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Coordinator Prof. Paola Spinozzi

SUSTAINABLE REGENERATION OF ACTIVE CEMETERY STRUCTURES IN URBAN AREAS.

Interdisciplinary assessment and development of a guidance system to support the decision-making process.

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CYCLE XXXV

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Scientific/Disciplinary Sector (SDS) **ICAR / 12**

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To all those who followed me
on this excited adventure.

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ABSTRACT

The urban area is subject to deterioration due to environmental factors and the strong anthropic load of the city. Interventions through the implementation of new strategies to regenerate not only the existing building heritage, but also the outdoor spaces, are multiplying. The purpose is to reverse the main urban problems of loss of biodiversity, landscape fragmentation, negative health impacts, climate change and pollution.

In this scenario, there are few cases where cemeteries are mentioned as capable of making cities more resilient and healthier. These structures could have a greater impact on sustainable urban environments if they were considered more as an essential infrastructure and not exclusively as sacred places. From this perspective, the research aims to establish a guidance system for the sustainable regeneration of cemetery structures located in urbanized areas.

Therefore, it was essential to conduct an analysis of the cultural, biological, legislative, management and architectural aspects, interdisciplinary areas with which the research dialogues. This unique framework highlights the complexity of cemeteries and their multiple needs through a critical examination of the state of the art from a review of the current literature.

Afterwards, numerous interviews were conducted with international researchers and experts in the areas of interest, investigating the current context of the topic in detail and comparing it with the theoretical information. In addition, site observations were carried out in several cemetery structures to document and evaluate different cemetery types within the urban context, examine examples of best practices and investigate the management of the cemetery.

In this way, the cemetery was classified into four contexts: urban infrastructure, outdoor environment, built asset and cultural heritage. For each context, functional elements responsible for affecting the organization and life of cemeteries were identified and interpreted. This approach made it possible to define cemeteries as an infrastructure as well as to determine the needs and requirements to guarantee the use of space, reduce environmental impacts, improve the quality of the urban landscape and enhance the cultural aspects present within burial areas.

A series of strategies and indications adopted in existing energy-environmental certification protocols, originally created to be applied on built environments other than cemeteries, were used as reference and adapted to the object of study. The redevelopment actions of existing cemeteries can bring a benefit in functional and technological integration. It supported the definition of operational actions to promote higher levels of sustainability in urban areas.

Finally, an operating procedure was developed for the evaluation and planning of an intervention project on cemeteries. This orientation tool characterizes the guidance system for sustainable management of cemetery structures to guide actors of public and private initiatives with a strategic vision of integrated planning. It supports the decision-making process during the planning stages of interventions on existing cemeteries and aimed to generate the scientific basis to support future research in this area.

L'area urbana è soggetta a degrado a causa di fattori ambientali e al forte carico antropico della città. Attualmente, si stanno moltiplicando interventi per rigenerare non solo il patrimonio edilizio esistente, ma anche gli spazi esterni. Lo scopo è quello di ridurre i principali problemi urbani di perdita di biodiversità, frammentazione del paesaggio, impatti negativi sulla salute fisica e sul benessere, cambiamento climatico e inquinamento.

In questo scenario, sono ancora pochi i casi in cui i cimiteri sono considerati capaci di contribuire a rendere le città più resilienti e più sane. Queste strutture potrebbero avere un maggiore impatto sulla sostenibilità degli ambienti urbani se fossero considerate più come un'infrastruttura essenziale e non esclusivamente come luoghi sacri. In quest'ottica, la ricerca mira a stabilire un sistema di indirizzo per la rigenerazione sostenibile delle strutture cimiteriali situate in aree urbanizzate.

È stato quindi fondamentale condurre un'analisi degli aspetti culturali, biologici, legislativi, gestionali e architettonici, ambiti interdisciplinari con cui la ricerca dialoga. Questo quadro unico evidenzia la complessità dei cimiteri e le loro molteplici esigenze attraverso un esame critico dello stato dell'arte a partire di una revisione dell'attuale letteratura.

Successivamente sono state condotte numerose interviste con ricercatori ed esperti internazionali nelle aree di interesse, approfondendo l'attuale contesto del tema e confrontandolo con le informazioni teoriche. Inoltre, sono state effettuati sopralluoghi in diverse strutture cimiteriali per documentare e valutare le tipologie cimiteriali all'interno del contesto urbano, esaminare esempi di buone pratiche e approfondire il tema della gestione del cimitero.

In questo modo, la struttura cimiteriale è stata classificata in quattro contesti: infrastruttura urbana, ambiente esterno, edificio e patrimonio culturale. Per ogni contesto sono stati identificati e interpretati gli elementi funzionali responsabili per incidere sull'organizzazione e la vita dei cimiteri. Tale approccio ha permesso di definire i cimiteri come infrastruttura, così come di determinare le esigenze e i requisiti per garantire l'uso dello spazio, ridurre gli impatti ambientali, migliorare la qualità del paesaggio urbano e valorizzare gli aspetti culturali presente all'interno delle aree sepolcrali.

Una serie di strategie e indicazioni adottate da protocolli di certificazione energetico-ambientale esistenti, nonostante siano originariamente nati per essere applicati su ambienti costruiti diversi dai cimiteri, sono state prese come riferimento e adattate all'oggetto di studio. Gli interventi di riqualificazione dei cimiteri esistenti possono apportare un beneficio in termini di integrazione funzionale e tecnologica, sostenendo la definizione di azioni operative per promuovere livelli più elevati di sostenibilità nelle aree urbane.

Infine, è stata definita una procedura operativa per la valutazione e progettazione di un intervento di rigenerazione dei cimiteri. Questo strumento di indirizzo mira a una gestione più sostenibile delle strutture cimiteriali per guidare gli attori delle iniziative pubbliche e private con una visione strategica della progettazione integrata. L'obiettivo è di supportare il processo decisionale durante le fasi di progettazione degli interventi sui cimiteri esistenti e generare le basi scientifiche per supportare la ricerca futura in questo settore.

KEYWORDS

Cemetery Structure | *Struttura Cimiteriale*
Sustainable Strategies | *Strategie Sostenibili*
Regeneration | *Rigenerazione*
Interdisciplinary Integration | *Integrazione Interdisciplinare*
Guidance System | *Sistema di Orientamento*

CHAPTER 1: INTRODUCTION AND RESEARCH FRAMEWORK

Figure Cover Chapter 1: Relation between the Cemitério Municipal Água Verde (Curitiba, Brazil) and its urban surroundings[1].

[1] The image source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

1.1. SIGNIFICANCE OF THE RESEARCH AND INTRODUCTION TO THE GENERAL THEME

The issues that cemetery structures are facing in the international context are related to the urban area being subject to deterioration from environmental factors and the strong anthropic load of the city. The number of interventions for the implementation of new strategies that has been studied to regenerate not only the existing building heritage but also the outdoor spaces is multiplying. The purpose is to reverse the main urban problems of loss of biodiversity, landscape fragmentation, negative health impacts, climate change and pollution. After all, it is an international problem and specific strategies have been created to overcome this issues.

In 2020 the European Commission approved a series of policy initiatives to support a climate neutral impact on all sectors of the economy until 2050, including construction, biodiversity, energy, transport, food, health and circularity (EC & DGRI, 2021). Addressed mainly to European Union countries but not exclusively, the European Green Deal (EC, 2019) is key for a sustainable transition for citizens and future generations, outlining environmental needs and promoting green investments.

The Green Deal policy provides several benefits for the health and well-being of inhabitants, some of which are the renovation of the building asset and the improvement of the environmental quality. Besides that, other relevant topic are defined by this policy, such as increase in biodiversity and protect ecosystems (EC et al., 2020 a), as well as raise awareness on climate movement and encourage citizens participation on discussions (EC et al., 2020 b).

In this scenario, there are few cases where cemeteries are mentioned as capable of making cities more resilient and healthier. These structures could have a greater impact on sustainable urban environments if they were considered more as an essential infrastructure and not exclusively as sacred places. However, when talking about these facilities it is important to understand the social relations that were built around cemeteries and how society conceives and faces death over time.

Cemeteries have always played a role of great importance in the history of humanity and its cities, reaching a point where their functioning is conditioned by cultural aspects. These values are solidified and expressed in the cemetery structure and raise relevant data about their configuration nowadays. It remains a symbolic extension of spiritual and transcendental values, rich in signs and symbols, but above all, a place of history and memory.

With the latest changes in society's beliefs, fear and denial before finitude lead to the transformation of architecture into a simple refuge for the disintegration of human matter. The result is a space for the dead that becomes a place of neutrality and where the relationship with spirituality undergoes a significant weakening. This process cooperates as an artifice of detachment from death and its rituals, making the material

object of memory, the cemetery, lose strength. Therefore, secularization can lead to a variety of problems, such as environmental pollution and an increase in urban problems.

Starting with the urban aspect, several urban areas are already facing problems related to modern cemeteries. Previously cemetery structures were located outside the urban perimeter, but due to an intense increase in population and an uncontrolled urbanization process, they have been incorporated by the city. It is common to find cemeteries totally integrated into the urban fabric, even in its most central areas, creating a confined area that does not allow the expansion to build new burial spaces (Figure 1).

Figure 1 - Cemitério Municipal Água Verde (Curitiba, Brazil), an example of an overcrowded cemetery completely incorporated by the urban fabric.[2]

A dense cemetery that receives regular burials may cause environmental and health problems. Depending on climate factors and local regulations, the decomposition of organic material may contaminate natural resources. However, even if there are records of serious contaminations that cause diseases (Bouwer, 1978; Neckel et al., 2017), for a long time this source of contamination was admitted as irrelevant and even unknown. Only with the beginning of historical cases of large-scale contamination has research on the subject began.

According to this, the research evaluates the contribution of cemetery structures to the sustainable context. Cemetery structures represent an important social-cultural function and cannot be simply dismissed. These are complex spaces with a lot of needs that go from urban space improvement, landscape planning, architecture innovation, public health care, religious independence and cultural value enhancement. For these reasons, they must be regenerated like other collective infrastructures strongly characterized by open spaces.

[2] The image source is: Google, Imagens ©2020 CNES/Airbus, Maxar Technologies

For this reason, this research intends to improve the discussions and propose interventions for the sustainable regeneration of cemetery structures. The structure of a cemetery can create significant impacts on the urban environment, as described in Subheading 1.3, and it is surprising to note that the number of published studies in the literature is very small compared to other topics. It means that even with timid but growing studies being developed in recent years, it is still not a frequently updated topic.

The innovation of this research concerns the object of study for proposing a reflection on burial spaces, in particular from an environmental and social point of view. It disseminates the topic in the scientific community and raises awareness of the importance to discuss about cemeteries and the sustainable planning of these facilities.

1.2. GENERAL RESEARCH AIM AND SPECIFIC OBJECTIVES

The purpose of this research is to incorporate cemetery structures in the contemporary technological and sustainable development scenario, considering solutions from cultural, environmental and legal aspects to help the sustainable development.

The main aim of the research is to:

- **improve the capacity of sustainable regeneration of existing cemeteries structures located within the urban areas according to an international interpretation and an interdisciplinary analysis.** Strategies from a wide range of macro-areas promote a more efficient operation and allow these cemeteries to continue operating in a more sustainable way;

- **identify universal and local principles to apply to a large number of cemetery structures for their regeneration.** These principles must be considered during the renovation planning of these facilities in different situations depending on cultural, urban and environmental interactions.

Related to these two main purposes, the research aims to reach specifically the following research objectives:

- **examine the interaction of the cemetery structure at the international level in different socio-cultural contexts.** Evaluate what is the current situation of cemeteries located inside urban areas from different contexts through the analysis of the:
    1. cultural heritage elements;
    2. principles of architecture and urban planning;
    3. interaction of the cemetery structure and the environment;
    4. comparison of legislations related to cemeteries;

- analyse specific elements of the cemetery structure. The spatial configuration of the cemetery structure, its relation to the urban fabric and its functional elements are the aspects focus of this analysis;

- propose strategies for the regeneration of existing cemetery facilities. Development of strategic interventions to assess the impacts and benefits of cemetery structures in urban areas.

1.3. INTERDISCIPLINARY FRAMEWORK OF THE RESEARCH

This research draws attention to the need to regenerate existing cemeteries structures following contemporary sustainable criteria. To achieve the expected result, it is necessary to examine the cemetery structure from different contexts and interact with a number of macro-areas from:

- cultural heritage aspects;
- environmental and ecological aspects;
- legislative and management aspects;
- architecture - urban aspects.

These are sectors of the scientific knowledge that composes the interdisciplinary framework of the research (illustrated in Figure 2). The different macro-areas of interest were gathered together to describe the potentialities and criticalities of cemetery topics, including the limitations of the field of study. With this integrated analysis it will be possible to determine solutions to regenerate the existing constructions, avoid environmental damage and enhance the urban environment.

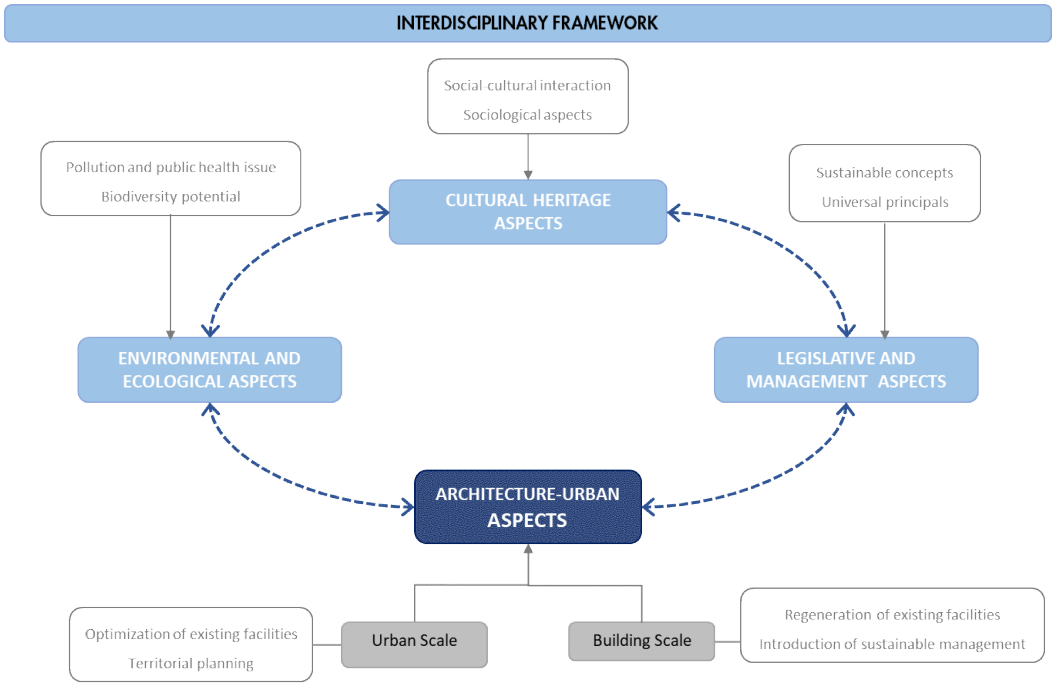


Figure 2 - Synoptic diagram of the interdisciplinary framework.

1.3.1. Cultural Heritage and Architecture-Urban Aspects

It is possible to identify two principal macro-areas related to cemetery studies, sociology and architecture. These areas confront topics associated with cultural elements, religious aspects, sustainable architecture and urban planning. They are different areas of study, but their interaction is important to interpret the concept of space in different socio-cultural contexts.

The **cultural heritage** recognizes transformations made by social behaviours and identifies how human beings conceive and occupy spaces. Cultural changes over time caused the abandonment of large structures inside urbanized areas, leading to environmental and urban problems. In this area of study, the proposal is to analyse how existing cemeteries relate to social dynamics, individual and collective expressions responsible for the production of the spatial configuration of cemeteries.

This phenomenon supports the improvement of cemeteries structures through the understanding of cultural behaviours in relation to the spaces for death. Respecting cultural values may reduce the tendency of people to avoid these spaces, ensuring that cemetery spaces do not fall into oblivion and abandonment. The success of any architectural-urban intervention is guaranteed if well accepted by the local community.

From the **architecture position**, the topics are related to the lack of maintenance, the use of space and the energy and environmental management.

Instead, the **urban aspect** is connected to the lack of space and the arrangements of cemetery structures within the urban network. This level of analysis regards the urban planning, a scale of study that regards cities with meso-scale frameworks. Both aspects work together to identify technical solutions for a sustainable structure, contributing to protect the environment and to reduce urban impacts.

