Iceland Liechtenstein Norway grants

Teaching module 6. Environmental projects management

6.1. Phases of environmental projects. Time management and cost management in environmental projects

Phases of environmental projects.

Time management and cost management in environmental projects

Authors:

Cezar-Petre Simion – Bucharest University of Economic Studies

Mihai Vrîncuț - Bucharest University of Economic Studies

Florin Anghel - Bucharest University of Economic Studies

Iceland Liechtenstein Norway grants

Table of contents

Transilvania University of Brașov

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

Introduction

The last decades have been marked globally by the increasing importance of environmental issues both for decision-makers in the governmental sphere and for society as a whole. One of the effects of this increase in concern and interest in the environment was the initiation and implementation of projects to reduce the environmental impact of economic-social activities. There have been programs dedicated to the environment, with public or private funding, which allow interested organizations (local authorities, NGOs, private companies) to propose projects focused on environmental issues.

The increase in the number and value of environmental projects implemented by various organizations, including in rural areas, creates the need for project team members but also interested stakeholders to know well the fundamental concepts regarding the management of environmental projects. The implementation of environmental projects without knowing what such a project means, what are its characteristics, how its execution can be scheduled in time and how its cost can be determined is the surest way to the failure to fulfill some objectives, the occurrence of delays with respect to the scheduled deadlines or cost overruns.

This unit of the "Environmental Project Management" module is dedicated to students acquiring the fundamental concepts regarding environmental project management, time management and cost management of this type of projects. After students have completed the content of this unit, students will have knowledge of:

- the notion of an environmental project and the main characteristics of the projects as highlighted by the specialized literature;
- typology of environmental projects according to different classification criteria;
- the phases within an environmental project and the projects' life cycle;
- the components of the time management of an environmental project and the realization of its execution program;
- scheduling the execution of an environmental project through classic and modern methods;
- the main types of costs that appear in the realization of environmental projects and their calculation;
- project budgets and project cost optimization through value added reporting.

Acquiring concepts related to time and cost management will allow students to have a scientific approach to planning and implementing environmental projects in the future with positive effects on the achievement of their objectives.

Transilvania University of Brașov

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

Chapter 1 - Definition, characteristics and typology of environmental projects. Management of environmental projects

The awareness of environmental issues has led in most countries of the world to an increase in the attention given to environmental issues. The most important ecological disasters (1989 – the Exxon Valdez tanker, 1991 – the oil spills during the Gulf War, 1991, 2010 – the Gulf of Mexico, in the USA) contributed to this. Among the most important reactions at the national and international level was the development of specific programs and projects aimed at the protection and conservation/remediation of the environment. The development of these projects created the need to develop/adapt specific project management concepts in accordance with the specifics of environmental projects.

In project management, the benchmark for professionals and specialists is the PMBOK (Project Management Body of Knowledge). In the 7th edition of PMBOK *"a project is a temporary effort undertaken to create a unique product, service or result"* (Project Management Institute, 2021). Since most environmental projects are financed by public funds, including EU funds, and for these projects an important methodology is PCM - Project Cycle Management. It defines projects as *"a series of activities aimed at achieving specific objectives in a limited period of time and with a defined budget"* (European Comission, 2004).

From the previous approaches, the four important characteristics of any project can be observed: clearly defined objectives, a determined development period, limited allocated resources and its uniqueness.

Starting from these approaches we can define environmental projects as a series of activities aimed at achieving clearly specified objectives related to the environment within a defined period of time and with a limited budget.

Environmental projects are intended for the environment by their nature, have specific environmental activities and sustainability results (Sholarin & Awange, 2015). According to these specialists (Sholarin & Awange, 2015), the activities of the environmental projects are carried out to achieve objectives in the area of sustainability, such as reducing the negative impact on the environment (oil spills, greenhouse gas emissions, soil contamination, etc.). Therefore, environmental projects have a number of additional characteristics that differentiate them from other types of projects:

- have specific objectives in the field of the environment (example: reducing household waste by 20% by 2030);
- the results are at least partially aimed at sustainability issues;
- are most frequently conducted outside the organization/organizations that initiate them;
- it implies important changes both at the level of the organizations that implement them but also of the area where the project results are obtained.

Usually, a definition is not enough to understand the specifics of a project, which is why we believe that a typology of environmental projects is necessary. From the perspective of the projects' objectives, we can distinguish:

- projects for the elimination of pollution;
- pollution prevention projects;
- projects for the regeneration of the natural environment;
- waste collection projects;

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

- waste recycling projects;
- research and development projects in the field of environmental protection technologies.

Depending on the funding source, there may be:

- environmental projects financed from private sources;
- environmental projects financed from public sources;
- environmental projects financed from mixed sources (public and private).

Depending on the environmental element targeted, environmental projects can be:

- water projects;
- air projects;
- projects that consider the land;
- projects targeting plants and animals.

Environmental projects are implemented in Romania both through EU-funded programs and with funding from national sources (public and private). Through the Sustainable Development Operational Program 2021-2027, environmental projects in the following fields (actions) will be financed:

- Investments in the water and wastewater sector to meet the requirements of environmental directives
- Efficient waste management in order to accelerate the transition to the circular economy, to meet the requirements of environmental directives
- Conserving biodiversity to meet the requirements of environmental directives
- Improving air quality monitoring to meet the monitoring and reduction requirements of the directives
- Preliminary and detailed investigation of contaminated sites
- Reducing GHG emissions and increasing energy efficiency in thermal energy production systems
- Improving energy efficiency
- Promoting the use of renewable energy sources
- Conversion, modernization and expansion of gas transmission and distribution networks to add renewable and low-carbon gas to the system
- Smart energy systems and networks

In Romania, the National Recovery and Resilience Plan Pillar I Green Transition includes the following components regarding the implementation of environmental projects:

1.Component C1 Water management has been allocated 1,462 million Euros for projects regarding: expansion of water and sewage systems in agglomerations of more than 2,000 equivalent inhabitants, Collection of waste water in agglomerations of less than 2,000 equivalent inhabitants, Collection of waste water in agglomerations of less than 2000 equivalent inhabitants

2. Component C2 Forests and biodiversity protection has allocated 1,173 million Euros for projects aimed at: the national afforestation and reforestation campaign, including urban forests, the development of modern capacities for the production of forest reproductive material; integrated systems to reduce the risks generated by torrential floods in

Transilvania University of Brașov

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

forest basins exposed to such phenomena; Integrated investments for the ecological reconstruction of habitats and the conservation of species related to meadows, aquatic and water-dependent areas

3.Component C3 Waste management with a budget of 1,239.01 million Euros allocated for projects regarding: Development, modernization and completion of integrated municipal waste management systems at county or city/municipal level, infrastructure development for waste management manure and other compostable agricultural waste, development of institutional capacities for public monitoring and control for waste management and pollution prevention

4. Component C4 Sustainable transport with allocated resources of 7,620 million Euros to increase the sustainability of the transport sector in Romania by supporting the green and digital transition of the sector, respectively to develop a sustainable and ecological transport infrastructure with adequate safety standards

5. Component C5 - The Renovation Wave with a budget of 2,200 million Euros allocated for projects to improve the built stock through an integrated approach to energy efficiency, seismic strengthening, fire risk reduction and the transition to green and smart buildings .

6. Component C6. Energy – with the role of addressing the main challenges of the Romanian energy sector in terms of decarbonisation and air pollution.

