC module
O.4 Biogas production 	Anaerobic degradation of organic waste to produce biogas	⊕ Produce biogas that can be used for onsite cooking; Shorter treatment time than composting (10-40 days) ⊖ Required expert design and skills for construction; Medium level investment costs; Required know-how for operation and maintenance; Need to treat the digestate slurry	Wasteaid 2017 [55]; Vögeli et al. 2014 [56]; Blue Schools Kit (8.4) [53] Anaerobic digestion MOOC module

Table 11: Organic waste treatment option for schools

Additional resources:

- *Zurbrügg, 2017. Biowaste management: the key to sustainable municipal solid waste management [33]*
- *Lohri et al., 2017. Treatment technologies for urban solid biowaste to create value products: a review with focus on low- and middle-income settings [49]*
- *Zabaleta et al., 2020. Selecting Organic Waste Treatment Technologies (SOWATT) [31]*
- *MOOC module – Overview of biowaste treatment technologies (Eawag/Sandec)*

(G) Waste disposal

Waste disposal should be done in a way that controls and limits the impacts on the environment and public health (see examples of impacts in chapter "Impact of waste mismanagement"). Among waste common disposal practices, we can mention landfilling and incineration. Here it is important to make the distinction of landfilling versus open dumping as well as incineration versus open burning, as shown in Figure 32.

In low- to middle-income settings, incineration is usually not recommended due to the very wet type of waste generated, and the high cost associated with proper incineration technologies and therefore, landfilling should be preferred (see the additional resources for more information on landfilling and the level of control defined by UN-Habitat [9]).

LANDFILLING VS OPEN DUMPING

Sanitary landfill

Characteristics:

- Controlled access (fences)
- Waste disposal strategy
- Leachate and pollution prevention measures (geomembrane)
- Waste compaction
- Cover layer for waste
- No waste burning

Controlled disposal

Characteristics:

- Controlled access (fences)
- Waste disposal strategy
- No leachate /pollution prevention measures
- Waste compaction
- Cover layer for waste
- No waste burning

(Uncontrolled) dumpsite

Characteristics:

- Waste dumped, no strategy
- No leachate /pollution prevention measures
- No waste compaction
- Waste burning

INCINERATION VS OPEN BURNING

Incinerator

Characteristics:

- Complete combustion (sufficient oxygen + temperature)
- Control and cleaning of gas and fumes
- **VERY EXPENSIVE AND HIGH TECH**

"Burner"

Characteristics:

- Waste burned in a commonly-called «incinerator» which actually acts as a waste burner (controlled burning)
- No complete combustion
- No control and cleaning of gas and fumes

Open burning

Characteristics:

- aste burned in the open (uncontrolled burning)
- No complete combustion
- No control and cleaning of gas and fumes

Figure 32: Definition and characteristics of key waste disposal practices

Considering a school setting, the generated waste which cannot be recycled or recovered is usually either given for waste disposal outside the school compound to a SWM service - usually provided by the municipality or a private entity - , or disposed of onsite.

For onsite waste disposal, we recommend to dispose waste in waste pits having the following key characteristics[13] :

— Designated location & access control

  - Waste is disposed of in a single designated area (referred to as waste pit)
  - Access to people and animals is limited using fences or barriers

— Environmental protection measures:

  o Air pollution & waste wind blowing
    - No waste is burnt
    - Green buffer with trees or bushes are used to reduce the visual impact, reduce waste wind blowing and act as vegetation filter for potential smell emissions reduction
    - Waste is covered regularly with a layer of soil to avoid wind transport as well as birds and vermin

  o Groundwater protection:
    - Bottom of the waste pit is located well above the highest groundwater level (>2m)
    - Small berm and ditch are dug around the waste pit to avoid rainwater accumulation inside the waste pit
    - If possible a layer of clay should cover the bottom and the walls to avoid water leaching into the environment

These elements are summarized in Factsheet D.1 Waste pit.

Additional resources:

Jaramillo, 2003. Guidelines for the design, construction and operation of manual sanitary landfills [57]

Wasteaid, 2017. Making Waste Work: A toolkit – How to design and operate a basic waste disposal site [58]

Blue Schools Kit, 2018. Blue Schools - Linking WASH in schools with environmental education and practice, Catalogue of Technologies (8.5) [53]

UN-Habitat, 2021. Waste Wise Cities Tool - Step by step guide to assess a city's municipal solid waste management performance through SDG indicator 11.6.1 Monitoring (Step 5) [9]

MOOC module – Upgrading a Dump Site (Eawag/Sandec)

Part 4 –

Tools

T 1.B Zero-Waste principles & process

Summary: When mobilizing your team to start a Zero-Waste project, it is important that everyone involved understands the key Zero-Waste principles and agrees on the main project steps and activities. This will ensure transparency over the process and lay a solid foundation for the project to run smoothly.

Description

The Zero-Waste approach is based on the following principles:

1. Waste hierarchy, where the focus is on preventing waste generation in the school compound to reduce the amount of waste generated;
2. Circular economy, where the aim is to close the loops of material and resources as close as possible to the source of waste generation so that more material and resources can be recycled inside and/or outside the school;
3. Behavior change and learning by doing, where the aim is that the whole school community can experience sustainable practices and that students are encouraged to adopt such practices in their daily lives;
4. Participatory strategic planning, where the aim is to involve a broad variety of school stakeholders to come up with an Action Plan towards Zero-Waste tailored to the school context, and which follows a structured approach allowing to take data-driven decisions.

Presenting these key principles to the school audience (being the Zero-Waste Committee or the school officials) is key to ensure that everyone understand and agrees on these principles.

Furthermore, the key project steps and activities should be presented and adapted according to the needs so that the key stakeholders can agree on them. A pre-defined presentation can be found in Tool 1.B1. General information about solid waste management and related impacts mentioned in the technical resources can be added to the presentation when needed.

Resources

Tool 1.B1 Zero-Waste principles & overview of planning process

Additional resources:

Waste hierarchy:

Wilson, D.C., 2015. Global Waste Management Outlook [5]

Circular Economy:

Ellen MacArthur Foundation (2013) [3]

Youtube video – Explaining Circular Economy and How Society Can Re-Think Progress (Ellen MacArthur Foundation)

Ellen MacArthur Foundation

Behavior change and learning by doing

UNESCO, 2014. Shaping the Future We Want [1]

UNESCO, 2018. Issues and trends in Education for Sustainable Development [10]

Mosler Contzen, 2016. Systematic behavior change in water, sanitation and hygiene. A practical guide using the RANAS approach [13]

Cavin, 2017. Behavior Change Manual [15]

MOOC module – Triggering Community Participation with the RANAS approach (Eawag/Sandec))

Ranasmosler.com

Strategic planning:

Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES [11]

Wilson et al., 2001. Strategic Planning Guide for Municipal Solid Waste Management [12]

Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 (UN-Habitat)

T 2.A1 Waste audit

Summary: Waste audit aims to determine the amount and the composition of the waste produced. Such information will serve in particular to identify potential for waste reduction/minimization, treatment and recovery options and waste management optimization (segregation, collection and disposal).
Waste audit usually takes place over a week in a defined area.

Description

A waste audit consists in collecting waste on a daily basis, over a week, and each day: weigh the waste, characterize the waste (i.e. separate the collected waste in different waste fractions, weigh each fraction separately), and report the gathered information on a document. At the end of the week, an average of waste production per day can be obtained. It is advised to repeat such audit at different times of the year to capture seasonal variations.

Waste audit should (i) provide consistent information/data, (ii) be simple, convenient and repeatable and (iii) the information/data must be collected and reported in a manner that permits an effective evaluation of waste reduction opportunities and management optimization.

Key steps are described in the table below.

Steps	
Step 1.	Adapt waste audit process to school settings and priorities (see Guide 2.A1)
Step 2.	Define time and location of waste audit
Step 3.	Prepare the team and the logistics (waste audit team and period, schedule and location of the measurements) (2 days)
Step 4.	Get the necessary equipment (1-2 days)
Step 5.	Train people who will conduct the waste audit (1 day)
Step 6.	Conduct the waste audit (6-8 days)
Step 7.	Complete the data and analyze the results (3 days)

Resources

Guide 2.A1 Waste audit at school – Procedure

Tool 2.A1.1 Recording sheet for waste audit

Tool 2.A1.2 Recording sheets for waste composition analysis

A. Kitchen/canteen

B. Other

Additional resources:

- *UN-Habitat, 2021. Waste Wise Cities Tool (Step 2)*
- *Wasteaid, 2017. Making waste work: A toolkit – How to measure your waste*
- *MOOC module – Conducting a Waste Generation and Characterization Study (Eawag/Sandec)*

T 2.A2 WABIs for school

Summary: The Wasteaware Benchmark indicators (WABIs) comprises quantitative and qualitative indicators used to evaluate and assess the physical components and governance aspect of solid waste management systems. They were developed by Wilson et al. (2015) to benchmark solid waste management services of different cities across the globe and were adapted for school settings.

Description

The WABIs uses a set of quantitative and qualitative indicators covering the aspects of:

- **Waste collection –** Percentage of waste collected and quality of waste collection
- **Waste treatment and disposal –** Percentage of waste treated and disposed of on site and quality of environmental protection from treatment and disposal methods
- **Resource management –** Recycling rates and quality of the 3Rs – Reduce, Reuse, Recycle
- **Stakeholder inclusivity –** To which extend are stakeholder involved in SWM service
- **Financial sustainability –** To which extend SWM service is financially sustainable
- **Sound institutions and policies –** School institutional capacity for appropriate SWM

The required information is gathered through observation, estimation and interviews and entered into an Excel file (Tool 2.A2). Each indicator is scored on a scale of 5 options, from very low, to very high. Guidance on how to assess each indicator is provided in Tool 2.A2.