1.3.2. Environmental and Ecological Aspects

The other two macro-areas are biological and ecological sciences. The precarious installations of modern cemeteries, caused by the lack of proper architecture and urban planning, can pollute the environment and impact human health. An understanding of the biological and chemical processes will help to find technical solutions that will help to mitigate the effects caused by anthropogenic activities of the toxic substances released from the decomposition process.

Cemeteries are a public health concern due to the high risk of contamination of natural sources and the proliferation of infectious diseases. As part of the sustainable assessment of cemeteries, it is necessary to analyse their **environmental aspects**. The intention is to recover the territory and improve structures, buildings and burial spaces.

Even if the cemetery has a fragile environment, it is capable of promoting the protection and restoration of ecosystem services. It tends to have a stable ecosystem because of its undisturbed nature, a potential that plays a conservation role and acts as a natural refuge for urban species. Therefore, from the **ecological perspective,** the aim

is to manage the cemetery structure to enhance the local biodiversity within its area, contributing also to the urban scale biodiversity.

1.3.3. Legislative and Management Aspects

Cemeteries do not receive the same level of attention and accuracy regarding sustainable management as other infrastructures present inside the urban context, meaning that the legislation related to cemeteries does not respect the contemporary concepts of sustainability. On the other hand, improvements in this matter have been done at the internal level of policies and procedures, resulting in the intersection of the law macro-area with management.

A cemetery structure creates a significant impact on the city because of its large dimension, being normally regulated by urban laws. They need to be clear and rigid, otherwise, they are not respected by the operational system. It is important to state that these laws are very different from one country to another, starting from construction details of the burial spaces to funeral procedures. For this reason, the research confronts **legislative aspects** through the analysis of internal rules and national legislation of competence. The comparison of legislations from international contexts allows the identification of universal principles to regenerate the existing structures.

Besides that, the operational management of a cemetery frequently finds ways to contribute to the sustainability of the urban structure. After complying with official laws and regulations, extra policies may apply to this matter. Thus, as mentioned before, solutions from all macro-areas have to incorporate additional **management aspects**.

1.3.4. Limitations of the field of research

This research intends to analyse **existing cemeteries** for the sustainable development of their structures and the urban environment. Preference is given to **operating cemeteries**, in other words, cemeteries that still have space available to receive new burials. The geographical range is limited to the Western world, using **international and urbanized cities** from countries with European cultures. They are not restricted to metropolises so the definition of urban scale may adapt to local characteristics.

There are some topics described above that will not be explored in all of its details, because they do not significantly influence the aspects of sustainability covered by the research. Therefore, some topics that are limited by the research are listed below:

Cultural Heritage Aspects: the funeral theme is present throughout the history of humanity and it is directly related to the local culture, being frequently a place of religious practice. The research aims to study the cemetery structure from its sustainable point of view, and religion is too specific for this analysis. There is a wide range of funeral practices according to individual beliefs. However, the research focus on understanding the **cultural dynamics** inside the cemetery, not its spiritual aspects.

The cemeteries analysed are mostly influenced by the Catholic Church, the Anglican Church and the public administration. The influence of Jewish culture on this analysis results in similarities between structures from Christianity and Judaism

traditions. Some cases of Jewish Cemeteries were used during the methodology process as a way to incorporate the social dimension of sustainability. Although it demonstrates the replicability of the research, the object of study remains **Christianity culture**.

It is impossible to analyse a cemetery without its transcendental values and because of that, religion and spirituality are examined as distinct elements. Therefore, these aspects will be translated into **cultural heritage**, which is a representation of general spirituality that maintains the importance and presence of certain traditions.

Architecture-Urban Aspects: many studies from this macro-area are focused on the historic or cultural concepts of the cemetery, and just a few are focused on improving the existing structures. The meaning of historic burial spaces is limited to historic and artistic value, without analysing funeral traditions.

Legislative Aspect: these cemeteries have strong management and rigid laws to follow, and even then, the funeral industry and stakeholders responsible for the cemetery structure have not seriously explored the possibility of using products with a lower environmental impact. The research does not aim to design a new legislation for cemetery structures but to examine **national legislations** from selected countries or **management strategies** that deal with sustainable recommendations.

1.4. EXPECTED RESULTS

The expected result of this research is to establish a guidance system for the sustainable regeneration of existing cemetery structures located in urban areas, proposing intervention strategies necessary to mitigate environmental impacts and increase the quality of the urban landscape. Sustainable solutions may avoid the abandonment, and subsequent closure, of these structures, by supporting cemeteries to continue operating the burial function and arranging to satisfy the city's burial requests.

As a results of the literature review, the mapping of best practices and a general overview of some cases of best practice, the expected result will take the form of:

1. the systematisation of cemetery structures and main elements to provide a system to analyse burial environment with simplicity and accuracy;

2. an operational tool, for the establishment of sustainable strategies for the regeneration of cemetery structures (Figure 3). This material is encouraged to observe new sustainable concepts without compromising local tradition and culture. In this way institutions, professionals and other stakeholders can have easy access to sustainable strategies related to cemeteries.

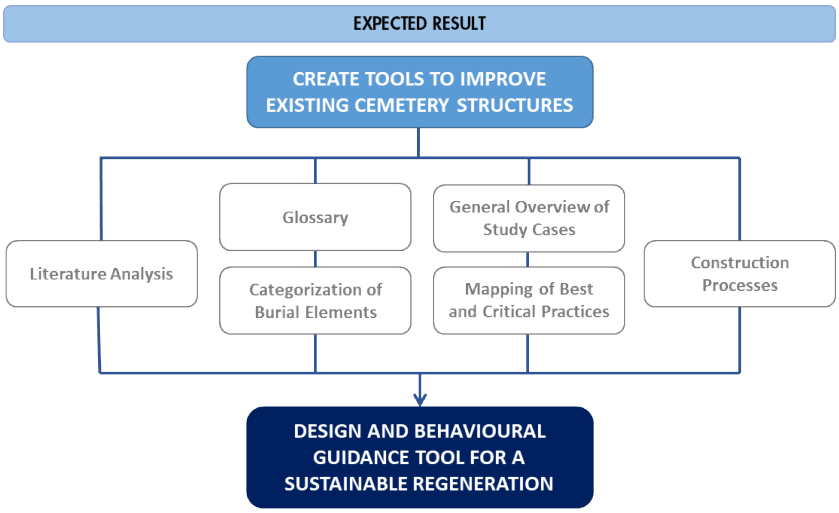


Figure 3 - Synoptic diagram of the expected result.

1.5. STAKEHOLDERS

The research aims to reach different audiences, which, depending on the contexts, enter at different levels into the process of cemetery sustainable regeneration. These targets are:

Administrators and Technical Office: the following research is for those who must interfere in the cemetery structure at a micro-scale (the building) or a macro-scale (the urban space). They may be the technical offices that need to improve cemetery structures or the administrators of municipalities responsible for the management of burial spaces that are interested in regenerating these structures. It is also important to consider the needs of other stakeholders such as, owners, managers and users. The guidance system would allow greater precision in planning, taking into consideration the relationships between the building and all the aspects related to it.

Research Institutions: other subjects to whom this research is addressed are international associations and university research groups that focus on studying cemeteries. Some examples are the Association of Significant Cemeteries in Europe (ASCE), the Cemetery Research Group (CRG) and the Institute of Cemetery and Crematorium Management (ICCM). These entities have long been engaged in research aimed at expanding an understanding of current and past burial culture by studying how social, emotional and religious concerns have interacted with economic and political imperatives to frame burial practice, promoting the cemeteries as a fundamental part of the heritage of humanity.

Every study in this sector must deal with an interdisciplinary framework, in such a way as to recognize the individual constituent elements that compose the funeral subject and, subsequently, collect the information useful for the purpose. Taking this into account, this research provides an interesting tool for recognizing the existing issues and possible solutions inside a cemetery structure, which can be assimilated and used in any other study whose object is the funerary structure.

Professionals: the reality of any profession hardly involves working on cemetery buildings or funerary structures, but over time these structures need to suffer interventions to reconstruct part or entirely of their space. For this reason, this research may reach its proposal by allowing professionals to have access to the guidance system of the regeneration process.

However, it is expected that professionals have a base knowledge of possible interventions inside their area of expertise, even if in practice they may face it just a few times. This research aims to contribute to cemetery studies and even professionals can take advantage of this study not only for professional practice but also for working updates or curiosity purposes.

1.6. RESEARCH METHODOLOGY AND PHASES OF THE RESEARCH

This research requires an examination of real-world contextual perspectives and knowledge affected by cultural behaviours. Therefore, to achieve the expected results, five fundamental methods of data collection and processing (Figure 4) were structured based on an integrated approach that explores qualitative data to generate new understanding and possible solutions for the problem. The qualitative method is more suitable for this research because of its flexibility and subjectivity in data collection, which emphasizes information that cannot be measured in numerical data.

The strengths and weaknesses of this methodology provide a stronger and more robust evidence that supports the set of sustainable recommendations specifically for cemetery structures that this research aims to achieve. The research methodologies are described as followed:

1. Literature Review: reviewing existing data is useful to explore the under-researched topic of cemetery structures, identify key gaps and verify existing theories and studies. For this reason, the first stage of the study concerns the analysis of documents and information acquired from the existing literature, which makes it possible to trace the intellectual progress of the topic of study and to situate this research in relation to the existing knowledge. The data was collected through databases covering broad publications and with a specific methodology to refine the results (described in Subheading 2.1). The material collected is analysed and described with an interdisciplinary framework, useful to guide the other stages of the research.

2. Field Observation: this method aims to gain an in-depth understanding of the object of study, integrating the previous data with descriptive data, personal perspectives and experiences. The data is gathered with observation directly on field (details on Subheading 3.1), including field surveys and direct observation of best practice cases identified as significant. In this case, it gives the possibility to narrow down a broad field of existing data by obtaining a realistic view of existing facilities and their current situation.

3. Technical Visit and Interview: data was also collected through technical visits in existing facilities and interviews. The technical visits were coordinated with managers from selected cemeteries, while the interviews target experts, researchers and organizations. Both were performed through virtual meetings with a quick presentation of the research framework and the latest findings. The difference is that the technical visits had structured questions about sustainable management, while the interviews had a flexible scheme to allow a freely expression from the interviewers. In a second moment, the technical visits counted with a meeting in person at the cemetery, followed by a guided visit to discuss the real context.

The perceptions and suggestions collected contributed in an enriching way to broadening the vision of the field of research. Therefore, it was essential to individualize professionals to collaborate on the interdisciplinary framework (Prof. Rachele Dubbini, UNIFE; Prof. Kostas Sbonias, Ionian University; PhD student Matteo Lombardi; Prof. Alberto De Franceschi, UNIFE; Prof. Claudia Amodio, UNIFE) ; with significant experience in green building's certification (Engr. Marco Mari, GBC Italy; Arch. Luca Magarotto; Prof. Paola Boarin, University of Auckland); and experts on cemetery studies (Prof. Andy Clayden, University of Sheffield; Prof. Julie Rugg, University of York).

4. Existing Sustainable Certifications: there are several sustainable certifications available that provide concepts and tools necessary to address solutions for ongoing policy issues related to sustainability and the acquisition of specific skills regarding sustainable management, functionality and technology. The comparison of the results obtained from the data collected about cemetery topics with information from existing sustainable certifications supported the definition of operational actions for regeneration interventions on cemetery structures (see Subheading 4.1). This method is useful to generalize widely concepts and to assess the solutions aimed by the research.

5. Mobility Programme: development of research activities in a six months period in total, at the Department of Landscape Architecture at the University of Sheffield (UK). The department deals with issues related to the quality of the urban landscape and the enhancement of biodiversity through an interdisciplinary environment. These topics are in perfect harmony with the research, which enabled further discussions with other members of the department on interdisciplinary topics.

The activities were focused on discussions about different aspects of the thesis with Prof. Andrew Clayden from the University of Sheffield, and Prof. Julie Rugg from the University of York. Both were interviewed in a preliminary stage at the interdisciplinary stage, where their experience with the specific research topic were considered a valuable contribution to the research. Once both universities are located close to each other, it was proposed to work together during the mobility programme.

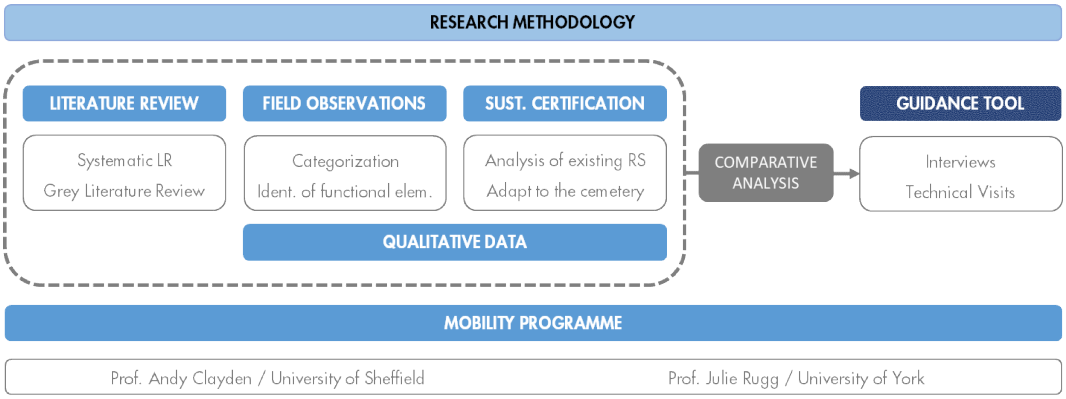


Figure 4 - Synoptic diagram of the research methodology.

The research is divided into four important phases, which summarize the process of investigation related to the methodology described. More than one method may be present in the same phase. The working methods for each phase are outlined as follows:

Phase 1. Definition of the state of the art on sustainability in urban cemeteries (performance of the literature review, systematic and non-systematic, to gather information from previous research, interdisciplinary topics, significant best practices, institutions and documents related to cemetery structures):

- construction of a glossary with the most significant words related to cemetery structures and concepts related to sustainability in urban-architecture areas;
- identification of international best practices, good or bad, for the development of observations;
- investigation of an essential bibliographic and sitographic reference index;
- identification of appropriate contacts and interviewers for the research topic;
- definition of the research framework and table of contents of the thesis.

Phase 2. Analysis of the scientific problem from interdisciplinary aspects (delimitation of the interdisciplinary framework of the research regarding the state of cemeteries, the urban sustainability and the residents well-being):

- identification of the main issues related to cemetery structures divided by macro-topics;
- analysis of existing green building certifications;
- determination of the requirements and objectives for a sustainable regeneration;
- conduction of several interviews with international researchers and experts in the areas of interest;
- draft of the first parameters to be considered for a sustainable assessment of cemeteries;
- evaluation of a preliminary guidance system to apply on cemetery structures;

Phase 3. Investigation of existing assets (deep analysis of the real condition of cemetery configuration using site observations to better understand the context under study and to compare it with theoretical information):

- analysis of the main components of cemeteries through site observations;
- identification of the factors that influence the environmental quality of the cemetery;
- identification of functional elements necessary for the operation of a cemetery;
- classification of cemetery elements divided into four contexts.
- definition of the cemetery characteristics during the mobility programme.

Phase 4. Development of a support tool for the regeneration of cemetery structures based on specific characteristics of the type of building in study (definition of the cemetery sustainable guidance system to support the decision-making process during regeneration processes and promote high levels of sustainability in urban areas):

- evaluation of the cemetery structure using sustainable strategies and indicators;
- connection of sustainable strategies with functional elements;
- determination of operational actions aimed at solving specific critical issues;
- association between operational actions and sustainable indicators in each cemetery's contexts;
- reorganization of the sustainable certification's structure to implement it in a different building typology for which it was initially created;
- definition of the guidance system for the regeneration of cemeteries comparing all the information collected previously.

1.7. OVERVIEW AND STRUCTURE OF THE RESEARCH

This research process describes the tools that cemeteries must follow to become sustainable spaces integrated with the urban structure and the surrounding community. It integrates an interdisciplinary approach with a multiscale design response. The result is composed of four parts divided into five chapters:

Part I. General framework of the research and methodological approach: CHAPTER 1 aims to frame the scientific problem, as well as to declare the objectives, the expected results and the methods in which the research is structured. This part introduces and guides the development of data collection actions, sources and their subsequent processing.

Part II. Characterization of the cemetery structure: this section of the research is composed of two chapters. First, CHAPTER 2 explains the methodology and results of the literature review, including the interdisciplinary analysis with references to cultural, biological and legislative aspects of cemetery issues. The analysis comprises the

historical evolution, the environmental and climatic context, the regulatory reference framework. It investigates the main sustainable measures and practices adopted internationally to promote interventions aimed at regenerating cemetery structures.