In Romania, the Ministry of Environment, Water and Forests manages a series of programs that finance environmental projects or projects with an impact on the environment. Among these, the most important for local communities in the countryside are:

- The program to improve the quality of the environment by afforestation of degraded agricultural lands, ecological reconstruction and sustainable management of forests;
- The national program for improving the quality of the environment by creating green spaces in localities;
- The program regarding the production of energy from renewable sources: wind, geothermal, solar, biomass, hydro,
- The program regarding education and public awareness regarding environmental protection;
- The program aimed at the protection of water resources, integrated water supply systems, treatment stations, sewerage and purification stations.

In Romania, projects with an impact on the environment are also financed by other ministries and government agencies. In Iceland, the Environment Agency finances projects dedicated to environmental quality monitoring, biodiversity conservation and management of protected natural areas, waste management, collaboration with other Scandinavian and European countries in the field of the environment. In addition to public sources, there are in Romania, but also in Iceland, there are many environmental projects financed from private sources (companies, NGOs, private individuals).

Environmental project management is the use of project management principles, methods and processes to improve an element of the ecosystem (water, air, plants, land or other living organisms) to achieve a sustainable outcome (Sholarin & Awange, 2015).

The same authors expressed the concept of environmental project management as follows (Sholarin & Awange, 2015):

Management of environmental projects = Environment + Project + Management

or

Environmental Project Management = Ecosystem + A temporary enterprise created to produce sustainable change + Organization, coordination and control of an element of the ecosystem.

Environmental project management involves the following elements (Havranek, 1999):

- control of the resources of the organization involved in a particular project;
- cost and time constraints;
- additional constraints generated by environmental, safety, customer relations and public relations regulations (as there is a high degree of public interest).

In our view, environmental project management represents the planning, organization, coordination and control of the project from its initiation to its completion, in order to achieve the objectives and obtain results in the field of the environment according to the quality specifications, costs and terms assumed in the relationship with the client/financier the project.

Chapter 2 - Phases of environmental projects. Life cycle of projects

For the realization of environmental projects, a series of specific phases are completed. In the field of project management there are several approaches to project phases. The set of phases that a project goes through in order to be considered completed represents the project's life cycle. The results obtained in a certain phase of the project are reviewed regarding the degree of fulfillment and approved before the start of the next phase. However, there are also projects that may not include all the stages of a life cycle or may carry out some of the stages in parallel with others.

There is no single definition of life cycle applicable to any project, organization or field of activity. Some organizations have created standard life cycles for their own projects, others leave it up to managers and project teams to choose the most appropriate life cycle. In addition, common practices in certain industries or business sectors have led to project life cycles that are generally accepted and used.

According to some authors, the life cycle of an environmental project includes the stages described in the following figure (Havranek, 1999):

Project life cycle			
Planning phases		**Implementation phases**	
Phase 1 **Concept**	**Phase 2 –** **Development**	**Phase 3** **Implementation**	**Phase 4** **Closure**
• Initial investigations • Extensive investigations	• Risk analyses; • Feasibility studies • Negotiation; • Design	• Installation; • Operation; • Monitoring; • Maintenance.	• Final reports; • Negotiations.

Project duration

Figure 1. Life cycle of environmental projects

source: adapted from Havranek, 1999

Other authors consider that an environmental project goes through the following phases (Gogoașe & Manoliu, 2000):

- ***Initiation*** – in which the idea, concept and objectives of the project are established (in this phase the necessity of the project is recognized and it is decided, if necessary, to carry out a feasibility study);
- ***Planning/design/organization*** – in which the most appropriate ways are found to meet the requirements/specifications of clients or project financiers;

- ***Execution*** – in which the tangible result of the project is created, according to the planning/design from the previous stage.
- ***Control*** – permanent monitoring of the progress made and removal of deviations so that the project does not deviate from the plan;
- ***Completion/reception/commissioning*** - phase in which the project results are received and the final reports of the project are drawn up.
- ***Operation, inspection and inspection/ warranty period*** – phase that is not always taken into account although it is part of the project life cycle.

There are also authors who define the life cycle of an environmental project as consisting of the following phases (Sholarin & Awange, 2015):

- **Initiation / definition –** which aims to establish whether the problem/need is significant enough to justify the initiation of an environmental project. In this phase, the study of needs and alternatives, the initial design and the selection of the project site are carried out;
- **Environmental impact study -** phase in which the protection/conservation/remediation alternatives are presented in detail;
- **Adopting the decision to carry out the project –** phase in which the impact study is reviewed, the project is authorized and the final design is carried out;
- **Implementation –** in which project activities are carried out **,** impact is monitored and performance is audited;
- **Close/Operate –** where the project is completed, all documents are signed and project deliverables are operationalized within the organization.

In our conception, an environmental project includes the following phases, graphically described in Figure 2:

1. **Initiation phase** – is the one in which the idea of a new project arises in response to an environmental problem and the organization/organizations participating in the project propose a series of additional studies/investigations/analyses that provide additional details. In this phase, as a rule, the purpose of the project is specified.
2. **The definition phase** – in which the project begins to crystallize as a result of carrying out specific studies (opportunity, pre-feasibility, feasibility and environmental impact), general design (if applicable). In the project definition phase, the approvals and approvals necessary for its implementation are also obtained and the most important objectives to be achieved are set.
3. **The planning phase** – during which the detailed design is carried out (if applicable), the resources are planned, intermediate and final deadlines for the project are established. Also in this phase, the main contracts for the realization of the project are concluded.

4. **The implementation/execution phase** – is the one in which the project activities are actually carried out and the expected deliverables/results are achieved. In this phase, intermediate evaluations of the project are also carried out. At the end of the implementation phase, all important deliverables that will work in the exploitation phase are verified/received/commissioned.
5. **The use/exploitation/operation phase** – in which the deliverables created by the project (products, works, services) are used to achieve its long-term objectives. The duration of the exploitation phase can vary from months or years to decades in the case of certain environmental projects. In projects financed from public sources, this phase is also called *the sustainability phase.*
6. **The post-use/reconversion** phase – is the final stage of the life cycle in which the original project or some of its components/deliverables are repurposed or recycled for reuse.