Results are automatically calculated using a "traffic lights" color system, which helps to visualize where improvements are needed in order to achieve a safer SWM system that protects the environment and human health.

Steps

Step 1. Get familiarize with Tool 2.A2 (1/2 day)

Step 2. Conduct interviews with key stakeholders and field observation and fill out Tool 2.A2 (~3-5 days)

Step 3. Check consistency of the results with key stakeholders (1/2 day)

Resources

Tool 2.A2 WABIs for school

Additional resources:

Wilson, et al., 2015 "'Wasteaware' benchmark indicators for integrated sustainable waste management in cities"

MOOC module – Comparing cities' performance (Eawag/Sandec)

T 2.A3 Water, sanitation & energy assessment

Summary: Going toward a Zero-Waste school goes beyond waste management only. Assessing all the resources and material produced and consumed at the school in terms of water supply, sanitation system and energy will help identifying potential rooms for improvement and synergies on material recovery options.

Description

In order to close the loop of all resources and material, water supply, sanitation systems and energy sources and consumption of the school should also be looked at. The main information of interest are:

— **Part 1 - Water:**
  — How much water is consumed at the school and from which water sources?
  — Is drinking water always accessible or not?
  — Is there any water treatment system?
  — Does the water quality meet WHO guidelines for presence of residual chlorine, E.Coli, Arsenic, Lead? (see values in Tool 2.A3)
  — Is there any storage system and how well it is maintained?
  — What kind of practices are done at the school to apply the 3R concept to water?

— **Part 2 - Sanitation:**
  — What kind of toilets type is used at school?
  — What kind of collection, storage and/or treatment system is used?
  — Is there any wastewater treatment system in place or is it connected to a sewer?
  — How many (usable) toilets are there?
  — In which state are these toilets?
  — Does the sanitation system works properly or is there any issues of smell, overflow, etc?

— **Part 3 - Energy:**
  — How much energy is consumed at the school and in which form? (electricity, cooking fuel, etc.)
  — What are the main electricity/energy sources?
  — Is energy always accessible/available or not?
  — What kind of practices are done at the school to apply the 3R concept to energy?

To access this information, you can use the pre-made questionnaires of Tool 2.A3. Note that the questionnaires might need to be adapted to your specific context.

People able to answer these questions at the school are typically:

— School administrator (for bills and payment on water and energy supply)
— School technicians or school caretaker

Key steps are described in the table below.

Steps	
Step 1.	Adapt the questionnaire to the school context (1/2 day)
Step 2.	Fix appointment for interviews and field observation and send the questionnaire to the interviewee (1/2 day)
Step 3.	Fulfill the questionnaire (1-4days)*
Step 4.	Preliminary analysis of the results (1 day)

• Time needed depends on the information already available

Resources

Tool 2.A3 Water, sanitation & energy assessment questionnaires

Additional resources:

Schelbert et al., Facility Evaluation Tool for WASH in Institution (FACET)

T 2.A4 Curricula review

Summary: The Zero-Waste approach in schools is best supported if educational strategies are in place allowing students to experiment Zero-Waste practices inside and outside the classrooms. Reviewing the school curricula helps analysing possibilities of integrating and/or adding Zero-Waste related topics in curricular and extra-curricular activities.

Description

The Zero-Waste approach in schools targets learning, application and practice so that strategies to reduce, reuse, recycle and recover waste can be experienced by students inside and outside the classrooms. Ideally, Zero-Waste education should be incorporated into different subjects of the curricula, going beyond science subjects only. Following the recommendation from UNESCO on Education for Sustainable Development (ESD) (UNESCO, 2018), practical teaching should be preferred over theoretical teaching targeting knowledge and comprehension only.

Reviewing the school curricula will help analysing the status-quo in terms of Zero-Waste teaching, as well as identifying rooms for improvements so that Zero-Waste-related topics can be successfully integrated into curricula and extracurricular activities.

To do so, we recommend to:

1. Check national strategies and policies from ministries of Education and of Environment to see if any education strategy is in place which could support the implementation of the Zero-Waste approach;
2. Check the current school curricula to see if environmental and/or SWM topics are covered or not and how;
3. Discuss with teachers and headmaster during workshop to see if there would be any ideas on how to integrate Zero-Waste concept in classroom teaching and extracurricular activities, and what would be the main challenges to be overcome to do so.

Typical objectives of a curricula assessment workshop are:

1. Review existing environmental and waste-related curricula at all age levels
2. Analyze possibilities of integrating/adding relevant topics in the curricula
3. Consolidate ideas to integrate Zero-Waste-related topics in relevant school subject in classroom teaching
4. Develop plans to include Zero-Waste-related activities in extracurricular activities

Steps

Step 1. Review national educational strategies and policies (3 days)

Step 2. Check the current school curricula to see if environmental and/or SWM topics are covered or not and how (2 day)

Step 3. Conduct a workshop on curricula assessment with teachers & headmaster* (1/2 day)

Step 4. Consolidate ideas to integrate environmental and/or SWM topics in classroom (2 days)

- You can use the Tool 2.A4.1 to help you defining Zero-Waste topics

Resources

Tool 2.A4.1 List of Zero-Waste-related education themes

Tool 2.A4.2 Curricula assessment matrix

Additional resources:

UNESCO, 2014. Shaping the Future We Want

UNESCO, 2018. Issues and trends in Education for Sustainable Development

T 2.A5 Stakeholder analysis

Summary: Stakeholder analysis is the process of identifying who has an interest in, is important to, or is influencing a specific process or project (CLUES, 2011). The present tool suggests a procedure for analysing stakeholders and helps determining appropriate stakeholder involvement.

Description

Identifying all the stakeholders and understand their needs and position towards changes in the SWM system will help the planning process. For this, it is important to consider the following elements:

— Role in SWM: In which step of the SWM do they play a role?

— Impact: How would a Zero-Waste Action Plan affect them? (from low to high)

— Influence: How much influence they have on the implementation success? (from low to high)

— Priority: What is important to this stakeholder?

— Contribution: How can they contribute to the Zero-Waste implementation success?

— Opposition: How could they block the implementation success?

— Engaging: How will they be engaged in the Action Plan development and implementation?

In a school setting, typical stakeholders groups are: students, teachers, school officials, non-teaching staff, parents of students, SWM company (if any), formal/informal waste recyclers (if any).

The stakeholders impact, influence, priority, contribution, opposition and engagement options can be mapped in a so-called stakeholder matrix (see Tool 2.A5).

Key steps are described in the table below.

Steps

Step 1. Make a list of all the stakeholders you should consider

Step 2. Build a stakeholder matrix by listing them and identifying the different attributes

Step 3. Think about when, how and for what purpose you could involve them in the planning process (last column of the stakeholder matrix)

Resources

Tool 2.A5 Stakeholder matrix

Additional resources:

Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES, Tool T5

Wilson et al., 2001. Strategic Planning Guide for Municipal Solid Waste Management, Annex 1.1

JICA, 2019. Guidebook for Environmental Education on Solid Waste Management in Africa, Chapter 2.2, (2)

Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 , Module 1.3 (UN-Habitat)

T 2.B1 Problem tree analysis

Summary: Problem tree analysis (also called situational analysis or problem analysis) is a method to identify and understand the main issues around a specific local situation and to visualise cause-effect relationships using the symbolic of a tree (CLUES, 2011).

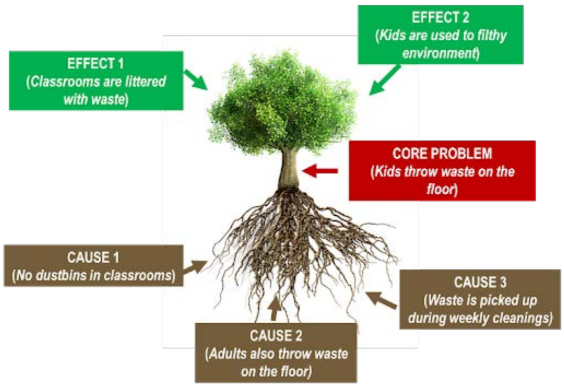
Description

Problem tree analysis helps stakeholders to establish a realistic overview and awareness of the problem by identifying the fundamental causes and their most important effects. The main output of the exercise is a tree-shaped diagram in which :

— Trunk: represents the focal problem

— Roots: represent its causes

— Branches: represents its effects.



Such a problem tree diagram creates a logical hierarchy of causes and effects and visualizes the links between them. It creates a summary picture of the existing negative situation and allow prioritising objectives by breaking down the problem into manageable units.

Problem tree analysis is best carried out by a group of stakeholder in a workshop setting (1/2 day is usually sufficient to come up with a coherent problem tree).

Key steps to create a problem tree are described in the table below.

Steps

Step 1. Identify existing problems

Step 2. Define the core problem

Step 3. Formulate the causes of the core problem

Step 4. Formulate the effects

Step 5. Draw a tree-diagram

Step 6. Review the logic and verify the diagram

Resources

Guide 2.B1 Problem tree analysis – Procedure

Additional resources:

📖 *Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES, Tool T8*

📖 *JICA, 2019. Guidebook for Environmental Education on Solid Waste Management in Africa, Chapter 2.2, (2)*

T 3.C1 | Priority identification per cluster

Summary: The cluster priority matrix helps you to define what are the priorities for each area of the school based on the results of the baselines assessment. By using a scale from "no specific improvement required" to "major improvements required", it allows you to visualize where attention should be paid.