To complement the theoretical information, CHAPTER 3 introduces a deep analysis of cemetery structures performed by observations in loco to collect information useful for determining the building heritage. This second chapter investigates the needs, the distribution solutions, the construction technologies and the management process. It defines the components of a cemetery, categorize specific typological elements and functional characteristics for a guiding operation of a cemetery. This phase is essential to define the object of research and clarify some concepts about the field of work.

Part III. Intervention tools and procedures for the cemetery's regeneration: finally, CHAPTER 4 defines the specific actions and operational procedure that defines the guidance system for the regeneration of a cemetery structure. After recovering the contributions developed in the previous parts, it was analysed the objectives and methods of intervention as well as the main factors and the sustainable parameters necessary for this type of building. They were integrated with some existing tools useful to attest the energy and environmental quality of built assets, adopting observations and definitions of the certification framework. With this analysis, the parameters to evaluate the quality of the building and the areas of intervention were identified. Each parameter was elaborated with intervention strategies based on the intentions of the managers and environmental characteristics of the cemetery. The last stage is dedicated to the identification and analysis of international best practices, particularly significant interventions of cemeteries, to obtain important technological and methodological observations about the approach to sustainability. It characterizes the description of the guidance system, a simplified tool which can facilitate the assessment of the functional, management and environmental quality of the cemetery and support the decision making process during the regeneration.

Part IV. Conclusions: in the last part of the research, CHAPTER 5, the results achieved were analysed and the possible future developments of the research were recommended.

In Figure 5 there is a representation of the research structure diagram. Alongside the respective chapters, it is indicated the tools or operational effects that arise.

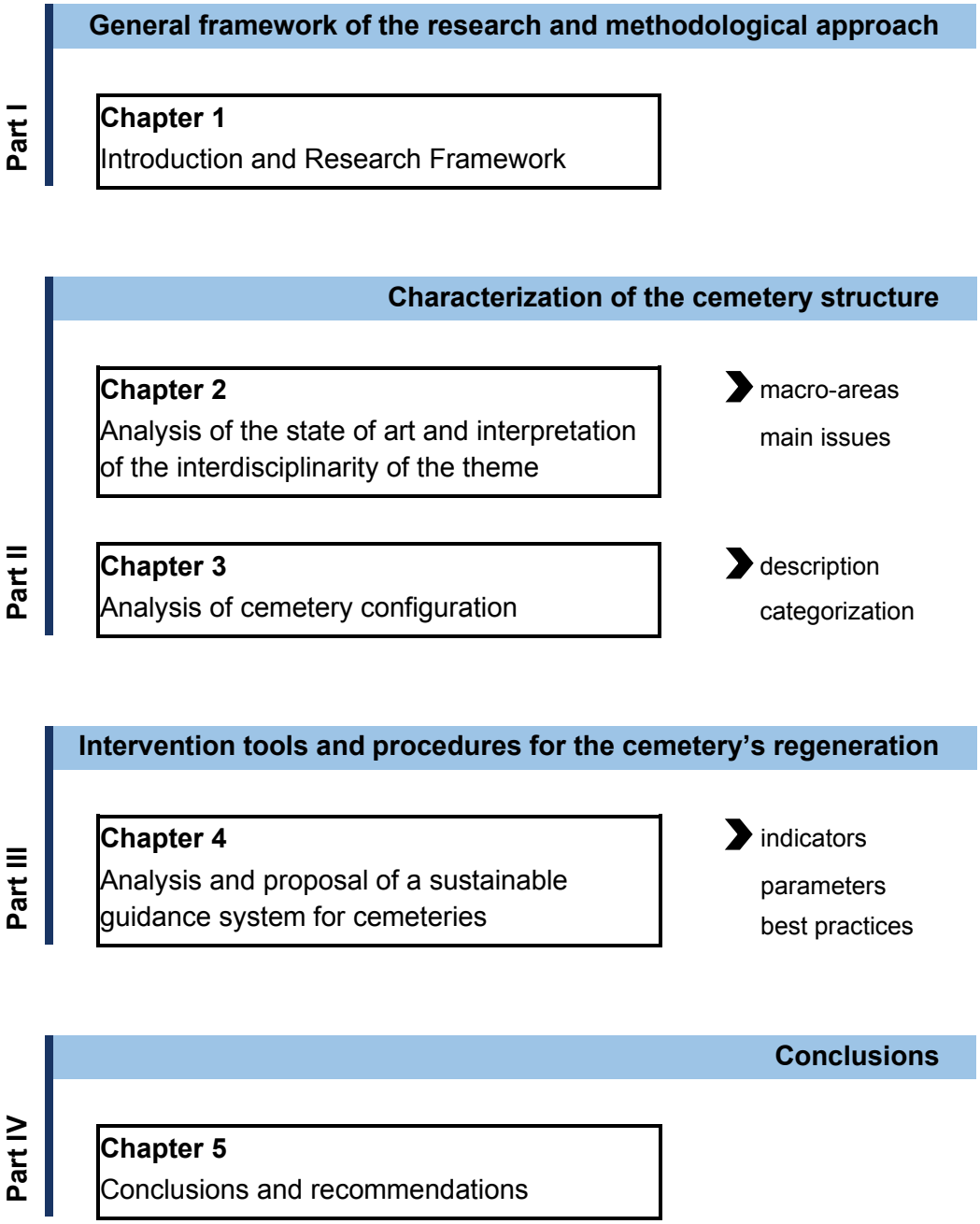


Figure 5 - Synoptic diagram of the research structure.

CHAPTER 2: ANALYSIS OF THE STATE OF ART AND INTERPRETATION OF THE INTERDISCIPLINARITY OF THE THEME

Figure Cover Chapter 2: Entrance building to access the Cimitero Monumentale di Milano (Milan, Italy).

2.1. LITERATURE REVIEW

When discussing about cemeteries, topics can be very broad and vast. They may describe cultural heritage, historical development, architectural manifestations, field innovations, environmental studies, and so on. This background knowledge supports a rich variety of frameworks and tools addressed to deal with specific elements of the context.

On the other hand, a critical overview may indicate that alone those key topics lack in solving the complexity of cemetery issues. Cemeteries are a continuum from culture to infrastructure and as so, they should be studied as a single entity that embraces several aspects. That is why an interdisciplinary approach is recommended for this research, allowing to understand what otherwise would not be able to comprehend in a single disciplinary approach.

As stated earlier, the cemetery topic can be studied from a variety of subjects and it is essential to examine the phenomenon from a wider perspective. When comparing different areas of interest, it was perceived the need to expand the interaction between some of them (Subheading 1.3). The starting point to deal with the cemetery topic was an assessment of the general literature, with the aim to analyse the insights and theories that different disciplines have to offer (1) and to demonstrate how previous research and ideas can be related to contribute to the sustainable development (2).

With an overall understanding of cemetery topics, it is possible to establish the strengths and weaknesses of existing approaches and evaluate how they interact with each other. Therefore, the theoretical foundation in CHAPTER 2 concerns the identification of the current level of development of burial topics and the definition of its relevance in the bigger context related to the research question “how to transform cemetery structures into sustainable urban spaces?”.

At first, it was performed a systematic literature review to identify relevant contributions, synthesize ideas and outline the field of research. The results are in Subheading 2.2, with significant references selected and listed in Table 1, followed by a summary of each entry in a short paragraph and an explanation of its relevance to the research. A glossary with the definitions of key terms (words, concepts and extra information) helped to develop the interdisciplinary structure (see Glossary).

Thinking about the diversity of the sustainable scenario, it was also necessary to analyse where the cemetery structure is framed in the green infrastructure context. For this reason, a review of the grey literature was also performed in Subheading 2.3. Information such as the classification of cemeteries in comparison to other buildings’ typologies and ideas in terms of innovation in the funeral industry were collected and described. Conclusions that emerged from the literature review are in Subheading 2.8. Particular issues and problems are addressed to conduct the research further.

2.1.1. Methodology to refine results - Systematic Literature Review

Cemetery research is a topic mature enough to analyse and synthesize related references through the conduction of a literature review. This literature review follows the concept-centric approach, where “concepts determine the organizing framework of a review” as described by Webster and Watson (2002). This approach is applicable in multiple discipline areas, whether there is a recent literature review, the existing literature review is expired or the literature review does not exist (Järvinen, 2008).

The methods of structuring the review were established following the research scope to deal with the topic from an interdisciplinary approach. Thus, the first decision was to use multidisciplinary databases to conduct the research. The bibliographic databases that best suit this research are Scopus and Web of Science. The reasons are because they have an extensive coverage of items and share common features in their search engine, which allows for setting the same work boundaries (Gasparyan et al, 2013). The boundaries to refine the results were defined by the following criteria:

- specific subject area or research areas (selected to be interdisciplinary): for Scopus ("*Environmental Science*"; "*Social Sciences*"; "*Arts and Humanities*" intend as built heritage (Ruggeri, Gabrielli, et al., 2020); "*Engineering*"; "*Energy*"; "*Materials Science*"; "*Chemistry*"; "*Multidisciplinary*"; "*Computer Science*"; "*Business, Management and Accounting*" and "*Economics, Econometrics and Finance*") and for Web of Science ("*Architecture*"; "*Arts Humanities Other Topics*"; "*Urban Studies*"; "*Art*"; "*Anthropology*"; "*History*"; "*Social Sciences Other Topics*"; "*Cultural Studies*"; "*Operations Research Management Science*"; "*Engineering*"; "*Construction Building Technology*"; "*Business Economics*"; "*Chemistry*"; "*Computer Science*"; "*Environmental Sciences Ecology*"; "*Biodiversity Conservation*"; "*Materials Science*"; "*Public Administration*");
- appropriate document type: for Scopus ("*Article*"; "*Conference Paper*" and "*Review*") and for Web of Science ("*Article*"; "*Proceeding Paper*" and “*Review Article*”);
- international language: documents written in “*English*”;
- no geographic or temporal boundaries were considered (aimed to be international).

The keywords were chosen to narrow the focus of the review to three main topics, and were searched through “*documents title, keywords and abstract*”. They represent a crucial research topic according to the research question: specific cemetery keywords; sustainability keywords; and urban keywords. At the end they were combined with Boolean Operations and organized as “*Group 1*” AND “*Group 2*” AND “*Group 3*”:

- Group 1: words related to cemetery, correlated structures and synonyms ("*cemetery*" OR "*burial**" OR "*charnel house*" OR "*graveyard*" OR "*graveside*" OR "*sepulch**");
- Group 2: words related to sustainability, ecology and general improvement ("*sustainab**" OR "*recycl**" OR "*environment**" OR "*conservat**" OR "*preservat**" OR "*restorat**" OR "*green**" OR "*ecosystem**" OR "*enhanc**" OR "*performance*");
- Group 3: words related to urban areas, urbanization and urban planning ("*urban**" OR "*plan**" OR "*develop**" OR "*expansion*" OR "*transform**" OR "*land use*" OR "*landscape*" OR "*city*").

The last boundary is the level of analysis to determine the selection of the most relevant publications that should be included in the review. Common key aspects were identified from a sustainable point of view: identify the main problems related to the cemetery structures in urban areas (1); evaluate management methods from a sustainable point of view (2); identify shared approaches to sustainable practices (3).

2.1.2. Statistical analysis of results - Systematic Literature Review

An analysis of the findings from the systematic literature review revealed that the results were related to a variety of perspectives about sustainable cemeteries located in urban context. The review leads to 2.023 document results from Scopus and 1.264 results from Web of Science Core Collection. Significant information was obtained from both databases and a preliminary analysis was performed following the information from Figure 6 to Figure 9 by comparing the results obtained.

Starting with the time distribution of the documents, Figure 6 shows that publications started to appear around 1934. However, the real growth in the number of documents related to the topic of sustainability in urban cemeteries took place in the 90s. It is important to notice that the internet development occurred around the 80s and the 90s, which makes it difficult to find older documents using only online search. For some subject areas those references may be considered out of date (e.g. construction technics, legislation), but for others it may be a rich source of information (e.g. cultural and historical aspects).

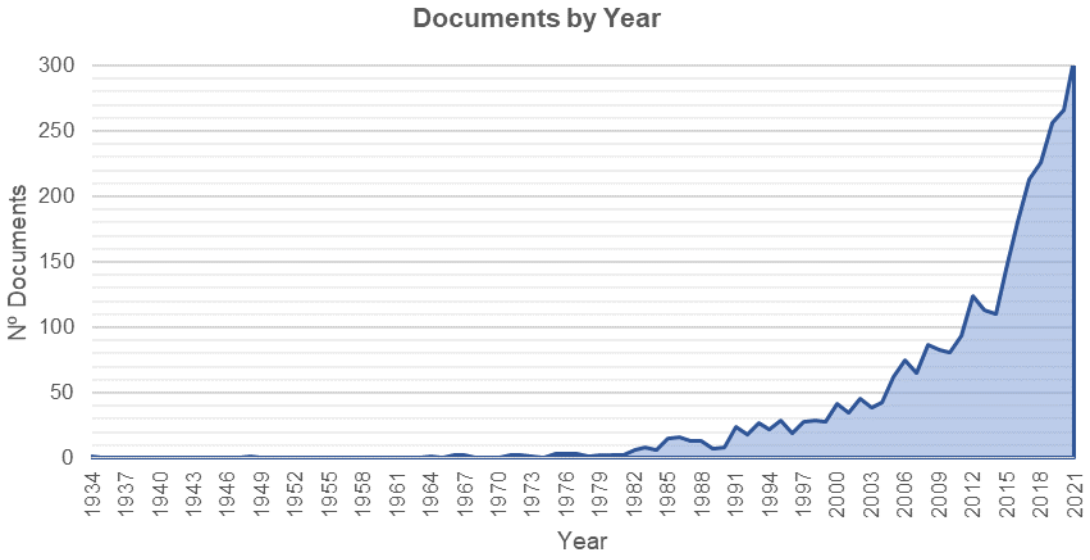


Figure 6 - Division of documents by year on sustainable urban cemeteries (it includes data until December 2021 extracted from Scopus and Web of Science databases).

In Figure 7, it shows the geographical distribution of the documents. The complete list comprises more than 100 countries, but for this analysis the first 20 countries with the most affiliated documents were examined. The results shown that European countries are predominant is terms of sustainable urban cemeteries topic (1159 documents in total), followed by United States (887 documents) and China (447

documents). The countries with less than 100 affiliated documents are India, Russian Federation, Japan, Malaysia, Mexico and Brazil.

During the literature review, relevant documents were found to be affiliated to United Kingdom. Once it is the third country with most documents, it contributed to choosing the country for a mobility program period of six months in the next phases of the research.

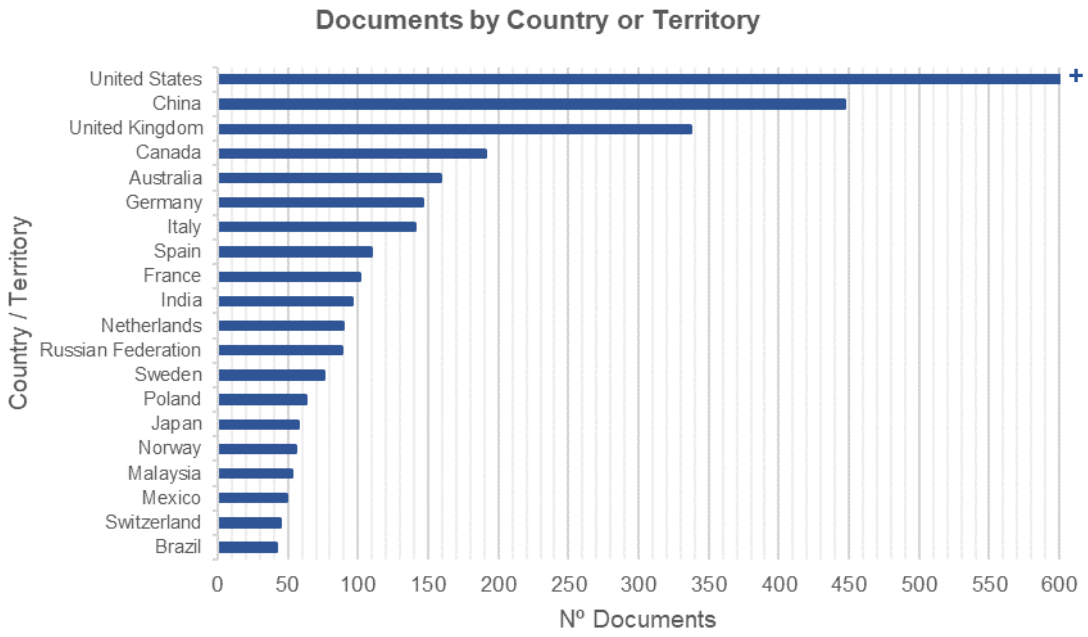


Figure 7 - Division of documents by country or territory on sustainable urban cemeteries (it includes data until December 2021 extracted from Scopus and Web of Science databases). The original data for the United States category is 887 documents, the graphic was compress to allow a better comparison between the subsequent categories (Country/Territory).