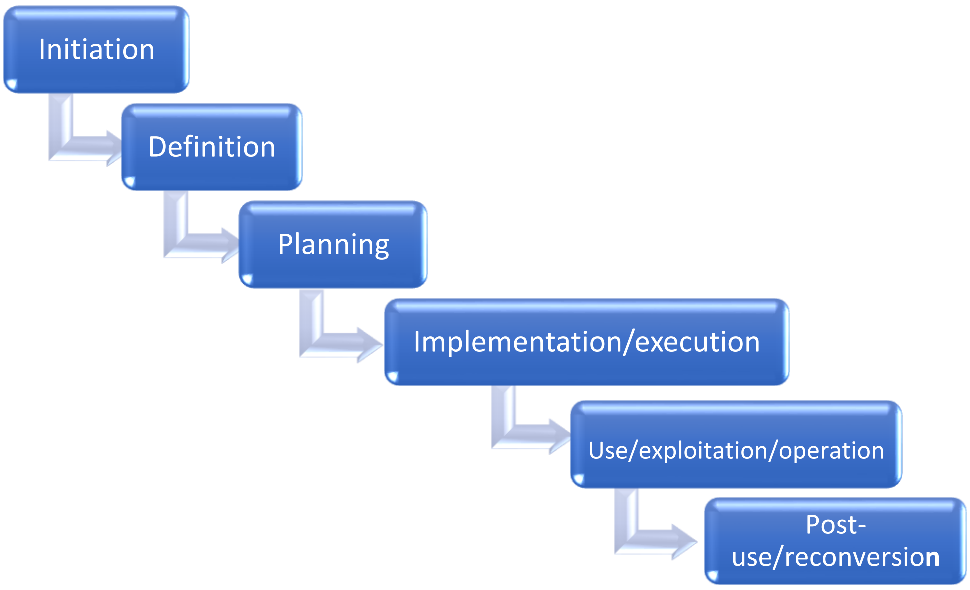

Figure 2. Phases of an environmental project

Chapter 3 - Time management in environmental projects

Today, the concept of project is present in all businesses and fields of activity. It is used from the construction of buildings or developing new products to improvements in our environment. Generally, projects are present in all fields of activity involving the achievement of specific tasks, bringing together diverse skills in order to achieve predefined objectives. Organizations are forced to undertake projects to achieve the desired results in well-defined periods of time and with limited resources. Therefore, any organization, regardless of its field, is using the concept of project to describe and characterize high complexity internal and external operations which require a multitude of resources (Deac , 2017). Time is money in any project, or, as the specialists like to call it, every project operates within the boundaries of scope, time, and cost. A change in one factor will invariably affect the other two. That's called the triple constraint theory in project management (https://www.teamgantt.com/blog/triple-constraint-project-management, 2021). Specialists nowadays are considering client acceptance (or the quality of the project as perceived by its final clients) as a fourth possible constraint for environmental projects.

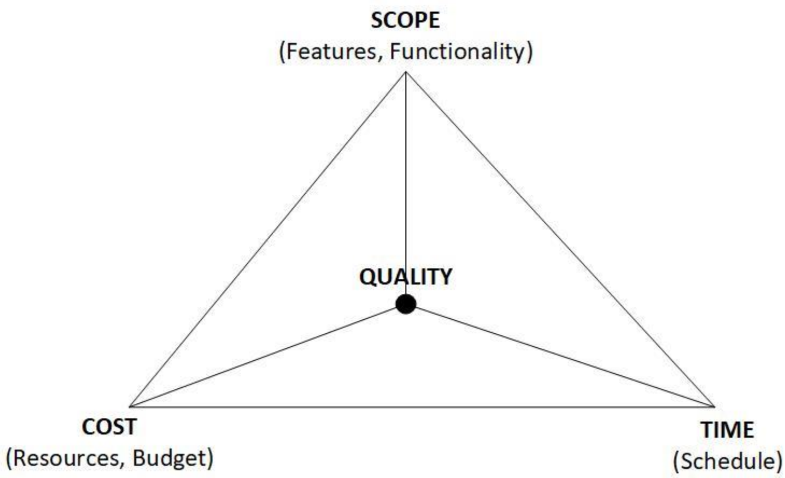

Figure 3. Triple constraint of environmental projects

source: adaptation from Deac, 2016, p. 285

Like any other type of project, environmental projects are also subject to this triple constraint, with one significant difference: a poor quality of the project in this case can lead to specific noncompliance costs, which can be civil, criminal, administrative, reputational, financial or market based. Environmental compliance typically includes compliance with environmental laws (enacted by legislative bodies), environmental regulations (created by regulatory bodies), standards, and other requirements such as site permits, licenses and approvals to operate. In recent years, environmental concerns have led to a significant increase in the number and scope of compliance imperatives across all global regulatory environments (Sholarin & Awange, 2015).

Most project managers agree that if you want a project done fast, it's going to cost you - especially if you're not willing to bend on the scope. That happens because a short deadline requires more resources to get the work done on time (https://www.teamgantt.com/blog/triple-constraint-project-management, 2021).

Regarding time management for environmental projects, the processes that a project manager needs to go through in order to ensure the timely completion of the project are: **defining project activities/tasks; sequencing the**

activities/tasks; estimating the duration of activities/tasks; developing the schedule for the project; controlling the schedule for the project (Project Management Institute, 2013).

3.1. Defining environmental project activities

Defining environmental project activities involves identifying and documenting the specific activities that the project team needs to undertake in order to deliver the project scope.

Writing a detailed scope document provides the perfect foundation for understanding your project's time constraint because it allows the building of an activity list and eventually a project estimate. The more accurate the project estimate, the better, since scheduling work is done based on it.

Imagine someone asks you how long will take to build a solar power plant for your village? Or how much would it cost? It would be quite hard to give an accurate estimate without understanding what specific activities are involved.

In order to be able to identify the activities in your project and build a project estimate regarding time and/or costs, you will need to build **a work breakdown structure – or a WBS**.

Definition: A work breakdown structure (WBS) is a logically structured hierarchical decomposition of the work to be executed by the project team in order to accomplish the project objectives (Haugan, 2002)**,** (Project Management Institute, 2006)**.**

Items that do not appear in the WBS are outside the scope of the project. Just like the project scope statement, WBS is often used to cultivate or confirm an increasingly detailed understanding of the project elements. Each descending level represents an increasingly detailed description of the elements of the project. Items on the lowest hierarchical level of a WBS are called work packages. They can, however, be broken down into smaller components.

> *The WBS should not be confused with another method of representation - drawing an unstructured list of activities in graphic form is not a WBS!*

A work breakdown structure from similar previous projects can usually be used as a template for a new project (Project Management Institute, 2013).

General steps to design and use a WBS are:

a. list the items in which the activity will split, in increasingly finer detail. This process continues until all relevant activities or work packages are identified and each activity can be planned, scheduled, monitored and controlled individually.

b. identify relevant data for WBS (e.g. suppliers, equipment, materials, specific instructions to accomplish). Create a list of people and organizations responsible for each activity.

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

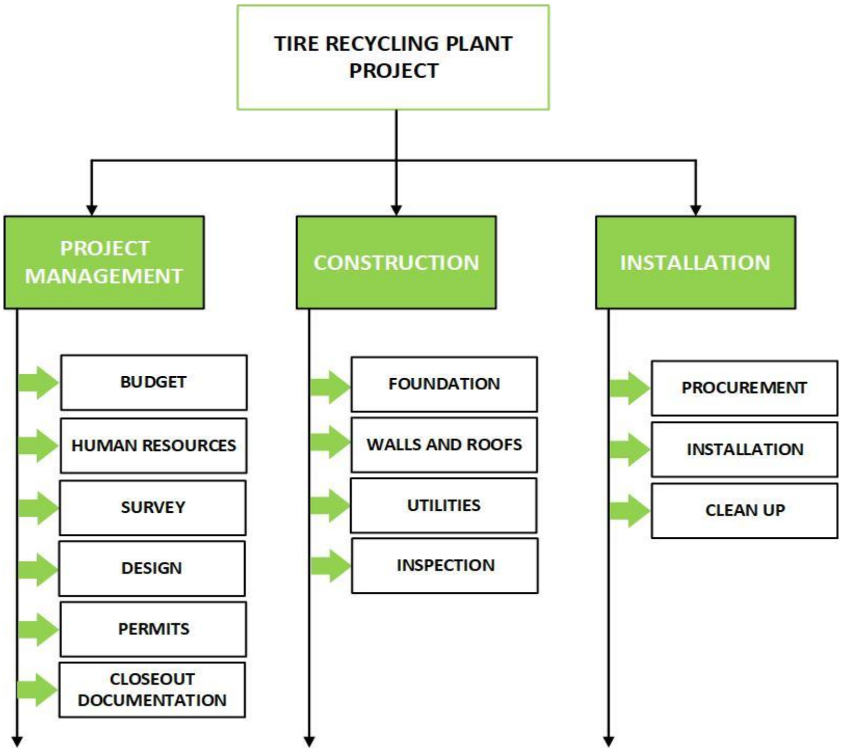

Figure 4. WBS for a tire recycling plant installation project

source: own creation

In Figure 4 we can see the WBS for a project aimed at constructing, operating and maintaining a tire recycling plant.