Description

Once the general goals and targets towards Zero-Waste are defined, it is important to define the priorities and what needs to be fixed urgently for each school waste generation source referred hereafter as "cluster".

To do so, fill out the cluster priority matrix by showing where improvements are required using a scale from "no specific improvement required" to "major improvement required".

Best is to fill out the cluster priority matrix (see Tool 3.C1) with representatives of each cluster to come up with a comprehensive overview.

Key steps are summarized in the table below.

Steps
Step 1. Adapt the cluster priority matrix to the school context
Step 2. Fill out the cluster priority matrix with representatives of each cluster
Step 3. Share and discuss the cluster priority matrix results with school stakeholders

Resources

Tool 3.C1 Cluster priority matrix

T 4.A1 Improvement options evaluation

Summary: The selection of solid waste improvement options requires a system approach where general as well as specific improvement option per waste fraction should be considered. Each option should be evaluate considering the 5A principles (applicable, appropriate, achievable, acceptable, affordable), as well as resources needed, level of stakeholder involvement required, need for supporting institutional policy and education strategy.

Description

Once the priorities for the school community are defined, it is important to identify and evaluation the improvement options, considering all the components required for the adequate management of the different waste fraction, from generation to disposal.

The options can be classified in two main categories:

— General solid waste management (SWM) improvement (waste segregation, collection, recycling and disposal)

— Specific improvement per waste fraction (reduce, reuse, recycle, safe disposal)

Following the 5A principles, for an option to be suitable in a given context, it should be:

— Applicable (i.e. feasible in the given context)

— Appropriate (i.e. fit the purpose)

— Achievable (i.e. have adequate resources available to be implemented)

— Acceptable (i.e. receive enough support from the school community)

— Affordable (i.e. enough monetary resources from the school to cover the associated costs)

In addition to that, for each option, the resources needed (i.e manpower, materials, infrastructure, funds, space, time and expertise), the level of stakeholder involvement, the need for institutional policy to support that option, as well as the required behavior change and possible education strategy to support it should be considered.

Tool 4.A1.1 provides a list of possible options per waste fraction. The templates provided in Tool 4.A1.2 can be used to evaluate the different options and corresponding needs for general SWM improvement (A), per cluster (i.e. waste generation source) (B), per waste fraction (C).

Steps

Step 1. Read through the technical resources on waste segregation, waste collection, recycling and waste disposal

Step 2. Select the relevant general SWM improvement options

Step 3. Read through the factsheets provided in the technical resources

Step 4. Revise the list of improvement options per waste fraction (Tool 4.A1.1)

Step 5. Select the relevant improvement options per waste fraction

Step 6. Fill out the improvement option evaluation matrix (Tool 4.A1.2)

Resources

Technical resources – Waste segregation, Waste collection, Waste recovery, Waste disposal

Technical resources – Factsheets

Tool 4.A1.1 Improvement options per waste fraction

Tool 4.A1.2 Improvement options evaluation matrix

T 4.A2 Recycling market assessment

Summary: Assessing the existing (in)formal recycling market helps to define what kind of waste material can be recovered outside the school. Depending on the situation, the recyclables can be either given to informal waste workers for free to improve their living condition, or sold to (in)formal waste recyclers to generate income for the school.

Description

In most cases, when some waste materials have a value on the local recycling market, a recycling system is already in place, being formal or informal. In order to not re-invent the wheel, whenever possible, it is important to link the recyclables waste produced at the school with the existing (in)formal recycling system.

To do so, we recommend to:

1. Identify formal and informal individuals, companies and/or organizations involved in waste recycling – This can be done by asking people involved in waste management outside the school (e.g. drivers of waste collection truck, street sweepers, waste pickers, etc.) if they know any (in)formal recyclers active in the area.
2. Evaluate the quantities and type of recyclables produced at the school by checking on the results of the waste audit – This helps to better define the exact type of recyclables to be handled and can prepare the ground for further negotiation once the most suitable waste recyclers has been identified.
3. Conduct interviews with the (in)formal waste recyclers to know what type of recyclables they collect, at what price, what kind of pre-processing is needed (e.g. cleaned, dried, compressed, sorted by colors, etc.), and under which condition (e.g. amounts required, if a contract is needed, etc.).
4. Compare the different options gathered and determined which one(s) would be most suitable in your case – For that, considers:
    a. The objective of the school (e.g. to improve living conditions of informal waste pickers, improve recycling rate of the school, reduce the amount of waste to be managed by the school, generate income through recyclables selling, etc.)
    a. The potential income generated
    a. Level of efforts to be done by the school (e.g. is the recycler coming to pick up the recyclables or does the school need to deliver it to them, does the school need to clean/dry/sort the recyclables/ compress the recyclables or do any other type of pre-treatment, is a storage system required to gather enough recyclables for selling, can the recycler take most of the recyclables, etc.)

The key steps to be undertaken are summarized in the table below.

Steps	
Step 1.	Identify individuals, companies and/or organizations involved in waste recycling (formal and informal) (2 days)
Step 2.	Check on waste audit results to see the quantities and types of recyclables produced at the school (1/2 day)
Step 3.	Revise the recycling assessment questionnaire (Tool 4.A2) (1/2 day)
Step 4.	Conduct interviews with individuals, companies and/or organizations involved in waste recycling (3-4 days)
Step 5.	Compare the different options and determine the most suitable ones (1/2 day)
Step 6.	Discuss with school officials on which recycler(s) should the school work with*

- Note that you may need to consider different recyclers for different waste materials. Also, depending on the situation, you might consider to give the recyclables for free to waste pickers to improve their living conditions.

Resources

Technical resources – Waste recovery

Tool 4.A2 Recycling assessment questionnaire

T 5.A1 Action Plan content

Summary: The Action Plan is a plan describing what needs to be done and by whom to achieve a Zero-Waste school. It does not have to address every detail but should rather serve as a guiding document. It should be realistic in terms of cost, include a timeline for implementation and address institutional and human resources issues. The Action Plan is "owned" by the school and is a "live" document, which needs to be updated regularly.

Description

Once the decisions are taken on what will be done at the school, a concrete Action Plan needs to be formulated considering:

1. The timeframe for the Action Plan implementation (e.g. 1 or 2 school year(s), X semester(s), etc.)
2. A list of activities to be undertaken to fulfil the goals and targets set in the framework of the Zero-Waste school
3. And for each activity, define:
    a. What the actions are – Activity
    a. Who should take the action – Owner
    a. When it should be taken – Timeframe
    a. Monitoring of action implementation - Progress

It is important to remember that the Action Plan is "owned" by the school and although it may be that other stakeholders such as an external SWM expert support the school in developing the Action Plan, the school must have overall responsibility and accountability. The Action Plan should be a "live" document that is updated regularly, as such it will detail activities which are on track and those that have been delayed for any number of reasons.

Examples of an Action Plan table of content and Action Plan activity timeline are presented in Tools 5.A1.1 and 5.A1.2. Note that in the provided example, the Action Plan was developed with the help of external support and therefore the selection of alternatives was part of the Action Plan activities to ensure the school ownership over the Action Plan developed.

Steps

Step 1. Define the timeframe for Action Plan implementation

Step 2. Make a list of activities and actions

Step 3. For each activity, define : what, who, when and how progress will be monitored

Step 4. Define the Action Plan activity timeline

Resources

Tool 5.A1.1 Action Plan table of content - Example

Tool 5.A1.2 Action Plan activity timeline - Example

Additional resources:

Lüthi et al., 2011. Community-Led Urban Environmental Sanitation Planning: CLUES, Tool 23

Online course – From Data to Tangible Impact: Achieving Waste SDGs by 2030 , Module 6.5 (UN-Habitat)

Part 5 –
Factsheets

DIRECT ANIMAL FEED

Input materials	**Pre-condition/Pre-treatment**	**Operation & maintenance needs**	**Objectives / Key features**	**Key technical parameters**
Suitable organic waste: – Food leftovers – Vegetables/fruit peels **Unsuitable waste:** – Wood, branches – Leaves – Animal manure	Segregate and ensure purity of specific organic waste types that are considered suitable feed for the type of animals considered	Low operation & maintenance required	Use specific organic waste as animal feed for animal breeding purposes. For instance pigs are omnivorous and can eat various organic waste materials.	Process time: - Mass reduction: - Space: -
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Farmed animals that themselves or their products are used	Very easy to do No particular skills required No infrastructure required	Widespread practice	**Topics:** Animal growth, Nutrients recycling **Practical exercises:** Feeding animals (if done onsite)	

Organic waste can be used for feeding animals either inside or outside the school compound. Care should be taken to provide only pure organic waste to animal (i.e. segregated at source and without any plastic or contaminating material in it).

Using organic waste as animal feed is a very-well established option to recover the nutrients contained in the waste. Humans have beenfeeding biowaste to animals since the beginning of animal domestication [1]. This process works very well for swine breeding as omnivorous animals. Other animals can also be fed with organic waste but a selection of specific organic waste types suitable as feed for the targeted animals must be considered.

Applicability: Small or large-scale operation is possible, and animal feeding can happen in the school or outside the school. If no animals are bred onsite, it is possible to ask nearby farmers if they are interested in collecting food leftovers and vegetable/fruit peels from the school to feed their animals.