About the type of documents, the majority of the documents are article papers (83%), including a small portion of review articles. Just a few documents are presented on conferences, seminars and other events (17%), which means that the topic is not very diffuse in discussions of common interest. These data are illustrated in Figure 8.

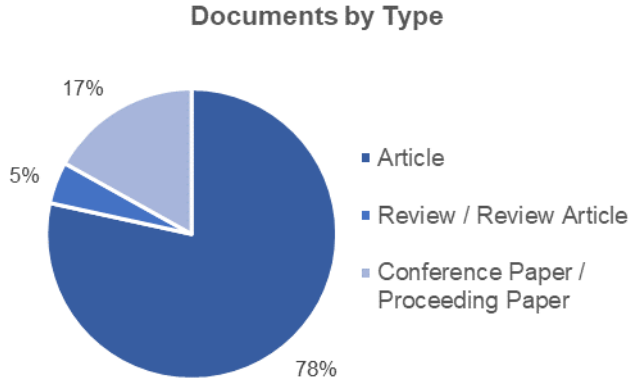


Figure 8 - Division of documents by type on sustainable urban cemeteries (it includes data until December 2021 extracted from Scopus and Web of Science databases)

Finally, in Figure 9 the documents are identified by the subject areas previously used to limit the research approach of the systematic literature review. Some of the main topics of this research are connected to the subject areas with most number of documents: Environmental Science, Ecology, Biodiversity Conservation; Engineering, Construction Building Technology; Social Sciences, History, Cultural Studies; and Arts, Architecture, Urban Studies. While legislative and management aspects are less represented in this analysis. The other subject areas were selected because of their rich contribution to the research based on interdisciplinary framework.

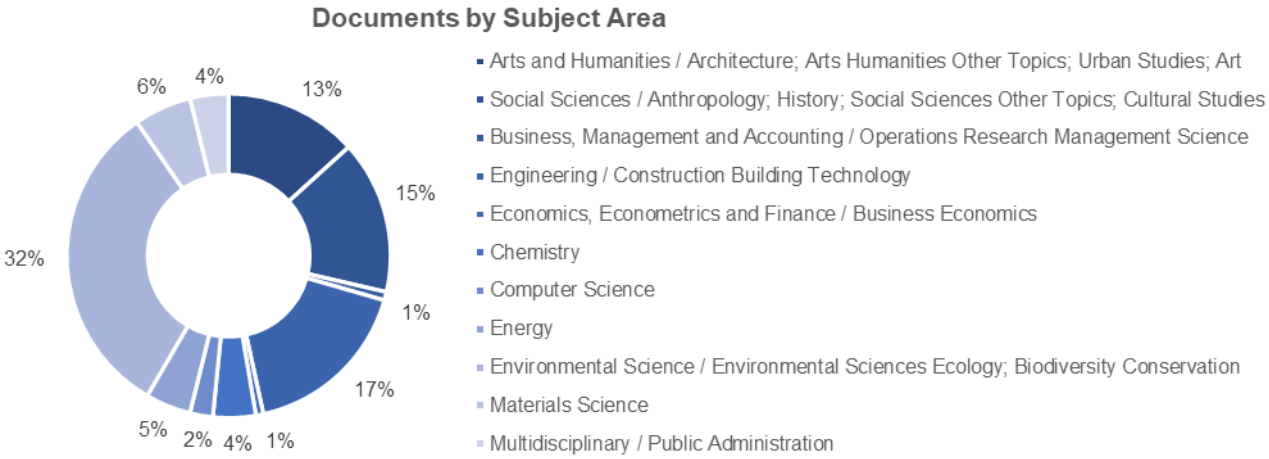


Figure 9 - Division of documents by subject area on sustainable urban cemeteries (it includes data until December 2021 extracted from Scopus and Web of Science databases).

After analysing the documents retrieved from the systematic literature review and narrowing down the results, the subject areas are dipper identified in Subheading 2.2 through a literature review concept matrix. A first description of the interdisciplinary framework of the research is presented dividing the findings into three broad topics: Cultural Heritage and Architecture-Urban; Environmental and Ecological; and Legislative and Management.

2.1.3. Methodology to refine results - Grey Literature

Although difficult to develop a systematic search, grey literature gives relevant information about the current situation of cemetery structures. The aim is to increase the comprehension about the cemetery topic and balance the literature review with the real context. It is a complementary strategy that results in the identification of extra evidences that contributes to the research topic.

The development of the grey literature review includes the collection of data from specific websites with international impact (ArchDaily and Architizer) and the systematisation of the data into tables. In this phase, data was collected on the classification of cemeteries inside the construction context. Discussion and observations about the grey literature review are described in Subheading 2.3 and it will contribute to further analysis in CHAPTER 3.

Several other grey literature were consulted, such as government and technical offices reports, newspapers, websites from private companies related to cemetery services and any document from organizations and stakeholders from interest. Because this data is diffused in the interdisciplinary field, it will essentially support the framework of Subheading 2.5, Subheading 2.6 and Subheading 2.7, but it will also impact some aspects of CHAPTER 3 and CHAPTER 4.

2.2. RESULTS OF SYSTEMATIC LITERATURE REVIEW

The analysis of the results from the systematic literature review is meant to identify the main topics discussed about cemeteries and the ones that are missing. After screening the first 100 results by title and abstract, eight documents were considered related to the topic. These results were useful to group existing perspectives into the interdisciplinary themes described in Subheading 1.3.

After reviewing and synthesizing the literature across disciplines, a concept matrix was compiled with information from the selected documents (Table 1) and a discussion was presented comparing the information according to a review matrix. Although these themes can cover a wide field of research, only aspects in support of the research question were considered relevant. First the topics from the documents analysed were separated into the following aspects:

- Cultural Heritage and Architecture-Urban Aspects;
- Environmental and Ecological Aspects;
- Legislative and Management Aspects.

On the interdisciplinary literature that will be discussed in Subheading 2.5, Subheading 2.6 and Subheading 2.7, several documents were added to the previous data. They were found through the reference lists analysis of the reviewed studies and extended to bibliographic databases, non-electronic sources and grey literature.

All the documents analysed highlighted the problems related to urban sprawl and the difficulties that cemeteries located in urban areas are facing. The main issue is the need to expand the land of overcrowded cemeteries to allow new burials, which in many cities it is already a contemporary problem. Burials inevitably occupy space and depreciate the immediate urban surroundings, which could be used to satisfy the urban demand for space. One way to start facing the problem is to calculate the area that a particular city has to provide to attend the burial demand. This analysis depends on the death rate and the dimension of the burial space, as illustrated by Hariyono (2015), and it should consider a plan for future cemetery development.

The need for valuable land to deal with the city's expansion is incompatible to the perpetual use of cemeteries once "land use is a serious contemporary issue, inhumation cannot be ignored as a contributor to it" (Scalenghe & Pantani, 2019, p. 5). Hariyono (2015) states that verticalization is an alternative to optimize the land occupation in urban areas, which could be a challenge for cemetery structures. However, using the right technology and promoting the social acceptance of verticalization in certain building typologies, it is possible to improve burial spaces.

Besides the problems related to urban context, Scalenghe and Pantani (2019) describe an exhaustive background of issues that burial sites are facing nowadays from cultural, religious and environmental perspectives. They resume burial traditions from different religions and explain how each believe influence the cemetery structure. Some of the funeral and burial traditions analysed are Catholic Church, Protestantism, Eastern Orthodox Church, Judaism, Islam, Hinduism and Buddhism (Glazer, 2016; Hariyono, 2015; Scalenghe & Pantani, 2019).

The influence of cultural aspects on the cemetery planning is accurately interpreted by Leuta (2019), that analyses a case in South Africa where the cemeteries are still planned in a conservative way. The author propose to regenerate cemeteries to become multifunctional spaces, as McClymont (2016) and Anna & Ewa (2020) also stated, but there are cultural practices and religious beliefs that prevent the implementation of alternative infrastructure within cemeteries. These barriers influence from users to the local authority (Leuta, 2019; McClymont, 2016).

Other publications emphasize the importance of the cemetery to society as a place of memory and culture heritage. McClymont (2016) collected narratives from cemetery managers in United Kingdom about “civic identity and local place attachment” to interpret the multifunctionality of cemeteries in the city and illustrate behaviours that are considered appropriate (or not) within the cemetery, cited also by Leuta (2019). On the other hand, Hariyono (2015) highlights the importance of respecting personal beliefs and burial rites, predominant in the site area, during the strategic planning of a cemetery because the “combination of religion users will be an attempt to embrace different society group” (Hariyono, 2015, p. 212).

From the environmental perspective, seven out of the eight articles in the concept matrix discuss environmental and ecological aspects, which indicates it as a critical topic. Neckel et al. (2017) introduced the theme of the decomposition process of organic matter that occurs within the cemetery and performed an analysis of soil contaminants in an urban cemetery in the south of Brazil. They carried out a physicochemical and microbiological analysis and compared the results with recommended limits by the Brazilian law. The results concluded that many parameters exceeded the acceptable levels, which could represent a danger not only for the environment, but especially for inhabitants living close to the cemetery. The authors recommended a greater maintenance of the burial space to avoid percolation of harmful substances.

In addition to their recommendation, there are other possibilities that could contribute to avoid environmental contamination. Harker (2012) analyses the process at an earlier stage, the funeral process. Contemporary funeral practices uses embalming fluids and concrete vaults, which requires a high maintenance of the cemetery landscape. The author encourage the replacement of contemporary funeral practices by natural burial practices. It is described also by Scalenghe and Pantani (2019), which used the term “green funeral” as a sustainable funeral process.

Scalenghe & Pantani (2019), Leuta (2019) and Anna and Ewa (2020) suggest a new vision of burial sites as green spaces and ecological corridors to integrate the cemetery with the urban green infrastructure. Green cemeteries are easily connected with social interactions (Leuta, 2019) and contribute to increase biodiversity, wellbeing and quality of life for citizens. McClymont (2016) agrees with the benefits of having cemeteries as green infrastructures, but when managing cemeteries there were reported conflicts between wildlife, conservation strategies and visitors.

The legislative and management aspect of cemeteries was the last to be analysed, because it is the aspect less mentioned in the documents selected. According to McClymont (2016), “there is limited policy or research at local or national level to guide the planning of cemeteries, crematoria or other spaces of death, bodily disposal and remembrance” (McClymont, 2016, p. 1). Most of the topics were related to the management of burial spaces, which makes difficult the implementation of certain strategies because of cultural restraints (Leuta, 2019; McClymont, 2016).

Another topic was the cost of funeral and burial processes. McClymont (2016) and Leuta (2019) analyses the commercial aspect of cemetery landscape as the source of income for management costs, for Harker (2012) the cemetery is a “business”. Some managers use the burial’s price to encourage sustainability by reducing the price of greener solutions, while in some cases there are regulations that can incentive ecological and cultural aspects (Harker, 2012; McClymont, 2016).

Other authors compared their research results with local legislations (Anna & Ewa, 2020; Neckel et al., 2017), proving the inefficiency and the need to update laws related to cemeteries. The fragmentation of departments responsible for cemeteries and it legislations was also highlighted in some documents (Harker, 2012; Leuta, 2019; McClymont, 2016).

Innovations on burial practices and alternative constructions developed over time were also reported during the literature review. Scalenghe and Pantani (2019) and Harker (2012) suggest cremation as an option to traditional burials for the advantage of saving space inside the cemetery and preserving available urban land. However, from the environmental perspective cremation also contribute to pollution and contamination of the environment.

An “ideal cemetery” was proposed by Neckel et al. (2017) represented by a vertical cemetery and illustrated by Hariyono (2015) through proposed designs and built structures. The general description of the vertical cemetery structure tries to solve environmental issues and includes also strategies to improve wellbeing and accessibility. An alternative that is being implemented in Jerusalem is that of an underground cemetery, a pilot project described by Glazer (2016) with a multilevel burial site similar to a vertical cemetery in concept but with more technical issues. Located under an existing cemetery, the project aims to be a respectful solution for the lack of space for new burials in confront to local traditions and beliefs.

Table 1 - Literature Review concept matrix divided by interdisciplinary aspects with insights on each of them identified during the literature review.

PUBBLICATION TITLE	CASE-STUDY	CULTURAL HERITAGE AND ARCHITECTURE-URBAN ASPECTS	ENVIRONMENTAL AND ECOLOGICAL ASPECTS	LEGISLATIVE AND MANAGEMENT ASPECTS
Connecting existing cemeteries Saving good soils (for livings) (Scalenghe & Pantani, 2019)	-	Analysis of burial practices according to different religions and their influence on the burial site distribution. Analysis of urban land use issue and introduction of cemetery structures in this context.	Interpretation of “green funeral” and “green cemeteries”. Development of a planning to transform cemeteries in ecological corridors and green belts.	-
Environmental damage and public health threat caused by cemeteries: A proposal of ideal cemeteries for the growing urban sprawl (Neckel et al., 2017)	Central Cemetery of Marau (Marau, Brazil)	Proposal of vertical cemetery as the ideal structure to cemeteries in order to avoid contamination of the environment	Biological, physical and chemical analysis to evaluate the contamination of soil inside the cemetery perimeter	Comparison of three international legislation for cemeteries: - international law for cemeteries; - Cemetery Care Act (USA); - Resolution 335 of April 3, 2003 from National Environment Council (Conama / Brazil).
How to enhance the environmental values of contemporary cemeteries in an urban context (Anna & Ewa, 2020)	Municipal cemetery (Gniezno, Poland)	Proposal of a new cemetery with integration of solutions related to the natural and cultural environment	Development of a pro-environmental solutions catalogue for cemeteries.	Analysis of national legislation for cemeteries in Poland: - Act of 31 January 1959 on Cemeteries and Burial of the Deceased; - Regulation of the Minister of Municipal Economy of 25 August 1959 on determining which areas are suitable for cemeteries in terms of sanitation; - Regulation of the Minister of Infrastructure of 7 March 2008 on requirements for cemeteries, graves, and other places for burial; - Building Law Act of 7 July 1994; - Act on Nature Conservation of 16 April 2004.
Reviving burial in tunnels (Glazer, 2016)	Minharot Olam (Jerusalem, Israel)	Explanation of a pilot project under construction to expand an existing cemetery with burial techniques compatible with the local culture and religion	-	-
‘That eccentric use of land at the top of the hill’: Cemeteries and stories of the city (McClymont, 2016)	England and Wales	Implications about the role of cemetery structures in relation to the urban context as a place of memorialisation, cultural identity and religion attachment.	Conflict between the green infrastructure characteristics, grief/mourning services and cultural heritage aspects of cemeteries.	Financial aspects of cemeteries: burial plot, memorials, funeral services, maintenance and other services.
Landscapes of the dead: An argument for conservation burial (Harker, 2012)	United States of America	-	Description of environmental contamination from contemporary funerary practices and from cremation. Comparison between traditional burial, natural burial and conservation burial practices from an ecological and public health point of view.	Urban planners as promoters of ecological spaces by including cemeteries during policy decisions. Costs of traditional burials, conservation burial and cremation.
Vertical Cemetery (Hariyono, 2015)	-	Comparison of different religious and funeral traditions aiming at combining all of them in an integrated space. Analysis of the vertical cemetery structure as an alternative to extend the land without consuming valuable urban land.	Promotion of public green spaces as elements that contribute to the contemplation of the cemetery landscape.	-
Institutional perceptions and barriers to multifunctional cemeteries (Leuta, 2019)	City of Johannesburg (South Africa)	Influence of local community perception related to the use of burial spaces, creating conflicts during the regeneration planning of cemetery structures.	Integration of green infrastructure in the cemetery design to increase urban ecological benefits and improve the wellbeing of visitors.	Issues such as fiscal constraints and cultural beliefs influence on decisions pro multifunctional cemeteries.

2.3. RESULTS OF GREY LITERATURE REVIEW

Construction typologies varies according to social formations and receives different classification depending on the community under analysis. But a general classification based on the main use of the built space could be interpreted as being divided mainly into domestic, religious, governmental, recreational, educational, commercial and industrial types.