Rules to follow while designing a WBS (Deac , 2017):

- **The 100% rule.** The work represented by your WBS must include 100% of the work necessary to complete the overarching goal without including any extraneous or unrelated work. Also, child activities on any level must account for all of the work necessary to complete the parent activity.
- **Mutually exclusive.** Do not include a sub-activity twice or account for any amount of work twice. Doing so would violate the 100% rule and will result in miscalculations as you try to determine the resources necessary to complete a project.
- **Outcomes, not actions.** Remember to focus on deliverables and outcomes rather than actions. For example, if you were building a bike, a deliverable might be “the braking system” while actions would include “calibrate the brake pads”.
- **The 8/80 rule.** There are several ways to decide when a work package is small enough without being too small. This rule is one of the most common suggestions—a work package should take no less than eight hours of effort, but no more than 80. Other rules suggest no more than ten days (which is the same as 80 hours if you work full time) or no more than a standard reporting period. In other words, if you report on

your work every month, a work package should take no more than a month to complete. When in doubt, apply the "if it makes sense" rule and use your own judgment.

- **Three levels.** Generally speaking, a WBS should include about three levels of detail. Some branches of the WBS will be more subdivided than others, but if most branches have about three levels, the scope of your project and the level of detail in your WBS are about right.
- **Make assignments!** Every work package should be assigned to a specific team or individual. If you have made your WBS well, there will be no work overlap and responsibilities will be clear.

For small or medium-sized environmental projects, and depending on the purpose for which the WBS is designed, some of the above steps can be skipped, combined, insisted upon, or they may be managed less formally than they were presented especially if the project type is familiar to the project team.

Based on the WBS, we can then identify the activity list, which will include descriptions for each activity in order to ensure that the project team members understand how the work is to be done.

3.2. Sequencing environmental project activities

Sequencing environmental project activities involves identifying and documenting interdependencies among activities that the project team needs to undertake in order to deliver the project scope. For instance, we cannot plan the activity of placing waste collection equipment before planning the purchase of the said equipment.

Sequencing can be done with the aid of a computer (most commonly used software dedicated to project management in Romania is MS Project from Microsoft, Primavera from TotalSoft and Spider from Spider Project Team; some organizations use Excel to plan their projects) or manually. A common method for constructing a sequence of project activities is the **precedence diagramming method** (Project Management Institute, 2013).

Definition: Precedence Diagramming Method (PDM) is a visual representation technique that depicts the activities involved in a project. It is a method of constructing a project schedule network diagram that uses boxes/nodes to represent activities and connects them with arrows that show the dependencies.

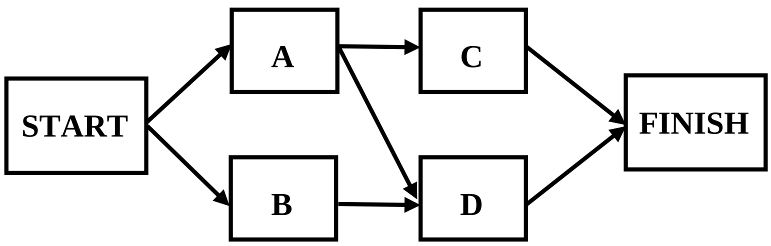

Figure 5. Precedence Diagramming Method graph

source: adaptation from Deac, 2016

PDM appears like a chart with boxes/nodes, as in Figure 5. The arrows that connect the boxes/nodes (activities) are the visual representation of the relationship between the project's activities. It is also the method used by most project management software tools.

Several types of precedence relations can be established between the activities of a project, depending on the succession imposed by the technological process. The precedence relations that a project planner can use are **finish-to-start**, **finish-to-finish, start-to-start** and **start-to-finish**.

The ***finish-to-start*** type of relationship is more restrictive because it involves the use of a series of activities that cannot overlap – the overall time for completing the project would be longer in this case. It is however the most commonly used type of relationship, since it avoids any possible mistakes in sequencing. Moreover, some of the methods we will later discuss, such as CPM or PERT, are restricted to this type of relationship.

The ***finish-to-finish*** relationship allows the planning of two activities that are synchronized in terms of the time when they should end, regardless of when they are scheduled to begin.

The ***start-to-start*** type of relationship allows the planning of two activities that are synchronized in terms of when they are scheduled to start, regardless of when they are planned to end.

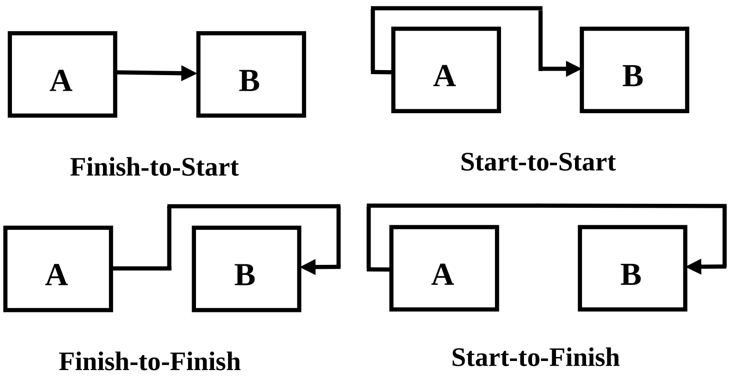

Figure 6. PDM precedence relations

source: (https://acqnotes.com/acqnote/tasks/precedence-diagram-method-pdm, 2021)

3.3. Estimating environmental project activities duration

Estimating environmental project activities duration involves assessing the time most likely needed to complete the activities the project team needs to undertake in order to deliver the project scope.

In order to estimate project activities duration, one can resort to **expert judgement** (Project Management Institute, 2013), guided by historical information. Such expertise can be provided by individuals or groups belonging to either the organization undertaking the environmental project or to other entities, such as consultancy firms or technical associations.

For a more mathematical approach to estimating activities duration, we will refer to instruments belonging to either **critical path method** (CPM) or **program evaluation and review technique** (PERT), which we will present in more detail when talking about scheduling.

The calculation of the **activity duration** is performed deterministically in the case of the *CPM* method using the formula:

$$d_{aij} = \frac{Q_{ij}}{PN_{ij} \text{ x } pi_{ij} \text{ x } \mathrm{W_{ij}}}$$

where:

d_{aij} = the duration of the "ij" activity;

Q_{ij} = the work volume for the "ji" activity;

PN_{ij} = the production norm per time unit (hour, day, month);

$\mathrm{W_{ij}}$ = the number of workers assigned to perform the "ij" activity;

pi_{ij} = the percentage of fulfilling the norms for the "ij" activity.

The *PERT* technique uses an estimate of **activity duration** calculated as a weighted average of three elements. These three elements are three different estimates of the activity's duration:

- Pessimistic duration of the activity (P);
- Most likely duration of the activity (M);
- Optimistic duration of the activity (O).

The formula used to calculate the estimated activity duration is:

Estimated activity duration = (P + 4 x M + O) / 6

We use the *standard deviation* from the mean to calculate the chances of finishing the activity in the estimated duration. This standard deviation has a specific formula for PERT:

σ = (P – O)/6

The probability that the duration of the activity is in the [estimated duration of the activity – *n* standard deviations; estimated duration of the activity + *n* standard deviations] interval is:

- ***n*** = one standard deviation → 68%;
- ***n*** = two standard deviations → 95%;
- ***n*** = three standard deviations → 99,7%;

- ***n*** = six standard deviations → 99,9%.

It is recommended to use PERT in brainstorming sessions to help team members reach a conclusion regarding estimates. The final activity duration estimation must be expressed in a particular time unit such as days, weeks, or as a percentage. Documenting "estimates premise" or methods and assumptions that were the basis for calculating the estimated durations should be included in the final duration estimates.