Technical considerations: Using organic waste as animal feed is very easy to do and does not require any particular skill, knowledge or infrastructure if done at small scale. Yet it is very important to make sure that the waste given as animal feed is pure and free of any pathogen. For that, segregating the waste at source and making sure that no substances that are toxic to the animal are present in the waste is key. Also, be aware of the risk of bioaccumulation of heavy metals, PAHs, organochlorine pesticides [1].

Materials needed: Specific recipients for collecting pure organic waste are needed.

Technical operation & maintenance: Recipients should be washed regularly to avoid any contamination.

Health and safety: Make sure to properly wash hands after handling organic waste. If organic waste is not properly handled and free of pathogen, there is a risk of diseases transmission.

Costs: -

Social, legal, and environmental considerations: Using organic waste to feed animal might be restricted by law to avoid diseases transmission. Revise the local legislation and regulation framework.

Strengths and weaknesses:

- (+) Largely practiced
- (+) Easy process
- (−) Pure organic waste free is needed to avoid diseases transmission

> References and further reading

1. Lohri, C.R., et al., Treatment technologies for urban solid biowaste to create value products: a review with focus on low- and middle-income settings. Reviews in Environmental Science and Bio-Technology, 2017. 16(1): p. 81-130.

COMPOSTING

Input materials	**Pre-condition/Pre-treatment**	**Operation & maintenance needs**	**Objectives / Key features**	**Key technical parameters**
Suitable organic waste: – Garden trimmings – Vegetables/fruit peels – Animal manure **Unsuitable waste:** – Big chunk of woody materials – Food-leftovers not preferred (risk of attracting pests and rodents)	Waste segregation at source Optional: shredding	Regular low operation and maintenance required.	Aerobic degradation of waste producing compost which can be used as soil-amendment.	Process time: 3-6 months Mass reduction: 35-40% Space: 180 - 300 m2/t*d
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Compost, soil amendment Compost is a stable dark-brown, soil-like material with earthy smell.	Limited infrastructure required (covered area) Low-level skill required for construction Medium-level skills required on composting process for appropriate operation and maintenance	Proven technology globally	**Topics:** Microbiology, Organic degradation, Nutrients recovery, Plant growth **Practical exercises:** Observing degradation process, Monitoring composting heap, Investigation on crops yield with compost	

Composting involves the controlled aerobic decomposition of organic matter that results in a soil like material called compost. This process occurs as a result of microbial activity under aerobic conditions (in presence of oxygen). Use of compost improves soil structure and increases the nutrients availability in the soil.

Composting is an ancient and widespread practice worldwide. Composting of organic matter is driven by a diverse population of microorganisms and invertebrates who break down organic matter and produce carbon dioxide, water and heat.

Controlling the process implies that the predominant parameters such as organic material composition (carbon–nitrogen ratio), particle size, free air space, aeration, temperature, moisture, or pH are managed, controlled and adjusted to achieve fast degradation and good compost quality [1].

A typically feature of a well-functioning composting process is a high temperature phase (50-70°C). The high temperature contributes to the hygienization of the material by partially eliminating pathogens and weed seeds. The end of the composting process is reached when the inner temperature of the pile is similar to ambient temperature and the oxygen concentration in the air cavities within the pile remains (10–15%) for several days [2].

Under ideal operating conditions, compost can be produced within 3 months. When conditions are not optimal, the process may be slower or may be hindered [3].

The main output product from composting is compost, a stable dark-brown, soil-like material, with dark color and earthy smell. The quality of the input material and key biological and physical operating parameters have a major influence on the quality of the final compost.

Applicability: Composting can be conducted at different scale and with different use of technology mechanization. Small-scale home-composting is most frequently conducted in bins or open heaps and rely on passive aeration process, while medium and large-scale rely on mechanization with regular turnings or active aeration, either with open windrow, bins, or in-vessel composting reactor [3].

Design considerations: Key components in the design of a composting facility include space for waste separation and preparation, fo the composting heaps or units, for screening the compost and storage of produced compost as well as space for a buffer zone. Depending on the climate and available space, the facility (at least the area of the composting heaps or units) may need to be covered in order to better control moisture. The facility should be fenced to avoid animals entering and should be located close to organic waste sources to minimize transport efforts and costs. Robust grinders can be used for shredding large pieces of organic waste before composting [4].

Materials needed: Composting facilities can be constructed with locally available material. The compost pad can be made out of concrete or well-compressed clay. Cover/roof can be made from local materials such as bamboo, grass matting, wood, plastic or metal sheet. Prefabricated composting vessels of different sizes are available on the market.

Operation & maintenance: A good mixture of carbon and nitrogen in the waste is required to allow composting. This is expressed by the C/N ratio. Moisture is also highly relevant. Depending on the moisture content of the feedstock used in composting and the climate, the addition of water may be necessary at the beginning or during the process to ensure sufficient moisture for microbial activity. Periodic turning of the composting pile ensures sufficient aeration. This can be done by hand using a pitch fork or shovel.

Health and safety: While composting is not an inherently dangerous activity, precautions are necessary to protect against injury [5].

Costs: Costs of building a composting facility vary depending on the method chosen and the cost of local materials and if machinery is included or not in the design.

Social, legal, and environmental considerations: Composting can create leachate at the beginning of the composting process. Leachate should be collected and used to water the composting pile when the moisture content decreases. When composting is not performed in a controlled way, may attract rodents and flies. Furthermore, if too wet, anaerobic degradation may occur (i.e. organic waste starts to rot) generating bad smells and greenhouse gases (GHG). Bad smells from uncontrolled composting process can decrease social acceptance for composting. Ensuring that the compost product conforms to local guidelines/standards is necessary prerequisites.

0.2

Strengths and weaknesses:

- ⊕ Proven, effective treatment method
- ⊕ Can be built and maintained with locally available materials
- ⊕ Low capital and operating costs
- ⊕ No electrical energy required
- ⊕ Easy to link with education purposes
- ⊖ Requires a large, well located land area
- ⊖ Long treatment time
- ⊖ Requires skills and knowledge on composting process and dedicated person to control the process

> References and further reading

1. Zabaleta, I., et al., Selecting Organic Waste Treatment Technologies. SOWATT, Eawag, Editor. 2020.

2. Cooperband, L., The Art and Science of Composting - A resource for farmers and compost producers, C.f.I.A. Systems, Editor. 2002.

3. Lohri, C.R., et al., Treatment technologies for urban solid biowaste to create value products: a review with focus on low- and middle-income settings. Reviews in Environmental Science and Bio-Technology, 2017. 16(1): p. 81-130.

4. Gensch, R., et al., Compendium of Sanitation Technologies in Emergencies. 2018.

5. Rynk, R., M. Van De Kamp, and G.B. Willson, On-farm Composting Handbook. 1992.

CCAC, ISWA. A handbook for schools on organic waste management. 2015

Rothenberger et al. Decentralized composting for cities in low- and middle-income countries. 2006

MOOC Youtube videos:

— *MOOC Mod.3.2 Science of composting*

— *MOOC Mod. 3.4 Operating the Composting Process*

VERMICOMPOSTING

Input materials	Pre-condition/Pre-treatment	Operation & maintenance needs	Objectives / Key features	Key technical parameters
Suitable organic waste: – Garden trimmings – Vegetables/fruit peels – Animal manure **Unsuitable waste:** – Big chunk of woody materials – Food leftovers (especially dairy product, meat and fish waste, salty and vinegary food)	Waste segregation at source Pre-composting (2 weeks) Optional: shredding	Regular low operation and maintenance required. ! Make sure to have pure organic waste!	Biological process where organic matter is digested by worms and microorganisms to produce vermi-compost.	Process time: 1.5-2.5 months Mass reduction: 40-80% Space: 300-580 m2/t*d
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Vermicompost Worms (animal feed) Worm tea	Medium-level skills required on appropriate vermicomposting technique Limited infrastructure required (covered area)	Proven technology globally	**Topics:** Microbiology, Biology, Organic degradation, Nutrients recovery, Plant growth **Practical exercises:** Observing degradation process, Investigation on crops yield with vermicompost	

Vermicomposting is a biological process where organic matter is digested by worms and microorganisms. The products are vermicompost or wormcompost, a stable soil amendment which has higher level of nutrients than compost and the worms themselves.

Vermicomposting depends on the interaction between microorganisms and earthworms. Microorganisms in the waste prepare the waste for the earthworms through a first step of aerobic degradation [1].

Appropriate earthworm species for vermicomposting are surface worms that have high adaptability to different waste types and conditions, rapid feeding and digestion, and fast growth and reproductive rate. Among these, *Eisenia fetida* is the most frequently used species besides *Lumbricus rubellus, Eisenia andrei, Perionyx excavatus and Eudrilus eugeniae* which is popular in tropical and subtropical countries [1].

Earthworms are able to process a broad range of organic waste but they do not tolerate food waste such as meat and fish waste, grease and oils, salty and vinegary foods. They also do not like onions and spicy peppers.

It is important to provide the waste as feed for eathworms in shallow layers placed into bins or beds and fed at least weekly. Thick layers will result in increase of the temperature in the waste layer or anaerobic conditions; both situations are unfavorable for the worms.

Vermicompost is a mineralized, nutrient-rich, microbiologically active organic amendment [2]. In some contexts, worms can also be used as high-protein animal feed or even for their medicinal properties. Another by-product is worm tea, the leachate from the worm bins. This can used as liquid fertilizer.

Applicability: Vermicomposting can be conducted at different scale, from household scale to large-scale facility. Vermicomposting usually takes place in worm bins or beds.