There is some difficulty thought to frame the cemetery into one of these categories. Sometimes they are considered religious places or infrastructures, sometimes even as open and green spaces. The cemetery function is better discussed in Subheading 2.7 but to complement this analysis two international websites were consulted to see how the grey literature frames the cemetery structure (Table 2). It is important to notice that the information was retrieved on May 2020, and due to the source being a grey literature, it can easily change over time.

Table 2 - Construction categories extracted from ArchDaily and Architizer websites (retrieved on May 2020). Here is represented only the categories related to the cemetery structure highlighted in grey.

Construction Typologies - State of Art				
ArchDaily Categories			**Architizer A+ Architecture - Typology Category**	
Religious	Worship	Churches Chapel Temple Monastery Mosque Praying Room Cathedral Synagogue	**Cultural**	Museum Gallery & Exhibition Spaces Hall / Theatre Pavilions **Religious Buildings & Memorials** Unbuilt Cultural
	Burial	Memorial Centre **Cemetery** **Crematorium** Crypts & Mausoleums **Grave**		

After analysing all the categories from each website and selecting the desired data, it sustained the different categorisation that cemeteries received depending on the source. For ArchDaily there are two types of “Religious” spaces, those for “Worship” and those for “Burial” services. Cemeteries in this case are considered in the last type, as well as crematorium, crypts, mausoleums and graves. Instead, for Architizer cemeteries are contemplated in the “Cultural” category, inside “Religious Buildings and Memorials”.

Cemeteries can be framed in both ways, but this research aim to analyse these structures in a way that they receive attention from a sustainable point of view. In this matter, major contributions are likely to occur when this structures are seen as multifunctional spaces rather than exclusively religious spaces. Therefore, the propose is to consider cemeteries as infrastructures with the primary function to serve the community as burial space with secondary functions such as religious, cultural and recreational activities.

Following the categories previously analysed, in Table 3 the cemetery structure was relocate in the "Public and Civic Buildings", within its own specific "Burial" type. This proposal intend to highlight the importance of this structures to society just like other infrastructures necessary in an urbanized area, as well as to expand the knowledge about environmental and social impacts.

Table 3 - Proposal to include the cemetery structure within the "Public and Civic Buildings" category, extracted from ArchDaily and Architizer websites (retrieved on May 2020). The cemetery structure is highlighted in grey.

Construction Typologies - Proposal		
Main Category	**Secondary Category**	**Subcategory**
Public & Civic Buildings	Government	Town & City Hall Municipal Building Other Public Administration Buildings Courthouse Embassy Ministry Building
	Security	Fire Station Police Station Emergency Services Facility
	Military	Headquarters Fort Training Facility
	Community	Community Centre
	Monuments & Memorials	Memorial Centre Memorials
	Burial	**Cemetery** **Crematorium**

2.4. METHODOLOGY FOR THE REORGANIZATION OF INFORMATION

The methodology used to process data started with the data collected from the Literature Review and the reorganization of the contents into the interdisciplinary topics described in Subheading 1.3 about the research framework. The bibliographic survey

consisted of the search for publications relating to the subject matter in order to obtain observations, data or current trends. These topics are highly related to the cemetery issues and intersect with each other, thus they are analysed together to give an overview of the problem, instead of contemplating fragmented views on the topic in question.

Another important contribution to this analysis was direct interviews with several experts from interdisciplinary areas and those responsible for the decision process. This type of survey is based on oral answers and free declarations to questions relating to the topics covered. Data were also acquired from observations on the dynamics, needs and priorities in the redevelopment by some managers. Finally, Subheading 2.5, Subheading 2.6 and Subheading 2.7 aimed to interpret the discussion concerning different perspectives, as well as identify criticalities and potentialities.

2.5. CULTURAL HERITAGE AND ARCHITECTURE-URBAN ASPECTS

Burial practices represent a significant component of human evolution and part of a cultural process between society and its existence. Cemeteries exist for as long as human history, however, at first, they were considered more as sacred places embedded in symbolism than formal infrastructures. Various indications of funerary behaviour have been found around the world, from prehistorical burials where the dead body was simply placed inside an excavated hole in the ground (Martinón-Torres et al., 2021), to monuments and different types of burials as we know today.

Many cemeteries that we know today were prestigious constructions when they were designed in terms of functional organization, architectural features and historical value. In this context, social and cultural changes related to the attitude toward death redefined these structures in contemporary society and this particular phenomenon is responsible for the current state of cemeteries. Issues have arisen associated with the lack of space for new burials and the abandonment of burial spaces, and as in many situations, it is extended to the entire structures inside urbanized areas.

Cemeteries tell the history of an entire society represented by memories, objects and intangible beliefs and practices. The cultural heritage of a cemetery is directly related to its architectural structure and it is not possible to analyse them separately. Thus, it is fundamental to analyse these aspects so that the regeneration process of cemetery structures has all the tools to promote access to cultural diversity and encourage a sense of belonging from the community while supporting a sustainable management.

2.5.1. Cemetery as cultural heritage and social function

Cemeteries are structures intended to accommodate the natural process of transformation of the corpse with an architecture where the living are confronted with death and this relationship is incorporated with symbology. Death is a mythological figure that has existed in popular culture since the dawn of man. The idea of the infinite, of the restlessness of eternity and the fear of the unknown, are impressive symbols of the sensation of the imminence of departure, something entirely explored in funerary architecture. Its journey through time can be read as a process of cultural order developed by social groups and their interrelationship with human existence and its

finiteness. In this case, culture, as a category of analysis, is conceived according to the perspective that certain societies elaborate and share symbols, signs, practices and values as expressions and translations of reality.

Archaeologists have discovered ancient burials dated between 90,000 and 130,000 years ago that prove the existence of prehistorical behaviour towards death. Several evidences indicate that burials did not happen accidentally or casually, but despite being seen as a natural passage in life, it appears that early humans demonstrated the “sense of death and the need to mark it in some way, especially when it happened in an unnatural way such as through trauma or the death of infants and children” (Martinón-Torres et al., 2021). Unfortunately, archaeological evidence is not enough to determine if ancient humans believed in life after death or if it was present in some form of religion during the burial rites. Distinct features related to the placement of the body, the preservation of the skeleton and the stratigraphy of the ground help to recognize if the practices had funerary intentions and demonstrated the care of the lost a closed person.

To better analyse the cultural topic of cemeteries, the research limited its analysis to the Western world, oriented by the Catholic culture, where the spaces intended for the dead undergo constant changes over the centuries. Researchers have highlighted the connection of cemeteries with local cultures from a historical and cultural point of view. Ariès (1975, 1991), Ragon (1986a) and Vovelle (2000) are responsible for many studies about the changes in the place for the dead over time. Already Morin (2014) studies the anthropological and human need to believe in the transcendence after physical death that generates a series of explanations and beliefs about the meaning of dying.

The space of the dead remained a symbolic extension of religiousness and transcendental values but what was once accepted and known as an inseparable part of life, started to be seen as something to avoid. Situations such as death superstitions create the desire to move away from the space intended for the dead and this new way of seeing the spaces of the dead leads to the start of a long process of secularization. Although the separation of the cemetery from the church was not enough to promote a break between death and religiousness, over time religious institutions lost control over the graves. At this moment death is denied in modern society and secularization functions as an artifice of detachment from death and its religious rites.

The secularization of death is a result of the denial of the spirituality around death. Not so long-ago death was seen in a familiar way, where it was a habit to die at home with the family reunited. It was a moment of farewell, but mass and consumer society has made the image of the young person a metaphor of healthy life, and as a consequence ageing has begun to be seen as a passage with death as its final destination. Death now takes place in hospitals, no longer at home. The world is permeated by these rational values, the enhancement of the present time and the accumulation and consumption of material goods.

Death begins to characterize a complete finitude and detaches itself from the explanations of life after death and the continuity of man. The cemetery thus becomes a place of neutrality. The expression "ecumenical" establishes a religious equality favourable to the creation of a neutral space, therefore favourable to the reception of any religion and, consequently, it distances itself from religious symbols. It creates a physical detachment from the symbol, and in turn ends up compromising the memory of a given community, being transformed into space without identity.

Fear and denial before finitude lead to an architecture for the dead transformed into a simple refuge for the disintegration of human matter. The spaces for prayer, despite the religious aura, present only a few remnants of a distant past related to the sacralization of death. Cemeteries are places with an important role in society and a structure that will always exist, even if contemporary society wants to ignore death. Several burial spaces are permanently maintained inside a cemetery because of their historical and artistic value, which in many cases does not allow the reuse of the burial space. This factor can lead to the valorisation of local tourism, but at the same time, it can increase the risk of abandonment of the sepulchres and increase the problem of lack of space in overcrowded cemeteries. Thus, because it interferes directly with the burial system, it is important to consider the amount of protected heritage inside a cemetery.

2.5.2. Evolution of building's heritage and its role in the urban structure

The act of venerating the dead, as we know it today, was born in the middle of the first century, when Christians began to visit the tombs of the martyrs in the catacombs to pray for those who died without martyrdom. The valorisation of the martyrs' cult, granted by the ecclesiastical institution, created the idea that being buried near these tombs meant protection for the moment of awakening. So, the first public buildings to store the corpses were the Christian catacombs, where the tombs to bury the dead were built on the walls of the underground tunnels.

This practice of burying in sacred soil, as the space of cemeteries was considered from religion, has expanded throughout the Middle Ages and many cemeteries located in open spaces began to rise near churches. It was also believed that the physical closeness between the body and the divine images contained within churches represented a pattern of spiritual continuity between the human being and God. In this way, being buried inside the church was a way to avoid a total break with the world of the living. However, not everybody could afford to have their bodies buried in these places, which were reserved for the richest or those who influenced the local society.

In the Middle Ages, death was considered a family and community matter. It was an experience expected with resignation from he who believed in the perspective of the eternity of the soul, where death announced its closeness through dreams and omens. This premonition was naturally accepted by the people who worked to ensure that the passage was carried out according to the will of the "dying".

So, churches were used more and more as cemeteries, creating a society where the living and the dead lived together, located in the heart of the city. The cemeteries were more than necropolises, they were places of social activities completely integrated into the community for socialization and coexistence. Cemeteries generally did not have walls, gates or even large burial spaces, so as not to cause oddities and inequalities among the living and in such a way that they could be enjoyed as peaceful spaces where individuals could carry out a silent dialogue without denying themselves to the surrounding world. This way, individual tombs became rare during the High Middle Ages, when it was not considered necessary to specify the burials or to identify them from some inscriptions. Inside churches the burial spaces were recycled, and bodies were placed in the same space without any identification.

Over the years, the space within the churches have become scarce, reaching saturation in the second half of the 14th century, when the Black Death devastated Europe, killing thousands of people in the period of a few months and leaving the cemeteries crowded. The only way to solve this problem was to bury the bodies in the outer courtyard of the churches, leading to the creation of cemeteries around churches. This mortality crisis in the late Middle Ages has interfered with death-related behaviour since at times of fatality men have relieved themselves from performing funeral rituals.

More significant transformations regarding cemeteries occurred in the first half of the eighteenth century when rituals were brought out from inside the churches and transferred to the intimate circuit of the family where the dead started being veiled at home. A new interpretation of death was then developed, that is romantic death. In this case, the arrival of death was seen and believed as a moment of reunion, of reconnection with the deceased relatives. These transformations in the consciousness and attitudes of men led to a more dramatic and personal conception of death. Indeed, this attitude was accompanied by the redefinition of the notion of ritual and the intensification of the individualization of the burials, once a privilege of nobility and clergy.

At that time the bourgeois desire to impose the organization and the rules on space was a common attitude, and this is how the concept of perpetual burial was born, initially assigned by the bourgeoisie, because of the possibility of burying several people in the same grave seemed unpleasant and even disrespectful, given the impossibility of recognition of the individual body. However, the perennial character of the tomb generates the problem of lack of space as it prevents the rotation of land use, reducing the possibility of areas for new burials.

Furthermore, medicine developed new important hygienic criteria, which advised the detachment of the cemetery location and from the living spaces. This thought, developed mainly in Germany, was based on the concern of some doctors about the problems caused by the bodies that were in the process of decomposition, as vapours or smoke emanated from the tombs, affecting the air and directly interfering with the health of living human beings, also being the cause of some types of diseases. From this new perspective, the presence of the dead started to feel uncomfortable and began to pose a danger for the living. The eighteenth century changed the mentality of death: it is the rise of death medicalization, of the sanitary and secular measures that determined the new human conception in relation to cemeteries.

In this period, the increase in population was another factor fostering the changes in the cemeteries. In London, the situation became critical in the early nineteenth century, when the city's population doubled, exceeding 2.3 million inhabitants. Until then, burials occurred in small parish cemeteries, which quickly became overcrowded, bringing the decomposing matter to reach the aquifer and causing epidemics.

Because of these two factors, the increase in population and the sanitary discourse, cemeteries started to be built outside the urban perimeter and far from the city. When the idea of building cemeteries in remote places was born, the risks and damages that the burial could cause to health and the environment had not yet been defined. Therefore, lands of low financial value were used for the construction of new cemeteries, neglecting any geological or hydrological study. It is important to state the fact that this phenomenon occurred in big cities that were facing these problems and not all churchyards were closed with the hygienist discourse. In some countries, for example, UK and Brazil, churches have continued to manage cemeteries in less urbanized areas.

From this point on, the monumental cemetery criterion was established, a type of cemetery close to the current cemetery concept. In the nineteenth century, cemeteries assumed great importance in the visionary imagination of architects, and it is during this period that the great projects of urban cemeteries were born as they are known today. The central cemeteries of Vienna and Stockholm, as well as the cemeteries of Père Lachaise, Montmartre and Montparnasse in Paris, are all dated to the early 19th century.

Cemeteries became privileged resting places, wild places rich in monuments capable of receiving all the homages of family memory and civic respect. A cemetery can be considered a second home, where the tomb is the house and the cemetery is the projection of a neighbourhood, a village or even a city. Cemeteries reproduce the architectural and landscape elements present in the cities, in which the socio-economic order of the living is reproduced. This urban morphology is clearly reflected in the cemeteries of the eighteenth and nineteenth centuries, from the construction of roads, blocks and lots (formed by burial spaces). The morphology of the city is reflected in the structure of the cemetery, and these resemble each other in their complications. This resemblance is seen in the modern cemeteries, organized spaces based exclusively on rationalization and on the efficiency of using the city's best physical space to solve the problem of the lack of space for new burials.

To solve part of the problem of the lack of space with the growth of cities and to solve environmental problems, new cemeteries were built in the twentieth century, though they were built differently: park-cemeteries or garden-cemeteries were created pointing to the development of areas where religious symbols are significantly reduced. They are, in general, ecumenical and treat death in a unique way, through simple and standardized spaces (the identification of bodies happens through equally arranged gravestones) to eliminate individual and social differences.

In the XXI century, the arguments of the last two centuries are combined to justify the interruption of the traditional image of the necropolises: a broader and more demanding hygienic and environmental notion is presented and treated together with the discourse of the lack of space. The horizontal cemeteries become vertical, with the burials arranged one above the other and distributed on floors. The difference is that the body is not buried, but enclosed in a room where it decomposes.

Through colonization, the European culture has expanded its influence to other parts of the world, but their development over the years was different in the end. The mechanism of rationalization and spatial optimization becomes a significant feature of the urban constitution in South America, which also includes cemeteries. That is, the vertical cemetery becomes a geometric architecture as a reflection of the urban organization, simple and without the use of ornaments, with the unique goal of rationalization and exploration of space to the maximum. North America and Australia also received many European influences regarding burial culture. In this case, the United Kingdom develop a strong sustainable awareness of cemetery structures, the United States of America started to implement some strategies to deal with the problems, while Australia is still very attached to the traditions.

2.5.3. Urban issues and introduction of new burial practices

The cemeteries were previously located outside the urban perimeter, but in the last century, they have been incorporated by large cities, due to an intense and uncontrolled urbanization process. Today it is common to find cemeteries totally integrated into the urban network, even in its most central areas. The occupation of the surroundings of the cemetery leaves these structures with no space to expand and increases the risk of contamination from toxic substances.

The demand for space to build new graves appears with the increase in population and the need for healthier spaces, leading to the need for larger burial spaces but with no available area for expansion. Unfortunately, nowadays it is impossible to completely stop using traditional burial methods for cultural and urbanistic reasons. Questions will be raised regarding the respect of local communities, the risk of abandonment of these areas and consequently the use of traditional burial spaces. Instead, the construction of modern cemetery structures, or even the substitution of existing burial sections by other systems, raises concerns about the costs of such operations and the contribution to environmental impacts.