Exercise: Determine according to PERT the estimated duration of the following activities from a household wastewater treatment plant project undertaken by the Scînteiești commune in the Galați country of Romania:

Table 1. Activity List

Activity	Pessimistic Duration	Optimistic Duration	Most Likely Duration
Documentation for obtaining permits	60 days	30 days	36 days
Installing the wastewater treatment plant	24 days	10 days	15 days
Installing a pumping station	4 days	3 days	2 days
Building a 15 km collector	14 days	8 days	10 days
Building a protection dam	7 days	4 days	3 days

What is the interval that these activities will fall in using a 95% probability?

3.4. Developing environmental project schedule

Developing environmental project schedule involves establishing start and finish dates for the activities the project team needs to undertake in order to deliver the project scope, while considering the dependencies established among the said activities.

As we mentioned before, tools and techniques for schedule development include **CPM** and **PERT**.

a. Critical Path Method (CPM) was developed and used in the USA to improve schedules for construction-assembly works in the chemical industry. Critical Path Method calculates for each activity a single early and late start and end date, based on a logical sequence of activities in the network, each of which has a deterministically calculated duration. The focus of this method is on the determination of time reserves in order to see which activities have the lowest flexibility in terms of scheduling

The path in a network graph is a sequence of activities and phases between the initial phase and the final phase of the network. The length of the path refers, in fact, to its total duration and is calculated by summing the durations of activities that make up that path.

The critical path in a network is the longest path, obtained as the sum of durations of activities between the initial and final phase.

Critical path is the minimum duration that the entire project can be completed in, because it includes the sequence of activities with the longest durations (critical activities). As exceeding the planned duration of a single critical activity automatically increases the completion time of the entire project, the project team should pay particular attention to these activities and make sure they get all the resources they need to complete.

To be able to understand the concept of critical path, and also to be able to identify it, first you need to understand the various terms used in this method.

Definition: Earliest start time (ES) is the earliest time that an activity can be started in your project. You cannot determine this without first knowing if there are any preceding activities, or figuring out other constraints that might impact the start of this activity (one of the resources required by the activity might be available only after a specific date).

Definition: Latest start time (LS) is the very last minute in which you can start an activity before it threatens to upset your project schedule.

Definition: Earliest finish time (EF): The earliest an activity can be completed, based on its duration and its earliest start time.

Definition: Latest finish time (LF): The latest an activity can be completed, based on its duration and its latest start time.

Definition: Float (or slack) indicate how much each individual activity can be delayed before affecting successor activities or the planned project completion date.

Formulas one needs to consider when working with CPM [9]:

- **EF = ES + d** (activity duration);
- **LS = LF – d** (activity duration);
- **Total Float = LS – ES** (it is also calculated by LF – EF);
- **Free Float = Lowest ES of successor activities – EF of the activity you're computing free float for**.

Let's exemplify scheduling the activities using CPM on a simple project aimed at creating the spaces for composting (installing wooden crates, plastic containers, or individual composting equipment) in the campus of a village school and also training teachers/pupils in using them.

Table 2. Activity List for Composting Project

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

Activity ID	Activity	Estimated Duration	Predecessor
1	Initiation	0 days	-
2	Staffing	7 days	1 FS
3	Planning	7 days	2 FS
4	Carrying out the procurement procedure for composting containers and composting facilities	1 month	3 FS
5	Carrying out the procurement procedure for teachers/pupils training services - teachers/pupils workshops and practical workshops	1 month	3 FS
6	Installation of the compost bins	7 days	4 FS
7	Carrying out the training workshops for teachers	14 days	5 FS
8	Carrying out the practical workshops for pupils	7 days	5 FS
9	Monitoring the composting process	1 month	6, 7, 8 FS
10	Closeout documentation	7 days	9 FS
11	Hand over	0 days	10 FS

source: own creation in MS Word

We will start from a more detailed activity list, including the estimated duration of activities and dependencies, as we can see in Table 2. In the aforementioned table, FS stands for "Finish-to-Start" dependency.

To determine the critical path, organize all activities into a flowchart like the one in Figure 7. The arrows indicate the sequence of activities. We'll mark the **Earliest Start** (ES) time to the left of the activity, and the **Earliest Finish** (EF) time to the right, the calculations being made directly on the flowchart.

We start by marking the Earliest Start (ES) to the left of the first activity. Usually, this would be 0. Next, we determine the Earliest Start (ES) time of each activity. This is given by the largest number to the right of the activity's immediate predecessor (i.e. its Earliest Finish time, or EF). If the activity has two predecessors, the one with the later EF time would give you the ES of the activity. The EF of an activity is given by its Earliest Start time (ES) and its duration (d), i.e. ES + d. Thus, if an activity's ES is 7 and will last for 7 days, its EF will be 14. Mark all these figures in the flowchart. See Figure 7 for results.(https://www.workamajig.com/blog/critical-path-method, 2021).

Transilvania University of Brașov

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

The longest path through the flowchart will be the critical path and the final figure to the right of the last activity in the sequence will give you the minimum time the project will take to finish. In our case the critical path is made of activities 1-2-3-5-7-9-10-11 and the project will take 75 days to complete.