Design considerations: The size of the bin or bed will depend on the amount of organic waste available. Holes or mesh are needed for aeration. Spout or holes in the bottom can be added to drain the excess liquid (i.e. worm tea) into a tray for collection [2]. Darkness should be maintained; cover the bins to keep them shaded and protected. To save space, bins can be stacked up. But make sure to also allow fresh air circulation. Roofing for shading and rain protection is recommended but a walled enclosure is not required.

Materials needed: Vermicomposting bins and beds are most commonly constructed with plastic (recycled PET, PP) or wood. Plastic bins will require more drainage than wooden ones, however, wooden bins will eventually decay and need to be replaced. Styrofoam and metal materials should be avoided, as well as cedar wood containing resinous oils [2].

Bedding material like shredded papers, cartons, moss, straw should be added to hold moisture and create structure to allow air exchange [2].

It is better to identify locally available earthworms species to introduce foreign species that can be harmful to the local ecology [3].

Operation & maintenance: The worms can process waste up to their body weight per day. From that amount, around 50% is converted in vermicompost. A feeding rate of 50% of worm mass per day is adequate for a good operation. Layer of waste should not be above 10cm to avoid heating pile and anaerobic conditions.

Feeding worms should happen once a week and water added if the bedding dries up. If the bedding gets too wet, add dry material such as paper strips [3].

Moisture should be always kept between 70 and 85%. The pH should be neutral or slightly above neutral and aerobic conditions maintained in the entire bin. Therefore it is important to not feed fresh waste (acidic) but rather precomposted waste.

Health and safety: Vermicomposting is generally a safe activity. Health risks can be minimised if workers adopt basic precautions and hygienic practices and wear personal protective equipment.

Costs: Costs of building a vermicomposting facility vary depending the cost of local materials and earthworms but costs are generally low.

Social, legal, and environmental considerations: Before considering a vermicomposting system, the concept needs to be discussed with the school community beforehand. If the community has experience with separating organic waste and composting this can be a facilitating factor. Seeing and studying the lifecycle of the worms can be exciting lesson and experience for students.

Strengths and weaknesses:

- (+) Simple technology
- (+) Can be built and maintained with locally available materials
- (+) Relatively low capital costs
- (+) No electrical energy required
- (+) High value soil amendment
- (+) Easy to link with education purposes
- (−) Requires a large, well located land area
- (−) Pre-composting phase recommended
- (−) Worms are sensitive to environmental conditions (too hot, too cold, too wet, too much sunlight; if too many) and these must be well controlled

> References and further reading

1. Lohri, C.R., et al., Treatment technologies for urban solid biowaste to create value products: a review with focus on low- and middle-income settings. Reviews in Environmental Science and Bio-Technology, 2017. 16(1): p. 81-130.
2. Khadka, R. and S. Chaudhary, Vermicomposting A promising technology to turn kitchen waste to organic compost. 2017.
3. Lenkiewicz, Z. and M. Webster, Making Waste Work: A toolkit - How to turn organic waste into compost using worms, wasteaid, Editor. 2017.

ISWA: A handbook for schools on organic waste management, 2015

MOOC Youtube videos:

— *MOOC Mod. 3.10 Vermicomposting of biowaste*

BIOGAS PRODUCTION

Input materials	Pre-condition/Pre-treatment	Operation & maintenance needs	Description	Key technical parameters
Suitable organic waste: – Fish or meat waste – Vegetables/fruit peels – Animal manure **Unsuitable waste:** – Garden trimmings – Big chunks of woody materials – Feedstock with high salt content	Waste segregation at source Optional: shredding	Regular operation and maintenance required.	Anaerobic degradation of waste producing biogas, which can be used as fuel, and digestate.	Process time: 10-40 days Mass reduction: None (or 20% total solids (SOWATT) Space: 100-530 m2/t*d SOWATT
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Biogas, combustible gas (mainly CO2, CH4) Digestate	Higher-level skill required for appropriate design of infrastructure Higher-level skills required on construction (gas-tight) Medium-level skills required regarding O&M	Proven technology globally Experience with application may vary depending on country	**Topics:** Anaerobic processes, Organic degradation, Microbiology, Emissions calculations, Renewable energy, Nutrients recovery **Practical exercises:** pilot example with balloon	

Anaerobic digestion (AD) is a microbiological process through which organic materials are biochemically decomposed while generating biogas and nutrient-rich digestate. Biogas is a mix of methane (CH4), carbon dioxide (CO2) and other trace gases, which can be converted to heat, electricity or light. The AD process occurs in absence of oxygen in airproof reactor tanks called digesters.

The AD process is common to many natural environments, such as swamps or the stomachs of ruminants [1].

A wide range of different biomasses can be used as substrates for biogas production. AD feedstock includes sewage sludge, animal manure, food industry waste (incl. slaughterhouse waste), energy crops and harvesting residues (incl. algae), and the organic fraction of municipal solid waste [2]. Usually, feedstock of with high moisture content (> 60% water content) can be processed without pre-treatment.

The main products of AD are biogas and digestate. The biogas is a combustible gas mainly composed of methane (CH4) and oxygen dioxide (CO2). Apart from CH4 (55–60%) and CO2 (35–40%), biogas also contains several other gaseous "impurities", such as hydrogen sulphide, nitrogen, oxygen and hydrogen. The energy value of biogas derives from the contained methane and shows typical lower heating values (LHV) for biogas of 21–24 MJ/m^3 or around 6 kWh/m^3.

Directly burning biogas in stoves is the easiest way of taking advantage of biogas energy. The produced slurry (digestate) is rich in nitrogen.

The AD process is only partly able to inactivate weed seeds, bacteria, viruses, fungi and parasites and depending on if sewage sludge is used as feedstock, a treatment is necessary to be able to use it as fertilizer.

Applicability: Biogas digesters can be used at different scale and with different use of technology mechanization. They are particularly applicable in rural areas where animal manure can be added and there is a need for using digestate as fertilizer and gas for cooking. Biogas reactors are less appropriate for colder climates (< 15°C) as the rate of organic matter conversion into biogas becomes very low. Even though biogas reactors are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding [3].

Design considerations: Biogas reactors can be built as fixed dome, floating dome or tubular digesters (also called flexidigester). In the fixed dome, the volume of the reactor is constant. As gas is generated it exerts a pressure and displaces the slurry upward into an expansion chamber. When the gas is removed, slurry flows back into the reactor. The pressure can be used to transport the biogas through pipes. In a floating dome reactor, the dome rises and falls with production and withdrawal of gas.

The hydraulic retention time (HRT) in the reactor should be at least 15 days in hot climates and 25 days in temperate climates. This means the size of the reactor should be able to contain 15-20 days of waste volume (incl. water if required). For highly pathogenic inputs, a HRT of 60 days should be considered. Sizes can vary from 1,000 L for a single family up to 100,000 L for institutional or public toilet applications. Because digestate production is continuous, there must be provisions made for its storage, treatment, use and/or transport away from the site [3].

Materials needed: A biogas digester can be made out of bricks, cement, steel, sand, wire for structural strength (e.g. chicken wire), waterproof cement additive (for sealing), water pipes and fittings, a valve and a prefabricated gas outlet pipe. Prefabricated solutions include geo-bags, reinforced fiber plastic modules, and router molded units and are available from specialist suppliers [3].

Operation & maintenance: To start the reactor, it should be inoculated with anaerobic bacteria (e.g. by adding cow dung). Once running, waste needs to be added regularly (ideally daily) else the bacteria will starve. Digestate needs to be removed from the overflow frequently and will depend on the volume of the tank relative to the input of solids, the amount of indigestible solids, and the ambient temperature, as well as usage and system characteristics. Gas production should be monitored and the gas used regularly. Water traps should be checked regularly and valves and gas piping should be cleaned so that corrosion and leaks are prevented. Depending on the design and the inputs, the indigestible materials accumulating at the bottom of the reactor should be emptied and the reactor cleaned and checked every 5 to 10 years.

Health and safety: The digestate is partially sanitised but still carries a risk of infection, therefore during digestate removal, workers should be equipped with proper personal protective equipment (PPE). Depending on its enduse, emptied liquid and digestate require further treatment prior to use in agriculture. Cleaning of the reactor can be a health-hazard and appropriate safety precautions (wearing proper PPE, ensuring good ventilation) should be taken. There are also dangers associated with the flammable gases but risks are the same as natural gas. There is no additional risk due to the origin of the gas [3].

Costs: This is a low to medium cost option, both in terms of capital and operational costs. However, additional costs related to the daily operations needed by the digester need to be taken into consideration. Community installations tend to be more economically viable, as long as they are socially accepted. Costs for capacity development and training for operators and users must be budgeted for until the knowledge is well-established.

Social, legal, and environmental considerations: Social acceptance might be a challenge for communities that are not familiar with using biogas or digestate. Social cohesion can be created through shared management and shared benefits (gas and fertiliser) from Biogas Reactors, however, there is also a risk that benefits are unevenly distributed among users which can lead to conflict [3].

If the digester is not gas-tight, there is a risk of methane leakages which is a greenhouse gas contributing to climate change. Also, digestate has an organic load (COD) 5 times higher than regulations for discharge into surface water. Digestate may contain pathogens and should not be used directly on crops without prior treatment nor directly discharge into the environment without appropriate treatment.

Strengths and weaknesses:

- ⊕ Generation of useable products like gas and fertilizer
- ⊕ Small land area required (if structure sis built underground)
- ⊖ Requires expert design and skilled construction
- ⊖ Incomplete pathogen removal, the digestate might require further treatment
- ⊖ Variable gas production depending on the input material and limited gas production below 15°C
- ⊖ Medium level investment cost

> References and further reading

1. Zabaleta, I., et al., Selecting Organic Waste Treatment Technologies. SOWATT, Eawag, Editor. 2020.
2. Lohri, C.R., et al., Treatment technologies for urban solid biowaste to create value products: a review with focus on low- and middle-income settings. 2017.
3. Gensch, R., et al., Compendium of Sanitation Technologies in Emergencies. 2018.