Therefore, existing cemeteries start to propose innovative solutions to extend their burial capacity and the most recent example is grouping the burial spaces in structures developed in height in a vertical element. This phenomenon also brought the growth of cremation and new burial methods to increase the capacity for new burials, cemeteries are using burial spaces for cinerary urns more often. The idea is to use cremation as an alternative to inhumation or entombment and, in this way, avoid environmental and urban problems.

Cremation and burial are the main methods for the funeral process. Cremating means reducing the corpse to ashes, burying means putting it under the ground. Both methods are very ancient and are considered practical and hygienic measures. Other examples of innovative practices are related to the cremation process, such as the Bios Urn, a sustainable urn in which the ashes are used as fertilizer for a seed planted in the upper compartment; The Capsula Mundi project, where the body, buried in a biodegradable capsule, serves as a nutrient for the growth of a tree; the legal shedding of ashes in nature, a reality in countries such as Germany, Austria and Switzerland; ashes becoming diamond.

2.6. ENVIRONMENTAL AND ECOLOGICAL ASPECTS

It is known that cemeteries face many environmental issues and the poor condition of their structures can contaminate the natural resources (water, soil and air) and cause health problems. This happens because most modern cemeteries were constructed in the 19th century, a period with a few urban and territorial planning, especially related to the management of natural resources.

This field aims to understand how the decomposition process occurs and the level of danger that contaminating materials represents for the built environment. Some studies are really important to admit the importance of the environmental impacts caused by cemeteries structures, proving that it can be measured by environmental indicators

(physical, chemical and microbiological contamination) and influenced by geographic factors (temperature, humidity, altitude, soil type, etc). The burial process is also a factor to be considered because it impacts the decomposition process.

Environmental pollution is aggravated by the high density of burial spaces within the cemetery, which results in the storage of significant amounts of toxic elements. The lack of proper management of the cemetery structure is also a threat in this matter, vases and ornaments that are not correctly disposed of can be the source of vector proliferation through the accumulation of rainwater.

Other environmental perspectives are also related to the cemetery structure and evaluate the possibility to develop the potentiality of cemetery structures on increasing biodiversity.

2.6.1. Decomposition process of organic matter and the influence of environmental characteristics

Neckel et al. (2017) separate the decomposition process into eight different phases (Figure 10), which usually occurs in places with hot and humid climate and heavy rains. Until phase four (from 2h until 48h after the time of death) the decomposition initiate inside the body, with the liquefying process, when the solid elements become liquid. From phase five to phase seven (from 48h to 3 years after the time of death) this liquid substance is released into the environment together with gas substances. Finally, the last phase (phase eight occurs around the third year) represents the end of the skeletonization process, in other words, when the decomposition of the soft body is complete. The remains are mineral portions of the body, such as bones and hair.

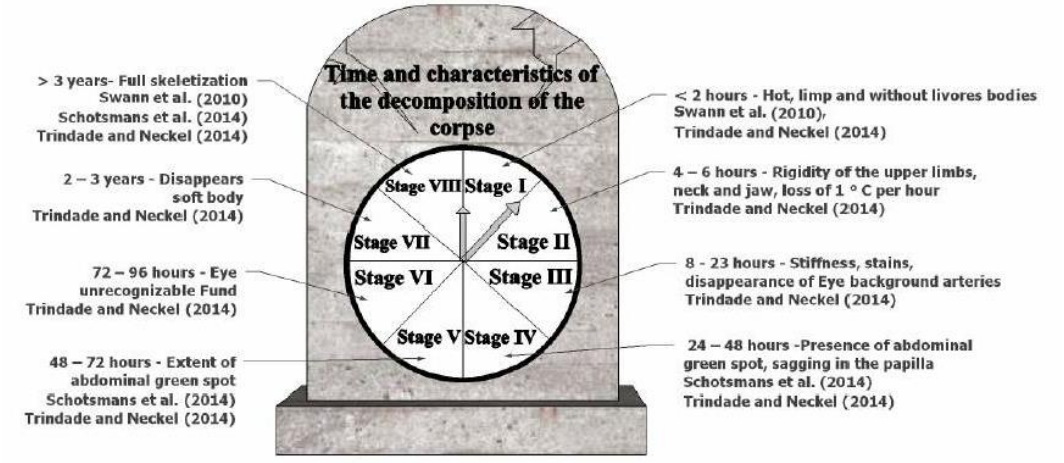


Figure 10 - Diagram of the eight phases of the decomposition process of the human body described by Neckel et al. (2017).

The decomposition of a corpse releases a great quantity of liquid, solid and gas contaminants into the environment. An individual weighing approximately 70 kg releases from 30 to 40 litres of a substance called necroleachate, an organic material with a viscous appearance, strong smell and greyish colour (Fernandes, 2021; Neckel et al., 2017). It is composed mostly of water, mineral salts and degradable substances, all related to the potential of transport putrescine [$(CH_2)_4(NH_2)_2$] and cadaverine

[$(CH_2)_5(NH_2)_2$], two volatile diamines molecules. When they degrade, they generate ionized ammonia (NH4+), nitrite (NO2-) and nitrate (NO3-), components that in high concentrations are toxic to humans.

Other contaminants result of this process are released in gas forms, such as hydrogen sulphide (H_2S), mercaptans (CH_4S), carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3) and phosphine (PH_3). “The gases released from decaying bodies need to be controlled and neutralized as they present a high contamination risk, given their association with the presence of necroleachate” (Neckel et al., 2017).

The decomposition process is influenced by physical characteristics such as climate and natural features. For example, a high concentration of clay in the soil means a lower capacity of the soil to supply nutrients. In addition, some studies show that contamination can occur not only with the decomposition of organic matter but also from the coffin, clothing and personal objects, which release heavy metals.

2.6.2. Environmental contamination as a potential to transmit diseases

Several researchers verified the harmful impacts on the environment caused by the decomposition process, which can contaminate soil, surface water, groundwater and aquifers. This contamination happens because the decomposition of the dead body releases high levels of chemical elements, microorganisms and heavy metals that infiltrate the soil until it reaches the water resources. The necroleachate is rich in nutrients, which provides the ideal conditions for the proliferation of large amounts of microorganisms. It creates the perfect environment for the proliferation of vectors responsible for transmitting infectious diseases from viruses (Hepatitis A) and bacteria (tetanus, gas gangrene, tuberculosis, typhoid fever and bacillary dysentery), among other pathogens.

The danger of cemeteries in urban areas for public health derives from the possibility of using groundwater contaminated by cadaveric liquid for human consumption. This contamination occurs in a direct way when the population consumes the water of the contaminated aquifer, or indirectly when the toxic substances are stored in the soil and groundwater that later will be used for irrigation. After the identification of the physical-chemical and bacteriological indicators, in some cemeteries, the results were that different parameters exceeded the potability limits recommended and showed the presence of ions, nitrogenous and a high concentration of heavy metals above the maximum values permitted for human consumption.

This unhealthy situation is related to the precarious facilities of modern cemeteries, allowing the interaction of the contaminants with the building and visitors. Studies were made all over the world. In Europe, there are some examples like Bower (1978), a collection of studies between 1800 and 1900, that included the study of Schrops, a study made in West Germany in the '70s. In North America Konefes (1991) raised suspicion about the presence of traces of arsenic in the aquifers near a cemetery on the east coast of the United States. In South America, Migliorini (1994), Costa (2002) and Francisco C. da Silva (Cola, 2017) carried out studies in large cemeteries with great demand for burial in big metropolises in Brazil.

According to Neckel et al. (2017), in “ambient conditions, the transmission of infectious diseases can reach a radius exceeding 400 m beyond the cemetery”

boundaries. It means that the population near cemeteries risks being exposed to contaminants that are harmful to human health. Some researchers proposed interventions such as the closure of cemeteries for new burials or the prohibition of consumption of groundwater in areas characterized as critical. Recommendations were also made in the geothermal, geophysical and hydrogeological fields, that should be considered before the construction of cemeteries.

2.6.3. Current situation of cemeteries in the built environment and ecology potentialities

Information about the current condition of cemeteries located inside large urban areas around the world can be found in newspaper editorials. In 2015 BBC News and The Guardian published articles mentioning some overcrowded structures. Cities like London, Sydney and Durban faced public concern about the lack of space for new burials because of the permanent grave system. The problem here is that local culture shows resistance to any solution of the local government, accusing of violation of religious and cultural traditions which makes it difficult to introduce new burial methods and policies.

It reveals that some cities already face the problem of cemeteries overcrowded, and the ones that still have some space left will run out of burial plots in a few years. In 2018 The New York Times published that the Arlington National Cemetery in Virginia, USA, the most famous military cemetery in the world, is nearly full and if the number of burials is not reduced, within 25 years all the available land will be occupied.

However, even countries that practice the recycling of graves are facing similar problems, for example, Norway, Germany, Belgium and Singapore. In their case, the main concern is that cemeteries have no sustainable system, which can represent a high risk of infections (BBC News and The Guardian, 2015). In Italy, local newspapers have shown irregularities in the maintenance of cemeteries structures and violation of environmental legislation. Torino (ObiettivoNews, 2018), Treviso (La Tribuna di Treviso, 2016) and Catania (MeridioNews, 2016 and LaSicilia, 2018) are some regions with problems related to abandoned graves and lack of maintenance. In the worst scenario, there are broken refrigerators and abandoned coffins that have to wait inside the mortuary room to be buried (some of them have been waiting since 2014).

There are rare cases where the planning of cemeteries includes strategies to enhance the natural system and support ecological corridors. The Polish law recommends designing and maintaining cemeteries as “park sites” (Anna & Ewa, 2020), considering the space with the potential to preserve urban flora and fauna (some examples in Figure 11). In this way, the cemetery acquires a unique position on social interaction and shows that burial spaces are composed not only of cultural elements but also of a green environment. It promotes the planting of a variety of plant species within the cemetery, considering the recommendations of a qualified landscape professional to decide the best composition of the natural elements. Other advantages of this type of management are the improvement of urban green areas, aesthetic valorisation of the space and the absorption of pollutants concentrated on the soil by vegetation.

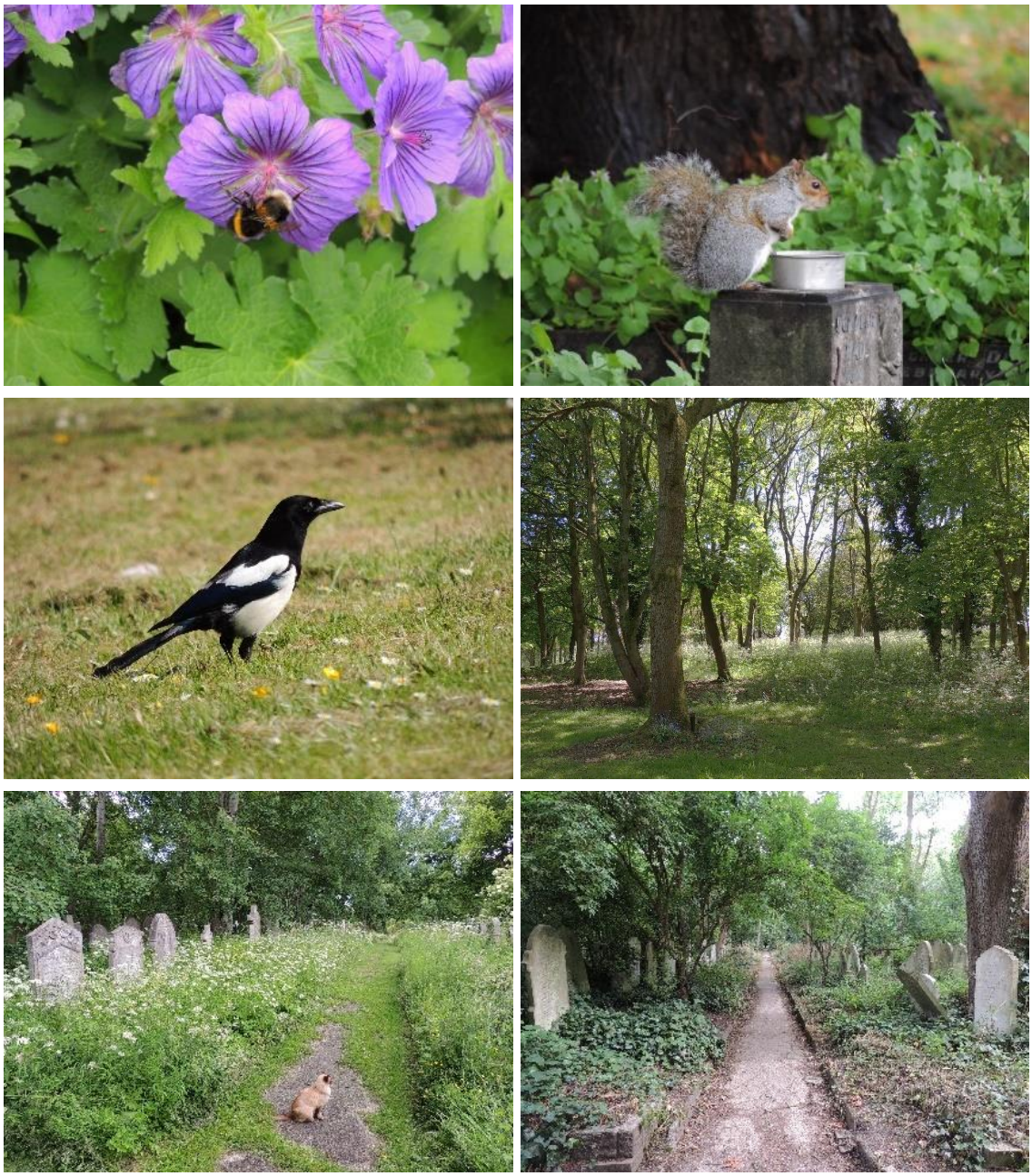


Figure 11 - Example of urban flora and fauna found on cemetery structures.

2.7. LEGISLATIVE AND MANAGEMENT ASPECTS

Cemeteries are legally bound to policies and regulations, different in each country and city. Usually, it refers to minimum dimensions of burial types, construction techniques required, methods of burial, services and spaces needed, etc. In some cases, the law is broader and leaves actions to be decided by the own cemetery management. It means that internal regulations may be very different between cemeteries.

The definition of the function of a cemetery is normally defined by law so the regulation can determine mandatory requirements for their operation. The main function of a cemetery structure is to provide a burial site for the placement of dead bodies and

in many cases, they are operated as a permanent land use for cultural and practical reasons, being also recognized as an “indispensable human right” according to the international law for cemeteries (Anna & Ewa, 2020; Neckel et al., 2017).

In many cases cemeteries are places of religious practice, mourning ceremonies and funeral practices that vary according to personal beliefs. Besides that, cemeteries are multifunctional spaces that also “serve as sacrum zone, archive, open-air museum, park, and an important part of the city’s natural habitat” (Anna & Ewa, 2020). This variety of approaches and overlapping of functions indicates the need for integrated planning of cemetery structures for both, private and public cemeteries.

To expand the topic on legislative and management aspects, some interesting international regulatory framework extracted from the data collection was analysed. The information found during the literature review is related mainly to regulations from Brazil, the United States of America, the United Kingdom, France, Italy and Poland.

2.7.1. Cemetery legality and temporality defined by the burial management

The time that a burial space must remain enclosed in a cemetery is stipulated by law and it varies in each country. Some cultures prefer the burial for perpetuity, so in this case, the temporality is “eternal” once the burial space will never be open again. Decisions against this type of management of the burial space started because the problem of the lack of space inside urban areas was rising.

Some cases have been reported of cemeteries, managed by the local authority, extending the burial area of existing structures to increase the number of burial spaces (see Subheading 2.5). However, restrictive environmental legislation together with the divergence between legislation and strong cultural traditions reveals to be an obstacle for some cemeteries. The solution was to adhere to the recycling process of the burial space, where the temporality is related to the time that it takes for the organic material to decompose (see Subheading 2.6.1).

From the environmental point of view, some countries stipulated the need of requiring environmental licensing in order to operate, guaranteeing that cemeteries will comply with environmental criteria and minimize risks of polluting the environment. Therefore, for the law to be effective it must be rigid.

Legislations usually provide for a minimum distance from which construction around cemeteries is permitted to avoid the contamination of the population from the cemetery (Neckel et al., 2017). Over time, population growth pushes the urban sprawl to occupy the cemetery surroundings and satisfy the social need for urbanized areas (Anna & Ewa, 2020). To adapt the legislation to the new reality, the minimum distances have been reduced or are not considered anymore as mandatory for construction planning.