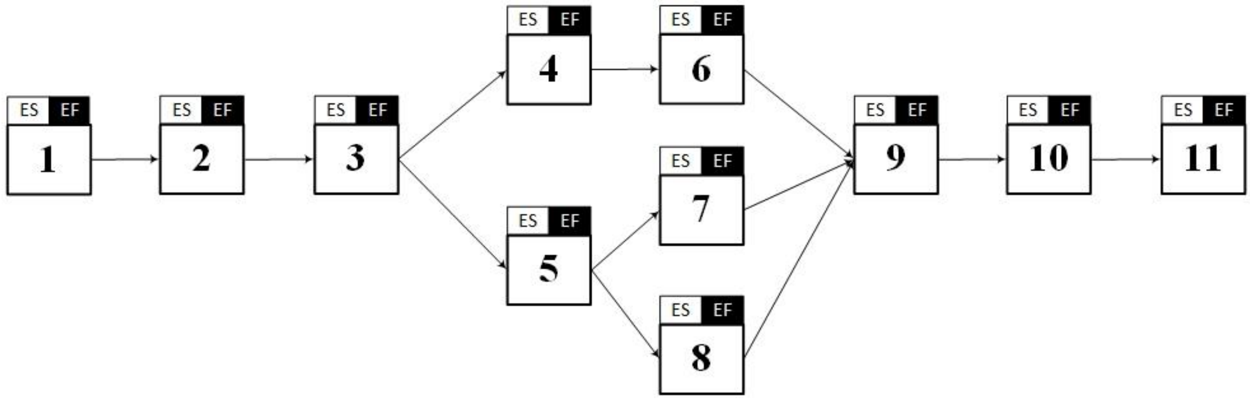

Figure 7. Activity Schedule Flowchart Template

source: own creation in MS Visio

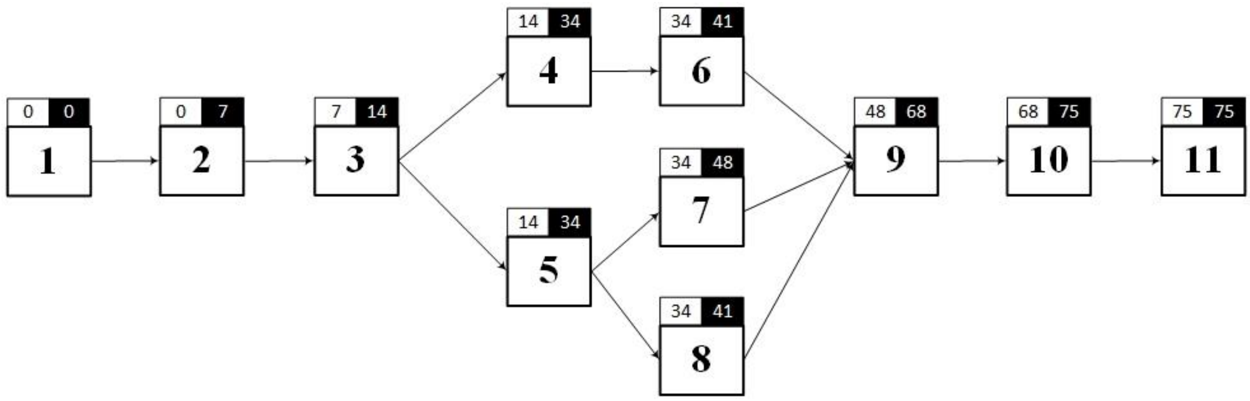

Figure 8. Activity Schedule Flowchart for Composting Project

source: own creation in MS Visio

b. Program Evaluation and Review Technique (PERT) - uses a logical sequencing of activities in the flowchart; activities are assigned probabilistic durations, based on the calculations previously discussed. PERT primarily differs from CPM in that it uses a weighted average duration estimate to compute project duration, whereas CPM relies on the most likely duration estimate. Nowadays, PERT is seldom used although PERT-like estimates are often used in CPM calculations (Project Management Institute, 2013).

One of the oldest but still very useful methods for presenting information on planning and scheduling a project is the **Gantt chart**. Developed at the beginning of the past century by Henry L. Gantt, a pioneer of scientific management. Gantt chart shows planned and realized progress as bars placed on a horizontal time axis. It is a very effective and easy to read chart indicating the current status for each of a set of activities compared to its planned progress.

The main **advantages** of using Gantt charts are:

a. although it can contain a lot of information it is easy to understand.
b. even though it requires regular updating (as any other control/planning tool), it is easy to maintain as long as the *workload requirements aren't changing or major alterations in the schedule of project activities don't occur*.
c. Gantt chart is a powerful tool for communicating with top management.
d. its network is easy to build;
e. although a simple Gantt chart can be plotted even in Excel, there are currently a number of dedicated software tools that help create and manage Gantt charts; among the best known - Primavera and MS Project.

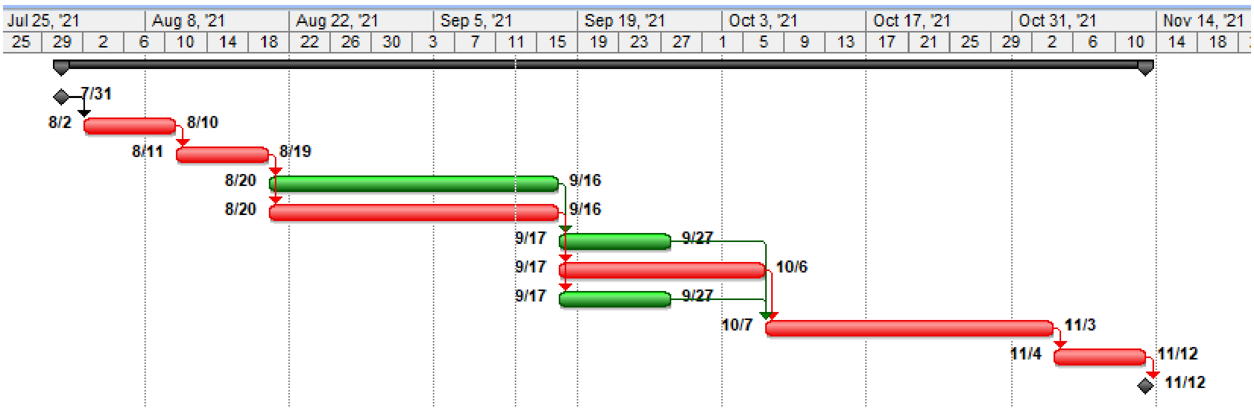

Figura 9. Gantt Chart for Composting Project

source: own creation in MS Project

The main weakness of a Gantt chart is that in the case of a complex project that requires performing many activities, it will be difficult to follow the evolution of multiple activities throughout the project.

Figure 9 displays the baseline Gantt chart for the composting project we discussed earlier. Activities shown in red are those on the critical path.

3.5. Controlling environmental project schedule

Controlling environmental project schedule involves constantly checking if the schedule has suffered changes, identifying if the changes suffered by the schedule have been positive or negative and managing the changes so that they don't affect project finish date and/or scope.

Example: Let's assume that the activity of staffing to the composting project in our previous example ended 3 days later than scheduled. Since this activity is on the critical path, this is obviously a negative change in the project's schedule (see Figure 10).

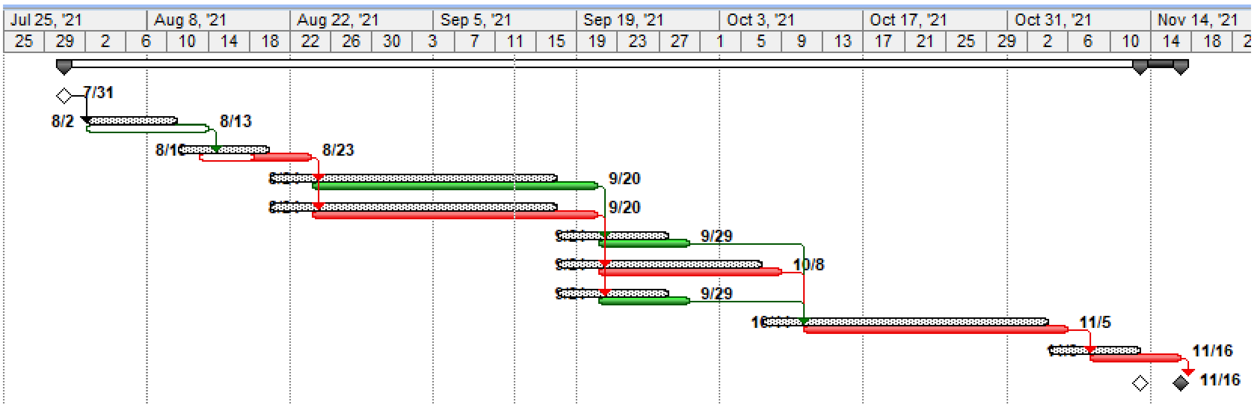

Figure 10. Gantt Chart for Composting Project with baseline and actual durations

source: own creation in MS Project

The first step in controlling the project schedule is to build a baseline Gantt chart, as we've discussed in the previous section. This baseline chart gives you a clear idea when each activity should have started and when it should have ended. In Figure 10, the baseline chart is the one in gray.

The next step is collecting data on the actual start and actual finish of each activity and plotting it on the Gantt chart, next to the activity, like in Figure 8. Doing that in a project management software, like MS Project, allows us to quickly see the impact of this delay on the entire project. As we can see, the whole project is now going to be late, ending on the 16th of November instead of the 12th.

Once we realize we have a problem in terms of schedule, the project management team has a couple of options to take control of the project schedule and bring it back on track (https://www.workamajig.com/blog/critical-path-method, 2021):

a. Fast Tracking - the process of running multiple activities on the critical path in parallel in order to reduce overall project time.

Fast tracking is only possible for activities which don't have "hard" dependencies, i.e. they don't depend completely on their predecessors to start.

For example, in our case we could try starting to write the closeout documentation while monitoring the composting process in order to get back on track.

b. Crashing - What if you need to rush an activity because of an early deadline?