Vögeli et al. Anaerobic Digestion of Biowaste in Developing Countries. 2014

MOOC Youtube videos:

- *MOOC Mod.3.7 The Basics of Anaerobic Digestion of Biowaste*
- *MOOC Mod. 3.8 Anaerobic Digestion Technologies and Operation*
- *MOOC Mod. 3.9 Using the Products of Anaerobic Digestion*

R.1

MATERIAL RECOVERY FACILITY (MRF)

Input materials	**Pre-condition/Pre-treatment**	**Operation & maintenance**	**Objectives / Key features**	**Key technical parameters**
Suitable recyclables waste: – Paper, cardboard – Metal – Glass – Clothes – Dense plastic (HDPE, PET) **Unsuitable waste:** – Organic waste – Hazardous waste	Waste segregation at source Optional: cleaning & drying	Regular low operation and maintenance required. Can be done internally or externally (outsourced).	Facility, which receives, separates and stores recyclables to facilitate their further use/recycling.	Space required depends on the recyclables generation rate & storage time
Outputs / paroducts	**Technical complexity**	**Maturity level**	**Educational aspect**	
Sorted recyclables ready for selling	Limited infrastructure required (covered area with storage space) Low-level skill required for construction & appropriate O&M	Widespread practice	**Topics:** Consumption; Finances **Practical exercises:** Storage size calculation; Revenue calculation	

A Material Recovery Facility (MRF) is a facility that receives, separates and stores solid waste to facilitate the further use and recycling of the materials.

At the MRF, the waste fractions are separated into specific categories such as Paper, Cardboard, Glass, PET bottles, Light plastic, etc. and then stored in different containers/compartments. Since an large part of the waste materials are recyclables, an MRF allows to maximize the recovery of these material that can be further sold, while reducing the quantity of materials requiring further transportation and final disposal.

Applicability: MRF can be used at school and community level and serves as storage unit before selling recyclables and partially also as sorting station. It can be managed by individuals and staff at the school or outsourced to external individuals or companies.

Technical design considerations: A covered area protecting from rain and winds is required. It is recommended to construct a concrete floor for easy cleaning of the area. The space needed will depend on the volume of recyclables generated and the storage time required. Metal cages or simple jute bags can be used to store different recyclables separately. Access to water and power are needed when cleaning of recyclables (and/or shredding) is envisaged to increase the market value.

The following formula can be used to determine the MRF compartment volume:

MRF compartment volume m3=

$$\frac{Daily\ compacted\ waste\ generated \left(\frac{L}{day}\right) * n_{storage\ days}}{1000\ \left(\frac{L}{m3}\right)}$$

Criteria for MRF location are:

— Easy road access

— Closest as possible to main waste generators

Materials needed: Cages or containers to store the different recyclable materials. Personal protective equipment (PPE) with gloves is necessary for workers. Broom are used to clean the floor. A table can be used to further sort the waste.

Technical operation & maintenance: Recyclables should be sorted on a regular basis. Depending on the local recycling market, cleaning and drying might be necessary. Shredding could also performed to increase the recyclable market value. Keeping records of recyclable amounts sold is advisable.

Health and safety: While sorting waste at a MRF is not an inherently dangerous activity, precautions are necessary to protect against injury, especially in presence of sharps.

Costs: Costs of building an MRF vary depending on the chosen design and further processing steps (i.e. sorting only, cleaning and drying, shredding, etc.).

Social, legal and environmental considerations: Collection and sale of recyclables are often informal sector livelihoods that could be negatively influenced by the implementation of an MRF. Where possible, opportunities to integrate these people into the management of the MRF should be assessed.

Strengths and weaknesses:

- (+) Enhance resource recovery
- (+) Easy-to-do
- (+) Revenue generation
- (−) Time consuming if managed by the school
- (−) Potentially negative impact on informal sectors livelihoods

> References and further reading

Wasteaid, Making Waste Work: A toolkit – How to prepare plastics to sell to market. 2017

ECOBRICKS

Input materials	Pre-condition/Pre-treatment	Operation & maintenance	Objectives / Key features	Key technical parameters
Suitable plastic waste: – PET (container) – Plastic film: – LDPE (e.g. plastic bags) – PP (food packaging) – PS (food containers & packaging)	Waste segregation at source Clean and dry plastic film and PET bottle	No operation and maintenance required	Very simple way to fill PET bottles with plastic films and then use as construction material. Effective way to reduce waste littering and reduce concrete or cement volume in construction.	Optimal ecobrick density: > 0.37 g/ml; Normal density: 0.33 g/ml (e.g. 600ml PET bottle: 200g ; 1500 ml PET bottle, 500 g)
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Filler for construction (e.g. benches, small walls, chairs, tables, etc.).	No infrastructure required No skills required to do ecobricks Medium-level skills required for constructing with ecobricks	Proven globally for small-scale application (e.g. schools, small community, etc.)	**Topics:** Plastic litter reduction, consumption **Practical exercises:** Produce ecobricks with students (school + home)	

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Making ecobricks is a downcycling method consisting in packing PET bottles with clean and dry non-recyclable plastics. They are a great way to mitigate the amount of plastic sent to landfill and the environment and can be used as building blocks for non-structural constructions (e.g. benches, small walls).

Soft and hard non-recyclable plastics such as bags, packaging, food containers, among others, are tightly packed in PET bottle to reach a density of 0.33 g/ml for further use in construction. The ecobricks can be stored indoors, away from heat, sun, and humidity until they are used.

Applicability: Ecobricks are aimed toward small-scale application (e.g. at communities or neighborhoods level), when appropriate solid waste management service is lacking.

Design considerations: The ecobrick should meet minimum weight requirements of 0.33 x bottle volume (i.e 600ml bottle should weigh more than 200 grams, and 1500ml bottle more than 500 grams). Experienced ecobrickers consider a density of > 0.37 g/ml as optimal [1]. Bottle selection should align with local availability. For building modules (small constructions that can be moved once, such as benches or stools), bottles should be of similar size and shape. For outdoor building projects, size and shape matter less than volume (e.g. small bottles make sturdier walls, large bottles make good benches).

Materials needed: To produce ecobricks, a stick is needed which is a smaller diameter then the bottle opening. An indoor storage space with low humidity and sun exposure is recommended. To construct small infrastructure with ecobricks, water and locally available earth/soil, clay and sand are needed. Once soil and clay are mixed together, they should achieve a non-crumbly texture referred to as "cob". Rice straw, coconut fiber or other organic source can be used as binder. Cement can also be used as construction material and binder.

Technical operation & maintenance: It is important to clean and dry the plastic used as bottle filling, as dirty plastic and moisture inside an ecobrick lead to microbiological growth and methane formation. Pushing of the plastic filling into the bottle must be done carefully in order to not break bottle walls. For efficient packing, the bottle is filled halfway and the filling pressed using the stick. The same is repeated for the second half of the bottle. A 1-2 cm between the plastic filling and the cap should be left to avoid overpressure. The bottle then needs to be closed with the cap.

It is recommended to protect ecobricks with a cloth or tarp during storage as PET attracts dust and chemicals. Horizontal stacking slightly above floor level with ends pointed outwards enables efficient brick categorization and prevents rats from chewing the ecobricks.

It is recommended to not leave the ecobrick caps exposed on walls facing the outdoors as the HDPE plastic of the cap degrades quickly with even small amounts of sun exposure. When filling around the ecobricks with cob, it can be helpful to lay small stones between the bottles to take up space and minimize the use of cob.

Health and Safety: The ecobricks should always meet the minimum density/weight requirements; if not, they are a potential fire hazard.

Costs: As ecobricks can be made out of plastic waste and construction with locally available material, the cost associated with it is very low.

Social, legal, and environmental considerations: Ecobricks should be closed correctly as their plastic filling can leach chemicals when exposed to sunlight, which can cause immediate damage to the soil and ultimately leach into water bodies [2].

Strengths and weaknesses:

- (+) Inexpensive
- (+) Effective way of mitigating release of macro and microplastics into the environment
- (+) Low technical know-how needed
- (+) Use locally available resources
- (+) Easy to get students and households involved in making ecobricks
- (+) Easy to link with education purposes
- (−) Downcycling option (no further recycling possible)

> References and further reading

1. Alliance, G.E., 10 step guide to making eco-bricks. 2020.
2. Duarte, L. and C. Barajas, Is the use of filled PET bottles as a building blocks a safe practice. Journal of Solid Waste Technology and Management, 2016. 42: p. 930-934.

Wasteaid, Making Waste Work: A toolkit – How to turn mixed plastic waste and bottles into ecobricks. 2017

www.ecobrickexchange.org

www.ecobricks.org

PAVING TILES

Input materials	Pre-condition/Pre-treatment	Operation & maintenance	Objectives / Key features	Key technical parameters
– Sand **Suitable plastic waste:** – LDPE (e.g. plastic bags, etc.)	Waste segregation at source Clean and dry LDPE	No regular operation and maintenance required.	Simple process of mixing LDPE plastic with sand to produce paying tiles.	Softening temperature: 70°C [1] Min. Melting temperature: 121°C [1]
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Paving tiles	Low-level skill required for appropriate construction of infrastructure Low-level skill required for making tiles	Few documented cases worldwide	**Topics:** Plastic litter reduction, Consumption **Practical exercises:** Calculation of plastic quantities per produced items	

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The process of making paving tiles is a downcycling method consisting of grinding plastic, melting it, mixing it with sand and eventually pouring it in tile molds before cooling.