In other cases, the changes in burial strategies confronted the culture of the local population, which happens in some communities in Brazil that were against the closure of the local churchyards and ruined the new municipal cemetery as a demonstration of disagreement. It demonstrates that it is very difficult to make changes to cemetery structures, and the result may even be the abandonment of the decision and the return to the previous tradition.

2.7.2. Analysis of different management types of cemeteries: private and public

The cemetery structure can be considered a public space, as anyone can enter most of its perimeter without the need for special permission. People can visit the structure, walk around the circulation system, pay tribute to someone, participate in events and perform many other activities. The only rule that has to be followed is to be respectful in confront of the special place.

At the same time, the individual burial space may be considered a private space. Some countries allow the purchase of the burial plot, which allows an individual to own the land and manage how to use the space. In other cases, people can purchase the right to burial, which will last for a specific period. During this period, the individual responsible for the right to burial can make decisions regarding the burial space. Some cemeteries may have more or more flexible internal regulations.

In this scenario, there are different business models and the decision will intervene on the charges for grave care, thus the cemetery can have public or private management. Usually, the expectation is that the private cemetery needs to be profitable, while the public cemetery can focus on sustainable aspects. At the same time, local authority management has economic difficulties because there are more limits on the way of obtaining income.

2.7.3. Operational of the cemetery and sustainability perspectives

Some cemeteries have already started to apply sustainable management strategies, one example is the case of cemeteries in England, where lawn cemeteries are predominant and requires a lot of maintenance of the outdoor environment (Figure 12). Therefore, to enhance the natural environment and increase biodiversity, the frequency of grass mowing was reduced and the use of pesticides was suspended. From a social aspect, some cemeteries tolerate residents to walk their pets or transit through the main paths while exercising, and they also may allow accessing the burial space with private vehicles if there is enough space (Figure 13). These actions encourage the integration of the cemetery space with the community and give better accessibility for people to access the burial spaces.

Figure 12 - Example of management activities in a cemetery structure.

Figure 13 - Example of people using the cemetery space for other activities rather than funerary services.

Regarding environmental impacts, there is a mix of waste produced inside cemeteries from natural to artificial ornamentals left by visitors, organic and inorganic materials extracted from the exhumation process, and traditional human waste. It is fundamental that all this waste receives the proper disposal methods to protect the environment. Unfortunately, some cemeteries continue to use materials for the burial process that are difficult to treat and dispose of, creating waste that is particularly critical and expensive to recover.

The Italian legislation can illustrate this situation by demanding the use of a double coffin for the entombment burial process, a traditional wooden coffin for the outside and a metal case (lead or zinc) for the inside. The aim is to prevent environmental contamination from the decomposition process, but the fact is that unrepaired coffins do not cope with this purpose and that these materials are not environmentally friendly. Fortunately, materials design has evolved in the past years and many of them can solve the problems related to the cemetery structure, for this reason, the Italian situation has introduced the use of biodegradable material. The problem is that the legislation did not make mandatory the use of the new materials and the high costs of production do not incentive the funerary market to replace the traditional materials that are still in use today.

Another solution is related to the use of proper construction technics. As stated in the previous chapter, it is easier for private cemeteries to apply sustainable strategies and one example is that of the *Necrópole Ecumênica Vertical Universal*, a private vertical cemetery (see Subheading 3.2.4 Types of Cemetery Structure) in Brazil (Figure 14). The niches were constructed using a simple system of applying a permeable coating in the interior walls of the niche, they used an asphaltic membrane but the market offers a variety of materials. A pipe system has also been planned at the end of each niche that comes out on a chimney at the roof with a carbon active filter. The last stage of the strategy is to use plastic bowls under the coffins when they are enclosed on the niche, allowing the natural process of decomposition until its end and minimising environmental impacts. This example shows a project strategy combined with management decisions to achieve strict environmental regulations, as are the Brazilian legislations in this matter.

Figure 14 - Structure of the niches of the Necrópole Ecumênica Vertical Universal (Curitiba, Brazil) to avoid contamination from the decomposition process in the indoor environment.

2.8. ANALYSIS OF INTERDISCIPLINARY ASPECTS AND CONCLUSION OF CHAPTER 2

The development and application of review search methods (systematic and non-systematic) revealed a large body of existing research and were used to avoid ignoring relevant sources. There might be further information available about the topic and future research could give a wider perspective on the design and assessment of cemetery structures. A possibility is to expand to other languages rather than English and different contexts described in Subheading 1.3.4 Limitations of the field of research (operating cemeteries, under European culture, located in urban areas).

All of these contributed to the definition of the “state of the art” of the research topic, to insert the research on the current sustainable development scenario, and to provide the justification for the research aim. This review identified critical literature gaps, interpreting the discussion concerning different perspectives, that motivated the next stages of the research.

The interdisciplinary literature review shows the complexity of assembling theories from a variety of fields. It underlined the fact that frequently discussions occur from one perspective and are usually considered issues separately. Thus, the innovation in this research is related to the organization of an interdisciplinary approach to give an overview of the problem as completely as possible and to establish the relevance of the research in the current sustainable development.

The interdisciplinary analysis revealed a comprehensive framework of issues related to cemetery structures, sustaining the need to find solutions to solve the problems that are emerging. Some issues are present in some countries and not in others due to different cultural habits and regulations. Some of them are related to the following topics:

- the need for larger burial spaces;
- the abandonment of large structures inside urbanized areas;
- cultural changes and introduction of new technology;
- the pollution of the environment;
- the concern about public health.

Cultural Heritage perspective and urban issues. The connection of urban planning with the development of cemeteries showed that there is a need for urban development without the consumption of virgin soil. At the same time, the multi-ethnicity of our society requires more and more multi-functional and multi-religious spaces as happens in many cities, almost like an urban park. The idea is to transform them into integrated urban spaces, but many existing structures are not available for this change.

Environmental issues. It is important to notice that many studies verify the damages to the environment caused by unsettled cemeteries and raise information about the proliferation of diseases, sometimes even epidemics. Thus, to avoid contamination originating from urban cemeteries, this research recommends carrying out regular environmental control, improving management services and regenerating the burial structure to avoid the percolation of contaminants from the burial spaces. To prevent the

problems described above, it helps to identify specific characteristics that should be considered in the cemetery structure to prevent contamination, such as construction technics, use of proper materials and management strategies.

Reflection of general regulations. The analysis of different regulations, cemetery management and the current situation of existing structures, made clear that in many cases the law is not entirely effective. From many aspects, the cemetery is considered predominant as a building facility, with several characteristics to respect, with less attention to the composition of green and open areas. There are some examples of initiatives for the sustainable management of cemeteries, but it still not includes all the cemetery aspects. Some recommendations in this matter to guarantee the sustainable regeneration of cemeteries is that local authorities must consider frequent visits from enforcement agencies to ensure that cemeteries carry on constant care of the burial space according to environmental requirements.

Insufficient sustainable solutions. Most of the interventions proposed are not intended for the regeneration of existing cemeteries and from all possible solutions found, only a few are feasible. Some of them are impossible to achieve or would even increase existing urban problems. Anyway, there are no references to an appropriate and sustainable construction method for burial spaces that aims to reduce the environmental impact in all its dimension.

CHAPTER 3: ANALYSIS OF CEMETERY CONFIGURATION

Figure Cover Chapter 3: Culture heritage in connections to cemetery management at the York Cemetery (York, UK).

3.1. SITE OBSERVATION METHODOLOGY

Architectural site observation is a suitable approach for gathering information on existing conditions and the actual context of the object under study in its natural setting without influencing it. It is possible to examine particular elements in detail and establish which factors have a negative impact and which conditions have a positive influence.

With this in mind, this methodology allowed the understanding of as many cemetery types as possible by observing a wide range of sites at an international level. The site observations were carried out between 2019 and 2022 with each visit taking from three to four hours. The selected cemeteries are listed in Table 4, chosen to cover different cemetery structures. Sites were limited to operating cemeteries accepting new burials, preferably under Christian culture but not exclusively.

Data were collected mainly through visual documentation (photographs) of the site's physical condition as well as the immediate urban surroundings. Different aspects were investigated, from specific cemetery infrastructure (layout, program, buildings, utilities, use of space), to environmental features (topography, water bodies, vegetation, animals) and general site characteristics (boundaries, access, traffic circulation, dimensions). Social and historical aspects were also recorded when occurred, due to their influence on the site development but they were not the main focus of observation.

Table 4 - List of cemeteries chosen for the development of the site observation, followed by their location and the main reason that led to their inclusion in the research. The list is in alphabetical order by the original name of the cemetery.

N.	CEMETERY NAME	CITY (COUNTRY)	REASONS FOR INCLUSION IN THE RESEARCH
1	*Cemitério Municipal Água Verde*	Curitiba (Brazil)	Burial Space (niches) Surroundings
2	*Cimitero di San Cataldo*	Modena (Italy)	Burial Section (ossuary) Cemetery Structure (horizontal)
3	*Cimitero Monumentale della Certosa di Bologna*	Bologna (Italy)	Burial Section (memorial garden) Cemetery Structure (monumental)
4	*Cimitero Monumentale della Certosa di Ferrara*	Ferrara (Italy)	Cemetery Structure (monumental) Surroundings
5	*Cimitero Monumentale di Milano*	Milan (Italy)	Burial Space (tomb) Burial Section (urnfield) Cemetery Structure (monumental)
6	*City Road Cemetery and Crematorium*	Sheffield (UK)	Burial Space (graves) Surroundings

7	*Hutcliffe Wood Garden of Remembrance*	Sheffield (UK)	Burial Section (memorial garden) Cemetery Structure (garden of remembrance)
8	*Necrópole Ecumênica Vertical Universal*	Curitiba (Brazil)	Burial Space (niches) Cemetery Structure (vertical) Management Strategy
9	*Wisewood Cemetery*	Sheffield (UK)	Burial Space (natural plot) Burial Section (natural ground)
10	*York Cemetery*	York (UK)	Burial Section (gravesite) Management Strategy

The cemeteries included in the table are those, among several visited, that best cover the spatial variation form of different cemetery typologies identified during the research, and therefore, become a sufficiently representative set of sites. Nevertheless, several other cemeteries contributed to increasing the international analysis of the topic and were often mentioned as examples. The full list of cemeteries can be found in Appendix A: List of burial sites that contributed to the analysis of cemetery configuration.

Even if the technical visit[3] of the *Necrópole Ecumênica Vertical Universal*[4] was carried out in 2017 (before the research began), this case study was included in the analysis because it is particularly interesting and it provides an understanding of the operation of a specific cemetery type, the Vertical Cemetery, and information on innovative strategies implemented in the cemetery structure was also collected.

Anyway, the research focuses on cemeteries under Christian culture, but two Jewish cemeteries were integrated into the research: the *Bushey Cemetery* (London, UK), both the old section and new section, and the *Cimitero Ebraico di Ferrara* (Ferrara, Italy). They are considered similar in layout to the other cemeteries and are of great value to this research in terms of sustainable strategies (CHAPTER 4).

Finally, after examining the findings, exploring their relationships, and combining the results with the literature review, the data collected was translated into the following systematization. At first Subheading 3.2 describes specific features of a cemetery and categorizes them into different types, which led to the division of the cemetery structure to demonstrate the complexity of the space in Subheading 3.3. Following this analysis, Subheading 3.4 illustrates the elements, such as buildings and service elements present inside a cemetery, perceived as essential for the composition of a cemetery structure. Conclusions and critical analysis are presented in Subheading 0. Photographs give support to the entire analysis process.

[3] Technical visits can be performed with different scopes as in (Cohen et al., 2001), where technical visits were planned at two different moments for the assessment of buildings occupancy for the Probe project, and in (García Sáez et al., 2016), used for educational purposes in a practical workshop on traditional Spanish architecture. The common aspect that characterizes this methodology is that the visit is guided by professionals experienced, allowing informal discussions and data collection that would not otherwise be obtained. “These technical visits provided the opportunity to see and explain many examples (…) in situ, (…), and serving as examples for the theory reviewed beforehand. [They] (…) acted as a sort of transition between theory and practice, and as an example of what had already been studied” (García Sáez et al., 2016, p. 1686). It is important to give a small description of this methodology because the technical visit used as a reference was not published yet.

[4] The technical visit was supervised by the project manager Wilson de Carvalho.

3.2. CATEGORIZATION OF CEMETERIES

The identification and extraction of recurrent terms in the literature review was a useful approach that permitted the composition of the glossary entries (see Glossary). Associating key terms with a preliminary definition was a good starting point to develop the discussion in CHAPTER 2 on relevant interdisciplinary aspects related to cemetery studies. On the other hand, a deep analysis of the literature revealed that it is missing a common language when discussing burial topics.

Interrelated concepts are frequently used as synonyms without considering details that may differentiate them, which can lead to the incorrect use of terms and create confusion. As mentioned by Rugg (2000), “a language of different burial space types needs to be set, establishing a common grammar for international, comparative and multidisciplinary studies” (p. 259). She explains that the lack of a clear and concise meaning generates a superficial debate that could have a negative impact instead of creating universal knowledge about the theme.

For this reason, before starting to analyse how to deal with the cemetery issues previously studied, it is necessary to ensure the uniform use of a few terms. A good definition “captures the meaning, the use, the function and the essence of a term or a concept. (…) A truly good definition is generative and creates value beyond its intended purpose of effectively describing something” (Krejcar et al., 2019, p. 94835). Therefore, the aim is to give meaning to specific cemetery terms, first explaining verbally and then clarifying with examples of photographs taken during the site visits.

Several authors already tried to establish a common ground to improve the debate on burial sites and to raise the level of analysis on the topic. Davies & Jokiniemi (2008) have described and sometimes illustrated a wider number of burial terms compared to Curl & Wilson (2015). Despite that, both gave a very generic definition for terms such as tomb, loculus, mausoleum, ossuary, cinerarium, etc. They incorporate characteristics of the building with aspects of history (ancient and contemporary) and construction technics.

From another perspective, Carbonara (1958) is possibly one of the first writers to put together history, design guidelines and legislative outlines specific to cemeteries and funerary monuments in Italy. More recently Marino (2014) and Franciosini (2022) followed the same structure as their compatriot, focusing more on the executive project to recover, restore and consolidate historic funeral buildings. In all of these references, there is an extensive number of definitions related to funerary topics.

In her paper, Rugg (2000) mentioned burial sites in the USA, Europe and Australia to “propose definitions of cemeteries, churchyards, burial grounds, mass graves, war cemeteries and pantheons” (p. 260). She discusses characteristics related to history, ownership, physical structure and religious influence to describe each concept.

Every cemetery space is embodied in historical and cultural significance, reflecting human behaviour toward burial practices at the same time that answers to a social need, as seen in Subheading 2.5. However, the site analysis supported the understanding of different burial forms based on their physical characteristics (shape, form, material, etc.), without the influence of variables elements such as culture, religion or legal requirements.

The purpose is to look at concrete elements that do not change (tangible qualities) to create patterns that are replicable under different circumstances while dealing with variables (intangible aspects) as an additional aspect that will adapt according to a given context. Analysing from this point of view would simplify the way of assessing burial spaces, allowing a more universal language.

3.2.1. Classification of general cemetery's features

Before giving a definition to burial terms, there are a few patterns that were noted to be suitable in most of the cemeteries visited. They can be influenced by decisions made by the cemetery management or by law, and in some cases, different patterns can influence the same burial term. They are not considered parameters for defining specific terms because they would interfere with a precise definition. Instead, they are used to classify general cemeteries features.

For example, the first pattern although very general allows the division of cemeteries into two categories based on their **overall visual characteristics**: cemeteries with a predominance of built-up elements (Figure 15) and cemeteries with a predominance of green areas (Figure 16). It directly influences the cemetery infrastructure in terms of layout, impacting the preference for the burial spaces and burial sections that will be present in the burial site.

Figure 15 - Examples of cemeteries where built-up spaces are predominant: a) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); b) Cemitério Municipal Água Verde (Curitiba, Brazil); c) Cemitério da Ordem Terceira de São Francisco de Assis (São João del-Rei, Brazil).