In such a situation, you can allocate additional resources to the activity to bring it to completion faster. This process is called "crashing".

Crashing is useful in activities which benefit from having additional resources, i.e. follow a linear relationship between resources and time to completion; can utilize resources from activities with high floats (those that can be late without

Transilvania University of Brașov

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

Iceland Liechtenstein Norway grants

impacting the deadline for the project). Since there is significant "slack" in these activities, you can delay them without jeopardizing the project.

Crashing is generally not recommended barring emergencies since it can impact activities on and outside the critical path. If you have to do it, however, divert resources from high float activities, not those on the critical path.

Chapter 4 - Cost management in environmental projects

4.1. Determining the resources needed by the environmental project

Estimating a project's time and effort also forms the basis for the project's budget. In order to be able to identify an environmental project's **costs**, first one needs to fully determine the **resources** needed to undertake it. For this, we can use the WBS and identify the resources needed by each work package. Generally, resources to consider when it comes to environmental projects fall into one of three general categories:

- Human resources – the people that will do the work during the project (engineers, consultants, economists, wind turbine technicians and so on);
- Material resources, such as: bricks, concrete and so on;
- Equipment resources, such as: trash bins, solar photovoltaic panels, battery charge controllers, bulldozer and so on.

The main difference between material and equipment resources is that material resources are consumed during the process they are involved in and incorporated in its final result, whereas equipment resources are time consuming and can be used for a number of processes before being depleted.
More about resources in the course section about them.

4.2. Cost estimating for the environmental project

All the resources identified generate costs which depend on their **standard rates** and the **quantity of work** they are needed for. So, after identifying all the resources required for completing the environmental project, **cost estimating** is performed either by **analogous estimating** (or top-down estimating) or **bottom-up estimating**.

Analogous estimating means taking into consideration the actual registered cost of previous similar environmental projects and using it as baseline for the current project. It is less costly than other techniques.

Bottom-up estimating means identifying the cost of individual work packages, then summarizing the costs to get a grand total for the environmental project.

Example: *Imagine that writing the feasibility study for your environmental project requires the participation of a consultant and also an engineer from your project team. You established the duration of the "write feasibility study" activity using expert judgement to 7 days (when talking about "days" in a project we actually refer to "standard work days", so a duration of 8 hours per day is considered). The standard rates are 200 RON/hour for the consultant and 50*

RON/hour for the engineer. So, the cost of the "write feasibility study" activity will be computed like this: (200 RON/hour x 8 hours/day x 7 days) + (50 RON/hours x 8 hours/day x 7 days) = 14.000 RON.

Regardless of the approach to cost estimating, the costs that resources in an environmental project generate can be included in one of the following categories:

- **Labor costs** – those costs associated with the employment and remuneration of the staff involved in the project. In order to be able to correctly estimate the labor costs, you need to establish the categories of employees that will be involved in the environmental project, the hourly wages of each category and the time duration for which we will need their services. While computing labor costs you also have to consider income taxes perceived by your country.
- **Materials costs** – it applies to the materials or equipment that the project team needs to complete its activities. The environmental projects' costs with materials are not considered among the lowest costs, but among the highest, since many environmental projects require construction works.
- **Equipment costs** – The equipment required may be unique or different from that of the equipment currently used by the organization undertaking the project. For environmental projects undertaken by local councils, the equipment is generally rented from the market and their cost is the cost of the rent paid by the organization. If however the organization decides to purchase equipment and it can be used at the end of the project in other activities carried out by the organization, their cost will be only partially allocated to the project. However, if special equipment has to be purchased for the project, equipment that will not find application in any other activity of the organization, their cost will be allocated entirely to the project.
- **Accommodation costs** – referring again to the situation in which the project takes place in a location other than the spaces owned by the executing organization, you must consider the costs associated with renting space in which the project team will operate and store the equipment during the project.
- **Transportation costs** – can be included in the costs of equipment, if they refer to their transportation; if however we refer to transportation of persons, for whom vehicles have to be rented during the project, we refer to transportation costs.
- **Outsourcing costs** – if certain activities of the project will be performed by entities that do not belong to the organization (consulting companies, suppliers of any kind), the costs related to them must also be considered. An example could be hiring a training company to carry out a workshop related to selective waste collection.
- **Overhead costs** - expenses encountered in the case of all organizations, they are constituted in salary costs of management staff, legal documents drafting to support the development of the project, utilities costs and so on.

Another way to classify the costs of an environmental project is to divide them according to their nature into **direct** and **indirect costs**; **recurring** and **non-recurring**; **fixed** and **variable**. Let's take a look at each category:

a. Direct and indirect costs. Costs can be categorized as **direct** when they can be easily associated with the element of the project that generated them (most common examples are labor and materials costs), and as **indirect** when they do not have a direct link with the activities generating added value, but are necessary for the good development of the project. Indirect costs example: overhead costs.

b. Recurring and non-recurring costs. Depending on how often they occur during the environmental project, costs can be classified as recurring and non-recurring. An example of non-recurring cost would be the documentation built to get building permits for a recycling plant, while the salary cost of a project team member is considered a recurring cost.

c. Fixed and variable costs. The costs that increase or decrease as the use of the resources that generate them increases or decreases are called **variable costs**. The costs that remain the same regardless of the change in the degree of use of the resources that generate them are called **fixed costs**. Examples of fixed costs include setup costs, rental costs, documentation costs and other related costs. Variable costs include materials costs.

4.3. Cost budgeting for the environmental projects

Cost budgeting involves allocating the overall cost estimates to individual work packages of the project. A cost baseline is established to be later used in measuring project performance, and it usually takes the form of a **project budget**.

A simple way to organize your costs is by the activity (based on the **bottom-up estimating**) that generates them, like in Table 3.

Tablel 3. Simple Budget for Composting Project

Activity ID	Activity	Cost
1	Initiation	0 €
2	Staffing	200 €
3	Planning	500 €
4	Carrying out the procurement procedure for composting containers and composting facilities	3,500 €
5	Carrying out the procurement procedure for teachers/pupils training services - teachers/pupils workshops and practical workshops	2,800 €
6	Installation of the compost bins	2,500 €
7	Carrying out the training workshops for teachers	2,500 €
8	Carrying out the practical workshops for pupils	1,000 €
9	Monitoring the composting process	1,000 €
10	Closeout documentation	500 €
11	Hand over	0 €
TOTAL		14,500 €

source: own creation in MS Word

A more complex budget template is presented in Table 4. It groups expenses by their type, and is computed based on the standard rates of each type of resource and the number of units from that resource that are necessary to complete all the activities in the project WBS.

Table 4. Budget Template

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

EXPENDITURE CATEGORY (1)	DESCRIPTION (2)	MEASURING UNIT (3)	STANDARD RATE (4)	NUMBER OF UNITS (5)	TOTAL COSTS (6 = 4*5)	OWN FUNDING (7)	CO-FINANCING (8)
Labor costs	Team member 1	€ / hour	100 € / hour	10	1,000	%	%
	Consultant	€ / hour	200 € / hour	10	2,000	%	%
	…	…	…	…	…	%	%
Equipment costs	Equipment 1	€ / hour	150 € / hour	20	3,000	%	%
	Equipment 2	€ / hour	80 € / hour	100	8,000	%	%
	…	…	…	…	…	%	%
Materials costs	Material 1	€ / unit	2 € / unit	50	100	%	%
	Material 2	€ / kg	5 € / kg	100	500	%	%
	…	…	…	…	…	%	%
Accommodation costs	…	€				%	%
Transportation costs	…	€				%	%
Outsourcing costs	…	€				%	%
Overhead costs	…	€				%	%
GRAND TOTAL							

source: own creation in MS Word

4.4. Cost control for the environmental project

Projects should not exceed their budgets in order to use resources as efficiently as possible. Companies do not write blank checks when it comes to projects, so a project manager will always be asked by his superiors "was the project within the approved budget?"