LDPE plastic films, such as plastic bags and water bags are melted in a container (e.g barrel) using a fuel source (e.g. woodor gas) . Once the plastic has melted, sand is added and the mixture is then transferred to a greased mold. Once the mixture has hardened, the tile is removed from the mold and the tiles are left to cool down further.

Applicability: Paving tiles are aimed towards small-scale application (e.g. at communities or neighborhoods level).

Design considerations: The melting container can be made out of an oil drum barrel cut in half, (~80cm wide and 50cm high) and three legs made of rebar attached to it [2]. If possible use a shield to keep the fire concentrated under the barrel.

The mold can be constructed the same way as mold for concrete floor tiles. The walls of the mold should not be more than 4cm deep to avoid the material to stick to the sides [2].

Materials needed: To produce paving tiles a melting barrel, stirring equipment (e.g. spade with metal shaft), a metal table, tile mold and trowel are needed. In addition to that, fuel (firewood, other solid fuel or gas), as well as grease or oil (e.g. used engine oil)and clean, dry, and sieved sharp sand (e.g. construction sand) are required.

Technical operation & maintenance: It is important to select the right type of plastic to ensure an even melting temperature (120-150°C).

Plastic is slowly added to the warm container. As it melts it should be stirred continuously until no lumps remain. The melting process can take up to 20min. Care should be taken to avoid the melted plastic to get too hot and start burning.

Once plastic is melted, sand is added continuously in small amounts while still heating and stirring. Usually the sand to plastic ratio is 3:1, but may differ depending on the sand and type of plastic used. It is recommend trying out different mixture ratios before starting producing paving tiles in mass.

The mixture of plastic and sand is then removed using a shovel or spade and poured into a clean and oiled mold with a trowel. The mixture is pressed into the mold to avoid air gaps and left to set for a few minutes, while repeatedly shaking the mold to loosen the edges. Once the mixture has hardened enough that the tile does not collapse, the mold is removed. The tile is then left to further cool.

Health and safety: The process of making paving tiles should take place in a well-ventilated area. Workers should be equipped with proper personal protective equipment (PPE) with fireproof gloves (fabric and not rubber), heatproof boots, and appropriate mask.

People should not stand directly over the melting plastic while stirring and try to avoid breathing any fumes released from the melt.

Ensure that there is only LDPE and especially that no PVC or other plics are melted, as as fumes from other plastic can dangerous for health. You can consider having a temperature measuring device on the barrel to have a better control over the melting temperature.

Consider that the equipment will get hot to avoid accidental burns.

Costs: As paving tiles are made out of plastic waste and construction sand, the associated cost is very low. Installing a temperature control device would considerably make the process safer but would also increase the associated cost.

Social, legal and environmental considerations: Plastic is flammable in nature, which is why sand is used as fire retardant. After the tiles are worn out, it is not possible any longer to separate plastic from sand for recycling. The plastic tiles may crack over time when loaded with weight, which can cause a release of micro plastic.

Strengths and weaknesses:

- ⊕ Cheaper than conventional tiles
- ⊕ Tiles are water resistant
- ⊕ Tiles are good insulators for keeping warm and cold weather
- ⊕ Uses locally available resources
- ⊖ Downcycling option (no further recycling possible)
- ⊖ Risk of harmful gas release if temperature is too high and plastic is burnt

> References and further reading

1. PreciousPlastic, Commodity plastic practical info poster. 2018
2. Wasteaid, Making Waste Work: A toolkit – How to transform plastic waste into paving tiles. 2017

SHREDDING

Input materials	Pre-condition/Pre-treatment	Operation & maintenance needs	Objectives / Key features	Key technical parameters
Suitable plastic waste: – Solid plastic (HDPE, PS, PP) **Unsuitable plastic waste:** – Soft plastic	Clean and dry plastic	Regular maintenance required	Process of breaking down plastic into smaller pieces for further processing or selling	Voltage: 380V AMP: 5.8A Nominal power: 1.5kW min Output speed: +/- 70 r/min [1]
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Shredded plastic	Higher-level skill required for appropriate design & construction of infrastructure Lower-level skill required for O&M	Proven technologies	**Topics:** Plastic litter reduction; Consumption **Practical exercises:** -	

Plastic shredding is the process of breaking down large plastic into small flakes by motorized mechanical means. The obtained shredded plastic can either be used for further processing onsite or be sold with a higher market value.

Cleaned and sorted plastic according to plastic type, and potentially color, are shredded separately to create homogenous plastic flakes of defined size. The size of the shredded plastic depends on the requirement for further plastic processing. While large flakes of 0 to 30mm are good to use in sheetpress, 0 to 7mm flakes is need for extruders.

Applicability: Shredding plastic is a process that can be used up to industrial scale. Yet, the design and infrastructure presented here is aimed towards small-scale application (e.g. at communities or neighborhoods level).

Design considerations: Shredders can either be built from scratch or purchased from the Precious Plastic bazar. Higher-level skill is required for appropriate design & construction. Link to blueprints for shredder construction are available in the references [1].

Materials needed: The shredder is composed of a hopper, a shredding box and mesh. Electrical components needed are a motor (approx.. 2.2kW geared down to 70 rpm), LED indicator and common household power cable.

Technical operation & maintenance: While shredding, blades should be regularly checked and plastic pushed down towards the blades. When finished working with the shredder, it is recommended to label and store the shredded plastic for further use [1].

When changing the type of plastic used, the mesh should be first removed and the little shredded flakes in the machine brushed away. Optionally pressured air or vacuum cleaner can be used to blow them away.

Health and safety: Shredder blades are sharp so hands must never be used to push the plastic towards the blades. Wearing any loose clothing, jewelry or having long untied hair should be avoided as they can get caught in moving parts. Power should always be switched off for maintenance.

Costs: Material cost is around 500 USD. Shredder prices on Precious Plastic bazar is around ~3000 USD. The price can decrease if built locally.

Social, legal and environmental considerations: Microplastic might be released to the environment due to the shredding process.

Strengths and weaknesses:

- (+) Important first step of most plastic recycling processes
- (+) Effective way to granulate plastic and reduce volume for storage
- (+) Relatively cheap
- (−) Higher-level skills are needed to construct the equipment from scratch

> References and further reading

1. Precious Plastic, Build a Shredder Machine, 2022.

Precious Plastic – Shredder starter kit

EXTRUSION

Input materials	Pre-condition/Pre-treatment	Operation & maintenance needs	Objectives / Key features	Key technical parameters
Suitable plastic waste: – HDPE or – PP	Waste segregation at source Clean, dry and shredded homogenous plastics (HDPE or PP)	Regular flushing of extruder with virgin material is recommended	Process of extruding plastic waste into a continuous filament to create new product	Voltage: 380V AMP: 5.8A Nominal power: 1.5kW min Output speed: +/- 40-140 r/min [1]
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Plastic filament, plastic beams, ornaments/ decorative objects, etc.	Higher-level skill required for appropriate design & construction of infrastructure Medium-level skill required for setting up and operations	Proven technology with large internet-based community of practice to provide support	**Topics:** Plastic litter reduction; Consumption **Practical exercises:** Calculation of plastic quantities per produced items	


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Plastic extrusion is an upcycling technology that converts discarded plastic waste into a continuous plastic filament, which can be further molded into any desired end-product shape.

Clean and shredded homogenous plastics such as HDPE or PP are put through an extruder, where plastic is transported by a screw powered by a motor, to the heating section of the machine. The heat created by the machine along with the pressure created by the screw allows the plastic to melt, and it passes through a nozzle. A continuous plastic filament exits the nozzle. A mold can be placed at the end of the nozzle to receive the melted plastic filament and shape it into the mold shape.

Applicability: Plastic extrusion is a process that can be used from small to large industrial scale. The design and infrastructure presented here shows a small-scale application (e.g. at communities or neighborhoods level).

Design considerations: Extruders can either be built from scratch or purchased from the "Precious Plastic" bazar. Higher-level skill is required for appropriate self-design & construction of the extruder. Link to blueprints for extruder construction are available in the references [2].

Materials needed: The extruder is composed of a metal hopper, a screw, a barrel, a nozzle and a electric powered motor. An electronic box and heating elements are necessary, such as: PID controller for temperature control, SSR switch, thermocouple, mechanical power switch with indicator and band heater.

If the equipment is built locally, a workspace with a lathe, drill press, welding machine, belt sander and an angle grinder are needed.

As a mold to produce beams, simple metal tubes can be used.

Technical operation & maintenance: Temperature testing is required when starting using the extruder. Indicative temperature values for different plastics are: PP 180°C in barrel, 200°C in nozzle; HDPE 190°C in barrel, 210°C in nozzle). Homogenous shredded plastic flakes should be continuously fed into the hopper during extrusion. If a mold is used after the nozzle, make sure to cool down the mold in water before opening it. Regular flushing of extruder after use with virgin material is recommended.

Health and safety: It is advised to use the extruder in a well-ventilated area. Consider that the barrel is hot and direct contact may lead to accidental burns. Workers should be equipped with proper personal protective equipment (PPE) with heat proof gloves, work clothes covering arms and legs, safety glasses or face shield to protect from spontaneous ejection of hot substances from the nozzle area.

Costs: Material cost for a Precious Plastic design is around 1’300 USD. Full extruder prices on Precious Plastic bazar range from ~2’000 – 6’000 USD.