When it comes to budget constraints, remember, it's best to communicate early and often. No one likes being surprised by a big bill (or the tense conversation that inevitably follows)(https://www.workamajig.com/blog/critical-path-method, 2021).

Paying attention to how the time spent stacks up against your estimate helps you keep project costs in check. Modern project management software hourly estimation and time tracking tools enable you to compare an activity's actual

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

versus estimated hours and see how the time spent tracks against the percentage complete. That way you can spot budget overages before they become a problem.

Methods for cost control include cash-flow analysis and earned value.

Cash-flow analysis allows you to look closely at the cash inflows and outflows associated with an existing or potential environmental project.

Cash flow characteristics:

- it shows the "state of health" of the project;
- represents a control of the incoming and outgoing amounts in order to avoid very big differences.

	7/25/21	8/1/21	8/8/21	8/15/21	8/22/21	8/29/21	9/5/21	9/12/21	9/
COMPOSTING PROJECT									
Initiation									
Staffing		100.00 €	100.00 €						
Planning			71.43 €	357.14 €	71.43 €				
Bins Procurement					700.00 €	875.00 €	875.00 €	875.00 €	
Training Procurement					560.00 €	700.00 €	700.00 €	700.00 €	
Bins Installation									
Teachers Training									
Pupils Training									
Monitoring the composting process									
Closeout documentation									
Hand over									
Total		100.00 €	171.43 €	357.14 €	1,331.43 €	1,575.00 €	1,575.00 €	1,575.00 €	

Figura 11. Sample Cash-Flow Report in MS Project for Composting Project

source: own creation in MS Project

Earned value is an approach that fully integrates cost and time. It makes it possible to measure the performance of project cost planning and actual recorded cost in the same system. When choosing another method of cost control, there will be separate reports for expenses and progress.

Earned value reports are cumulative reports. Values collected for the current reporting period are added to the values obtained from the last reporting period and the total is represented on a chart.

A major difficulty in illustrating the cumulative cost curve for a large project is that the scale necessary to show the total cost of the project can be so dense that relatively large changes may not be visible. A project of 1 billion EURO put on an A4 page depicts a variance of 2.5 million EURO in only 6 cm.

The earned value system depends on the identification of three project variables (Maylor, 2002):

- *Budgeted Cost of Work Scheduled (in short BCWS).* Each activity in the project has its own cost and its own estimated schedule. BCWS is the cumulative budget – it will be shown on a timeline that shows when should the expenses be performed according to the project plan.
- *Actual Cost of Work Performed (in short ACWP).* As the project progresses, the actual cost accumulates. The actual cost is cumulatively plotted along the same time axis. The real cost is implemented for each time period to which it refers.

- *Budgeted Cost of Work Performed (in short BCWP)*. This is also called earned value. The cumulative chart of effectively completed workload is considered. The estimated budget for the completed workload is assigned to the value of that workload. On the same time axis, the cumulative cost of the workload performed (the actual cost) is plotted. The added value is plotted for each time period based on the actual work performed.

If the project follows the project plan, each of these three parameters has the same value and representation. Significant deviations between the values of the three parameters should be a concern.

Values you need to understand in order to report earned value are:

a) Budget At Completion (BAC) is the point that represents the total project budget. On the cumulative chart, this is the last point on the BCWS curve. BCWS cannot be greater than BAC.

b) Cost Variance (CV) is the difference between the cost of the actual completed work and cost associated with the workload. A positive variation means that the situation is good, and a negative variation means that things aren't going well. The formula for cost variance is:

CV = BCWP – ACWP

c) Schedule Variance (SV) is the difference between the volume of actually completed work and the volume of work that was expected to be completed at a specific time. A positive variation means a good situation and vice versa. The formula for schedule variance is:

SV = BCWP – BCWS

d) Cost Performance Index (CPI) is a measure of the conformance of the actual work completed (measured by its earned value) to the actual cost incurred. The formula for cost performance index is:

CPI = BCWP / ACWP

e) Schedule Performance Index (SPI) is a measure of the conformance of actual progress (earned value) to the planned progress. The formula for schedule performance index is:

SPI = BCWP / BCWS

f) Estimate At Completion (EAC) is an estimate of the project cost at the completion of the project. This is BAC adjusted for current performance to date. It is considered that if the project continues along its current level of cost performance, EAC will become the final cost of the project. This is a pessimistic value, since it is considered that the mistakes previously made in the project are expected to be repeated until the end of it. The formula for estimate at completion is:

EAC = BAC / CPI

g) Estimate to Complete (ETC) is the remaining budget needed to complete the project, if work continues at the same pace as currently registered. The formula for estimate to complete is:

ETC = EAC – ACWP

This is how MS Project presents earned value for instance:

Transilvania University of Brașov

Acest document este realizat cu sprijinul financiar al Mecanismului Financiar al SEE 2014 – 2021. Conținutul acestuia (text, fotografii) nu reflectă opinia oficială a Operatorului de Program, a Punctului Național de Contact sau a Oficiului Mecanismului Financiar. Informațiile și opiniile exprimate reprezintă responsabilitatea exclusivă a autorului/ autorilor.

Task Name	Planned Value - PV (BCWS)	Earned Value - EV (BCWP)	AC (ACWP)	SV	CV	EAC	BAC	VAC
COMPOSTING PROJECT	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Initiation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Staffing	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Planning	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Bins Procurement	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Training Procurement	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Bins Installation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Teachers Training	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Pupils Training	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Monitoring the compo:	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Closeout documentati	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Hand over	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

Figure 12. Earned Value Report in MS Project for Composting Project

source: own creation in MS Project

References

Deac , V. (2017). *Management .* Bucharest: Editura ASE.

European Comission. (2004). *Project Cycle Management Guidelines.* Brussels: European Comission.

Gogoașe, D., & Manoliu, M. (2000). *Managementul proiectelor de mediu.* București: Editura H*G*A.

Haugan , G. (2002). *Effective work breakdown structures.* Vienna: Management Concepts Inc,.

Havranek, T. (1999). *Modern Project Management Techniques for the Environmental Remediation Industry.* New York: Taylor&Francis Group.

https://acqnotes.com/acqnote/tasks/precedence-diagram-method-pdm. (2021).

https://www.projectmanager.com/critical-path-method. (2021).

https://www.teamgantt.com/blog/triple-constraint-project-management. (2021).

https://www.workamajig.com/blog/critical-path-method. (2021).

Maylor, H. (2002). *Project Management* (3rd ed.). Essex: Financial Times/Prentice Hall.

Petts, J., & Eduljee, G. (1994). *Environmental impact assessment for waste treatment and disposal facilities.* Chichester: John Wiley.

Project Management Institute (2006). *The standard for portfolio management.* Newton Square : Project Management Institute.

Project Management Institute (2006). *Practice standard for work breakdown structures, global standard.* Newton Square: Project Management Institute.

Project Management Institute (2013). *A guide to the project management body of knowledge (PMBOK guide)* (5th ed.). Newtown Square.

Project Management Institute (2021). *A Guide to the Project Management Body of Knowledge (PMBOK Guide),* (7th ed.). Newtown Square: Project Management Institute.

Sholarin, E. A., & Awange, J. L. (2015). *Environmental Project Management.* Switzerland: Springer International Publishing.