Social, legal and environmental considerations: Toxic fumes can be released during plastic melting, however this can be mitigated with the use of appropriate temperature control equipment. Batches of mixed plastic should not be extruded, as melting plastic at incorrect temperature increases the risk of harmful emissions.

Strengths and weaknesses:

- ⊕ Continuous output of plastic
- ⊕ Effective plastic recycling technology
- ⊕ Simple to use, once the right settings are defined
- ⊕ Possibility of large variety of output product
- ⊖ Higher-level skills are needed to construct from scratch
- ⊖ Medium-level skill needed to test and set the right temperature

> References and further reading

1. Precious Plastic, Build an Extrusion Machine, 2022.
2. Precious Plastic, Set up an Extrusion Work space, 2019

Precious Plastic – Extrusion starter kit

PLASTIC FILM CROCHET

Input materials **Suitable waste:** – Clean light plastic (LDPE, PP)	**Pre-condition/Pre-treatment** Washing and drying plastic	**Operation & maintenance** Cutting of plastic strips	**Objectives / Key features** Crochet plastic films into bags and mats	**Key technical parameters** Crochet needle type K hook
Outputs / products Robust plastic bags, baskets, mats	**Technical complexity** No infrastructure required Low-level skill required	**Maturity level** Widespread use	**Educational aspect** **Topics:** Reuse; Consumption **Practical exercises:** Crochet film plastic	

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Strips of film plastic such as water sachet and single-use plastic bags can be easily crocheted and converted into long-lasting reusable plastic bags, baskets and mats.

Washed and dried plastic are cut into thin strips and crocheted into various product [1]. This is a very easy and cheap process to make use of low-value plastic waste.

Applicability: Handicrafts are aimed towards small-scale application by individuals or group of individuals.

Design considerations: -

Materials needed: Large sharp scissors and crochet needle size K (6.5mm) or larger are required.

Technical operation & maintenance: To make a plastic ribbon, plastic bags or films are rolled neatly. While the lip is kept intact., thumb-width strips are cut with a scissor along the way. Once done, plastic is unfolded and lied on a table. Diagonal cuts are made on the intact lip. The long ribbon can then be crocheted into bags, purses, baskets and mats.

Health and safety: Only clean plastic should be used and hand washing ensured after handling of dirty plastic.

Costs: -

Social, legal and environmental considerations: -

Strengths and weaknesses:

- (+) A very easy and cheap option to make use of single-use soft plastic
- (+) Easy to link with educational purposes
- (–) Very limited amount of plastic waste can be handled with such practice
- (–) Low-market value of end-product

> References and further reading

1. WasteAid, Making Waste Work: A toolkit - How to crochet film plastic into bags and mats 2017, L., et al., Blue Schools - Linking WASH in schools with environmental education and practice, Catalogue of Technologies. 2018.

D.1

WASTE PIT

Input materials	Pre-condition/Pre-treatment	Operation & maintenance	Objectives / Key features	Key technical parameters
Suitable waste: – Inert waste **Unsuitable waste:** – Organic waste – Recyclables – Hazardous waste	Waste separation	Low operation & maintenance required	Safely dispose of solid waste	Space required depends on the waste generation rate & pit lifetime (usually 5 years)
Outputs / products	**Technical complexity**	**Maturity level**	**Educational aspect**	
Safe waste disposal	Limited infrastructure required (pit) Low-level skill required for construction Low-level skills required for appropriate O&M	Widespread practice	**Topics:** waste degradation rate; environmental pollution **Practical exercises:** Calculating waste pit size	

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When plastic or other non-organic "inert" waste cannot be recycled, burying waste can be the easiest and safest option. However burying or dumping organic and hazardous/ contaminated waste poses a threat to the environment and should be avoided.

Practically, waste is dumped into a hole and then covered with a layer of soil. When the hole is full of waste a final soil cover is added to build a slightly elevated hill. Once full, a new hole is dug and the cycle starts over.

Applicability: Waste pits can range between houshold small pits to medium sized community or school waste pits depending on the amount of waste to be safely disposed of. At larger scale, it is often referred to as landfill.

Technical design considerations: A hole is dug and surrounded by a small berm and ditch to avoid rainwater flowing into the hole. The required size is determined by how much waste will require disposal over at least the next 5 years [1]. The bottom of the hole should be well above (>2m) the highest groundwater level. If possible, a clay layer at the bottom and covering the walls can avoid further water leaching into the surrounding [2].

The following formula can be used to determine the pit volume:

$$\text{Pit volume } m^3 = \frac{\text{Daily waste generated } \left(\frac{L}{day}\right) * 365 * 5 \text{ years (or more)}}{2*1000\ (Lm^3)}$$

Criterias for identifying the location of the pit are [2]:

- Close to an empty area to allow for site expansion
- Highest groundwater lever should be >2m lower than the bottom of the pit
- At least 200m away from the nearest residential area
- Far from main school activities

Materials needed: The pit can be dug manually with shovel or mechanically with excavator depending on the size required and the available resources. A shovel is used to regularly cover the pit with cover material (soil or low-quality compost).

Technical operation & maintenance: A layer of soil is regularly added onto the waste in the pit to avoid wind transport of waste and to hinder access to waste by birds and vermin. Burning waste in the waste pit is not allowed as this releases harmful gases and pollutants into the environment and endangers health.

Health and safety: While dumping waste in pit is not an inherently dangerous activity, precautions are necessary to protect against injury, especially in presence of sharps.

Costs: Waste pit is a low-cost disposal method.

Social, legal and environmental considerations: Social acceptance for waste pits is usually quite low. The major environmental burden results from waste burning in the pit (release of harmful gases and pollutants), which is not allowed, or elseby leachate contaminating groundwater if the distance between waste pit and groundwater is too small.

Strengths and weaknesses:

- (+) Easy and safe disposal method
- (+) Avoids waste burning and wind blowing waste around
- (−) Damages landscape
- (−) Possible soil contamination
- (−) Not sustainable solution (no resource recovery)

> References and further reading

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2. Leclert, L., et al., Blue Schools - Linking WASH in schools with environmental education and practice, Catalogue of Technologies. 2018.

MOOC Youtube videos:

MOOC Mod. 1.9 Upgrading a Dump Sit

Additional resources & References

Resources for schools

— **Blue Schools kit (Swiss Water & Sanitation Consortium) -**
https://waterconsortium.ch/blueschool/

- *Blue Schools Kit, 2018. Blue Schools - Linking WASH in schools with environmental education and practice, Concept Brief [59]*
- *Blue Schools Kit, 2018. Blue Schools - Linking WASH in schools with environmental education and practice, Catalogue of Technologies [53]*
- *Blue Schools Kit, 2018. Blue Schools - Linking WASH in schools with environmental education and practice, Catalogue of Practical exercises [6]*
- *Blue Schools Kit, 2018. Blue Schools - Linking WASH in schools with environmental education and practice, Facilitator's Guide [60]*

— **Guidebook for Environmental Education on Solid Waste Management in Africa (JICA)-**
https://unhabitat.org/african-clean-cities-publications

- *JICA, 2019. Guidebook for Environmental Education on Solid Waste Management in Africa [2]*

— **Waste Wise Toolkits and Guides (Un-Habitat) -**
https://unhabitat.org/waste-wise-toolkits-and-guides

- *Waste Wise Cities. A Comic book: My waste our wealth*

— **Waste Wise Education Factsheets (UN-Habitat) -**
https://unhabitat.org/waste-wise-good-practices

— **Zero waste at schools (Clean up Nepal) -**
https://cleanupnepal.org.np/zero-waste-at-schools/

- *Clean up Nepal, 2019. Zero waste at schools – Toolkit for Waste Management Education*
- *Online lessons for teachers & students (Clean up Nepal) - https://education.cleanupnepal.org.np/*

— **Teaching guides (Ciudad Saludable, ES) -**
https://www.ciudadsaludable.org/recursos

- *Ciudad Saludable, 2022. Guía de recursos educativos de residuos sólidos dirigido a docentes de inicial, primaria y secundaria*
- *Ciudad Saludable, 2022. Guía de recursos educativos para el cuidado de la higiene y su relación con las enfermedades epidemiológicas dirigido a docentes de inicial, primaria y secundaria*
- *Ciudad Saludable, 2022. Guía de recursos educativos para implementar un biohuerto dirigido a docentes de inicial, primaria y secundaria*

Online courses on solid waste management

- *MOOC (Eawag/Sandec) - Municipal Solid Waste Management in Developing Countries YouTube / Coursera*
- *Online course (UN-Habitat) – From Data to Tangible Impact: Achieving Waste SDGs by 2030*
- *Online course (UNITAR) – Waste management and circular economy*

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Solid waste management (SWM) is considered as "one of the biggest challenges of the urban world". Yet, 2 billion people still lack access to solid waste collection services, while 3 billion people lack access to controlled disposal facilities. This results in tremendous amounts of waste being littered, dumped or openly burnt, contaminating water, groundwater, and the world's oceans.

As solid waste management is closely linked to people and people's behavior, a shift of paradigm is needed to consider waste as a potential resource and not as trash. Such a shift in society requires awareness raising, pragmatic approaches, and concrete actions that, we believe, can be best transmitted through education.

This toolkit aims at developing innovative solutions, which maximize on the synergies between waste management, water, sanitation, food production, health, environment, and energy generation in schools.

The Zero-Waste at schools toolkit targets learning, application, and practice so that students become agents of change and ambassadors for sustainable behaviour and a cleaner world under a circular economy.