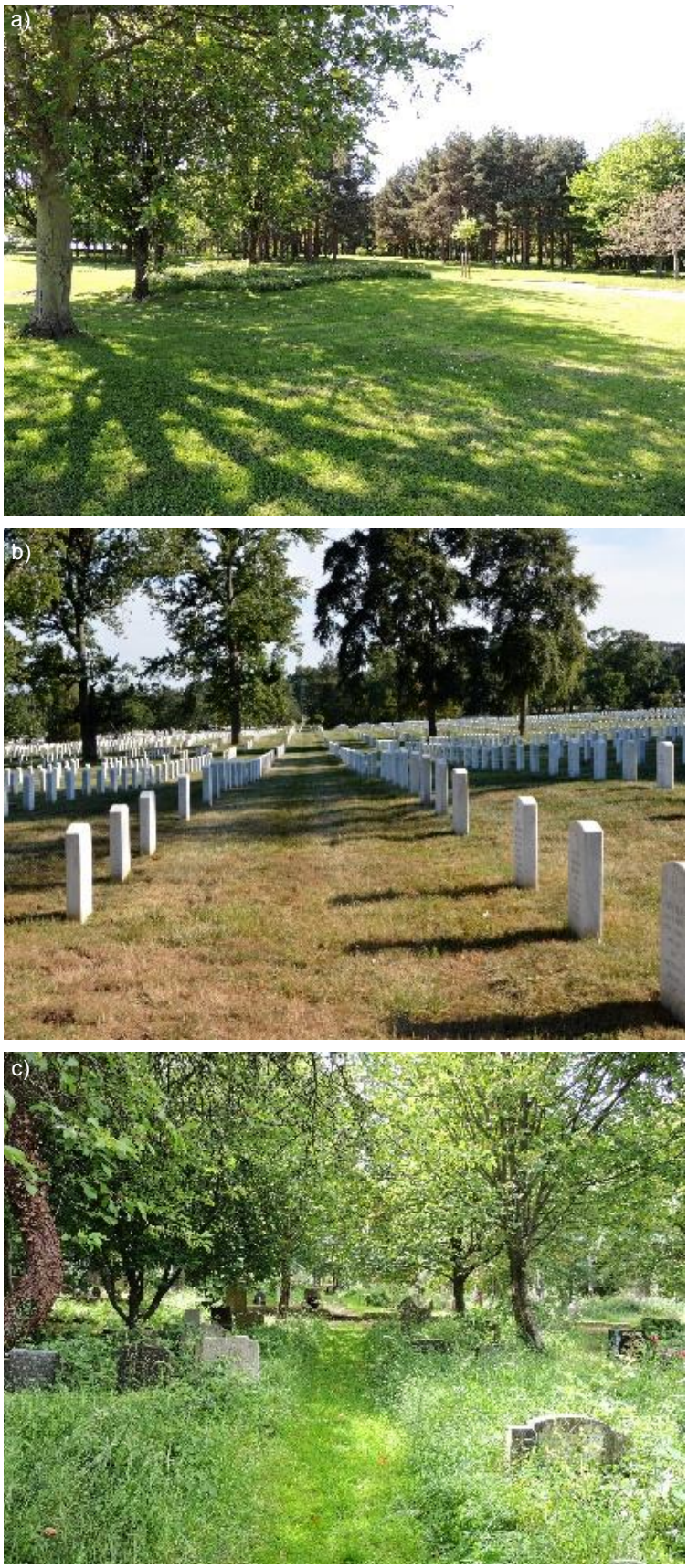
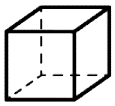
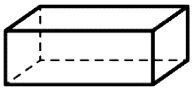
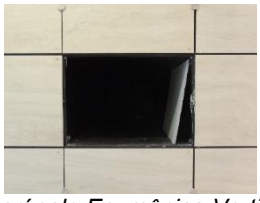


Figure 16 - Examples of cemeteries where green spaces are predominant: a) Hutcliffe Wood Garden of Remembrance (Sheffield, UK); b) Arlington National Cemetery (Arlington, USA)[5]; c) York Cemetery (York, UK).

Another pattern among the cemeteries is related to the **burial size** (Table 5). Minimum dimensions to fit the deceased remains are generally stipulated by law and depend on the options of final disposition available (e.g., interment, entombment, cremation). It is associated with the use of space within the cemetery.

The most common form of final disposition is confining a dead body inside a coffin, meaning that the burial space must have a rectangular box structure. Burials for bones or ashes are smaller in size and receive the skeletal remains inside a container or the cremated remains inside an urn. This arrangement is not mandatory, containers and urns can be stored in burial spaces meant for coffins, but for obvious space reasons, the opposite cannot happen[6].

Table 5 - Different classifications of burial sizes determined by the method of final disposition: interment, entombment or cremation. The burial size will be suitable for coffins, containers or urns. Both are suitable for burials under or above ground level.

BURIAL SIZES			
ELEMENT	**ICON**	**EXAMPLE**	
BURIAL SPACE FOR CONTAINERS OR URNS (at least a small-sized structure / square box)		 *Abbey Lane Cemetery* (Sheffield, UK)	 *Cimitero di San Cataldo* (Modena, Italy)
BURIAL SPACE FOR COFFINS (rectangular box structure)		 *Bushey New Cemetery* (London, UK)	 *Necrópole Ecumênica Vertical Universal* (Curitiba, Brazil)

It brings to the third classification to be analysed in the cemetery, the **density of burials**. This characteristic regards the capacity of the burial space to hold multiple or single interments or entombments. Burial spaces are situated inside a burial plot (Figure 17) and in particular cases, the burial space is itself the burial plot (see Subheading 3.2.2). It is within the burial space where the burial will effectively take place.

The density of the burial space will influence the density of the burial plot and, as a consequence, the density of the entire cemetery structure. It is related to the type of burial management, whether the burial space is reused, reclaimed or granted in perpetuity (see Subheading 2.7). When it is reused more than one deceased will be buried in the same burial space, thus it will be able to receive multiple burials. However,

[5] The image source is: adapted by the author from an original photo courtesy of Marta Calzolari.

[6] The *Necrópole Ecumênica Vertical Universal* (Curitiba, Brazil) is managed with the aim of keeping the space as flexible as possible. For this reason, the owner may choose to occupy a niche with a compartment either for ash and/or bones. Other cemeteries are managed to have their area divided in such a way that each space has a specific function, which is the case of the *Cimitero di San Cataldo* (Modena, Italy), where containers with bones are inserted into the ossuary.

burial in perpetuity means that the remains will never be disturbed, so there will be only a single burial in each burial space. The reclamation of the burial space ensures that the burial plot receives multiple burials while the burial space receives a single burial, usually in perpetuity.

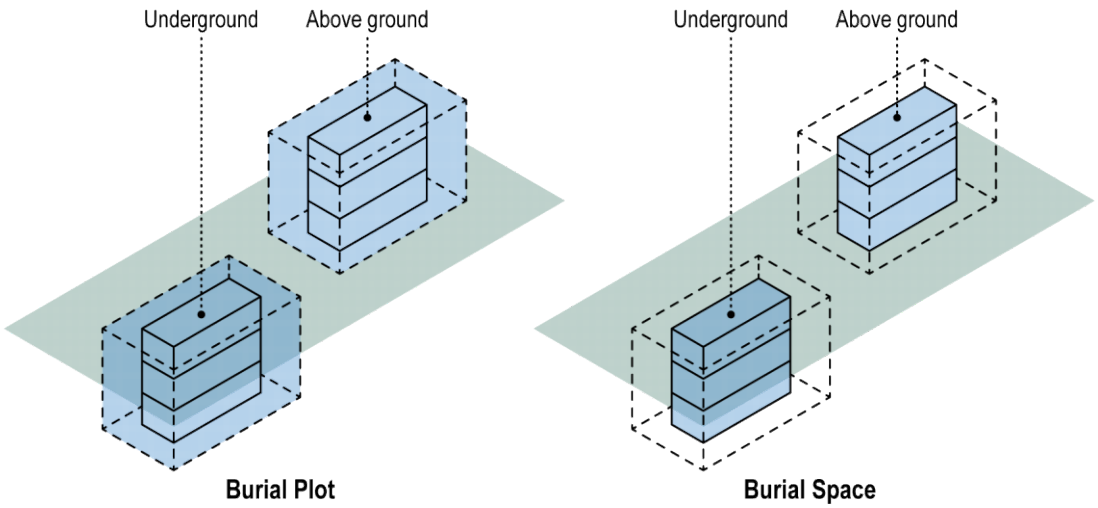


Figure 17 - Diagrams of burials under and above ground level to illustrate the difference between the burial plot (left) and burial space (right). In this case, each burial plot contains three burial spaces. Dimensions are indicative and may vary according to legislation and manager decisions to organize the cemetery.

The last pattern regards the use of a **burial box** (Figure 18a) to protect the coffin or the urn when they are buried underground. Usually, it is a container made of concrete that prevents the ground from settling with the weight of the earth or the weight of the maintenance equipment that needs to circulate around the cemetery. It can be lined and sealed (Figure 18b), being then called a vault and providing additional protection from water infiltration.

Burials above ground can function as a burial vault (Figure 18c) because their walls protect the burial space from natural elements that otherwise would damage the contents. On the other hand, underground burials can be performed with or without a vault. Depending on the management, it will be required to use a burial vault to preserve the landscape layout of the burial site. It can also be required for cultural reasons, for example, the burial vault helps speed up the preparation of the burial when the burial should take place soon after the deceased.

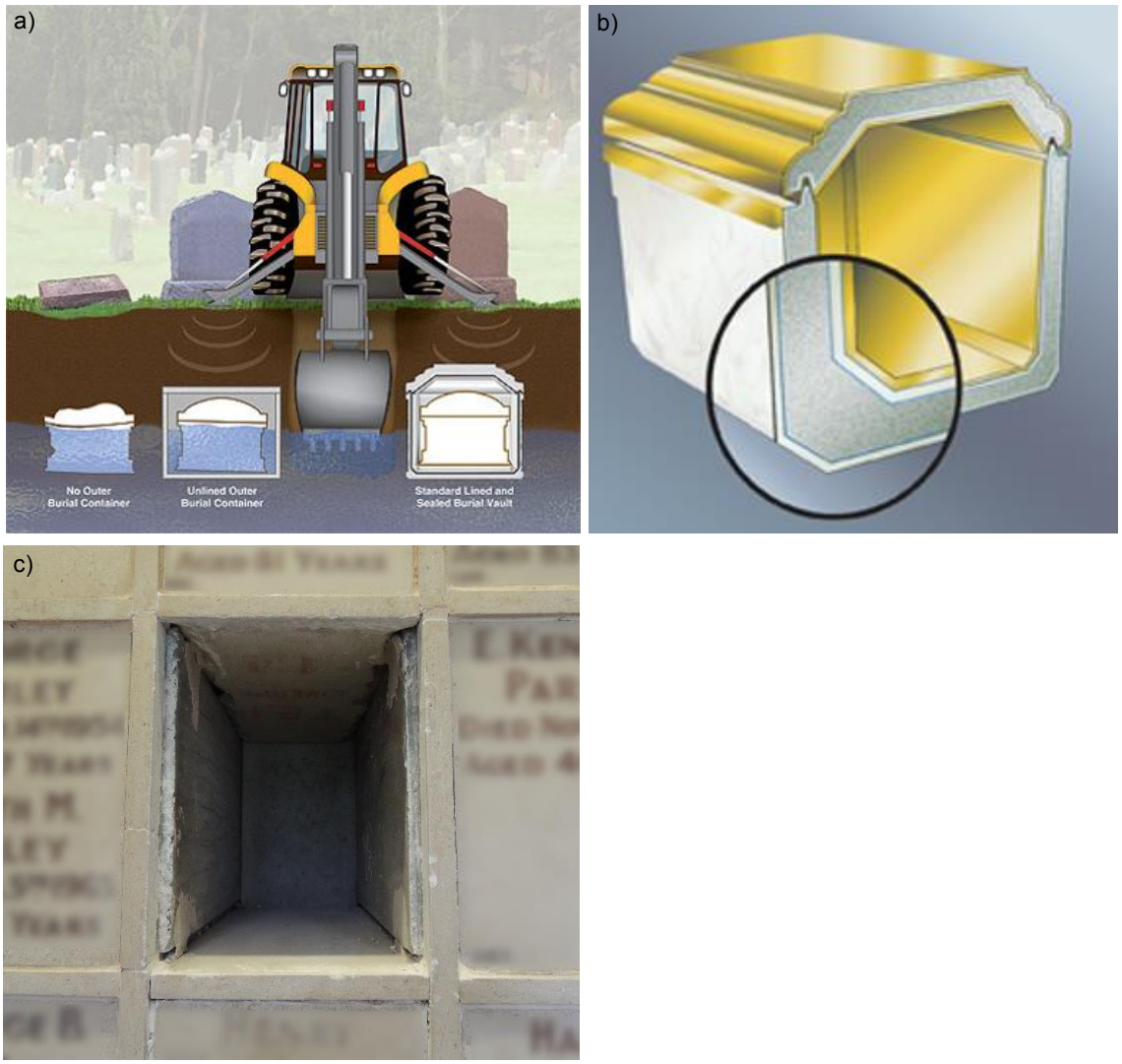


Figure 18 - Examples of burial boxes: a) illustration of what happens underground when a coffin is buried directly in contact with the soil (left), with an unlined container (middle) and with a sealed vault (right)[7]; b) a three-dimensional diagram of a sealed vault divided by layers[8]; c) the inside of a columbarium niche at the City Road Cemetery and Crematorium (Sheffield, UK), a vault at an above ground burial space.

In the end, further characteristics led to the comprehension that the cemetery can be analysed in three groups determined by their scale: burial space, intended as the individual burial spot; burial section, for areas containing significant burial spaces of the same type; and cemetery structure, as the entire structure including burial spaces and burial sections, as well as buildings, services and utilities.

Each group contains a variety of elements with particular features in common. To distinguish these elements, a specific term will be assigned along with a brief description of their qualities and characteristics, separating them by type. The result is a classification of several types of burial elements inside different scale groups (synthesized into Table 6, Table 7, and Table 8).

[7] The image source is: https://colefuneralservices.com/151/Burial-Vaults.html. Retrieved March 7, 2022.

[8] The image source is: https://www.wilbert.com/store/burial/burial-vaults/premium-protection/. Retrieved March 7, 2022.

3.2.2. Types of Burial Space

While visiting cemeteries, the first thing easy to notice is the burial plot. It is a small piece of land where the family have the authority to choose the memorial and decorations to place in reference to the burial (Figure 17). The burial plot and burial space are essentially connected and can accommodate individual or multiple burials in multiple forms, depending on their physical form, determined by:

- position of burials (under or above ground level);
- features of the structure above the ground (material and dimension);
- proportion between the volume of the burial space in relation to the burial plot.

To be considered a burial space type it must be framed within all the parameters mentioned above with a unique combination. For the convenience of this analysis, the burial plot and the burial space will be considered equivalent as they will share the same features, so the discussion will be carried out predominantly using the term burial space.

A large, deep hole in the ground is the first stage in building a **grave**, an underground burial (Figure 19). After digging out the right dimensions (e.g., there are standard dimensions for adult, child and oversized burials), the deceased remains are then placed in the desired position and covered with earth.

In this way, a **public grave** (or “Common Grave”) is created (Figure 20). Although not commonly used, they are usually for public burials for economic reasons. They have no headstone for an accurate identification of the burial and the grave can be reclaimed by the cemetery without needing the permission from the family. In other words, the burial right is retained by the cemetery management and unrelated individuals can be buried in the same plot. So due to the lack of monuments, the surface is left covered by natural soil and the costs of burial are cheaper than any other type of burial space.

Figure 19 - Examples that represent the first stage of burial in graves in the Abbey Lane Cemetery (Sheffield, UK). The graves on the left and in the middle have been recently excavated and covered. The one on the right was only excavated and to prevent accidents, wooden boards were placed to cover the open hole. All graves would have a headstone installed shortly afterwards.

Figure 20 - Examples of public graves at the City Road Cemetery and Crematorium (Sheffield, UK). To create visual harmony in the cemetery's layout, public graves are occasionally placed between traditional graves. It creates a pathway and optimizes the land, using space that in any way would not become an available burial plot.

The **grave with a headstone** is a burial entirely underground level with a solid headstone (or gravestone) emerging above ground to mark the grave and identify the deceased. It has a small impermeable coverage area and depending on the management of the cemetery and the owner's wishes, it can be left uncovered (Figure 21a) or it can be shaped with a kerb[9] (Figure 21b and Figure 21c).

Figure 21 - Examples of graves with a headstone: a) York Cemetery (York, UK); b) City Road Cemetery and Crematorium (Sheffield, UK); c) Cimitero Monumentale di Milano (Milan, Italy).

[9] A kerb is a line, usually made of stone or concrete, that establishes a boundary and encloses a piece of land to be decorated by the owner of the grave.

A **grave with a landing stone** is a lot similar to the burial space described above, the difference is the presence of a landing stone covering the entire surface of the grave (Figure 22). It can receive decorations such as sculptures, headstones or writings on the stone slab, depending on the deceased and/or family's choice. For safety reasons, any type of grave described above usually accommodates no more than three burial spaces underground in the same plot.

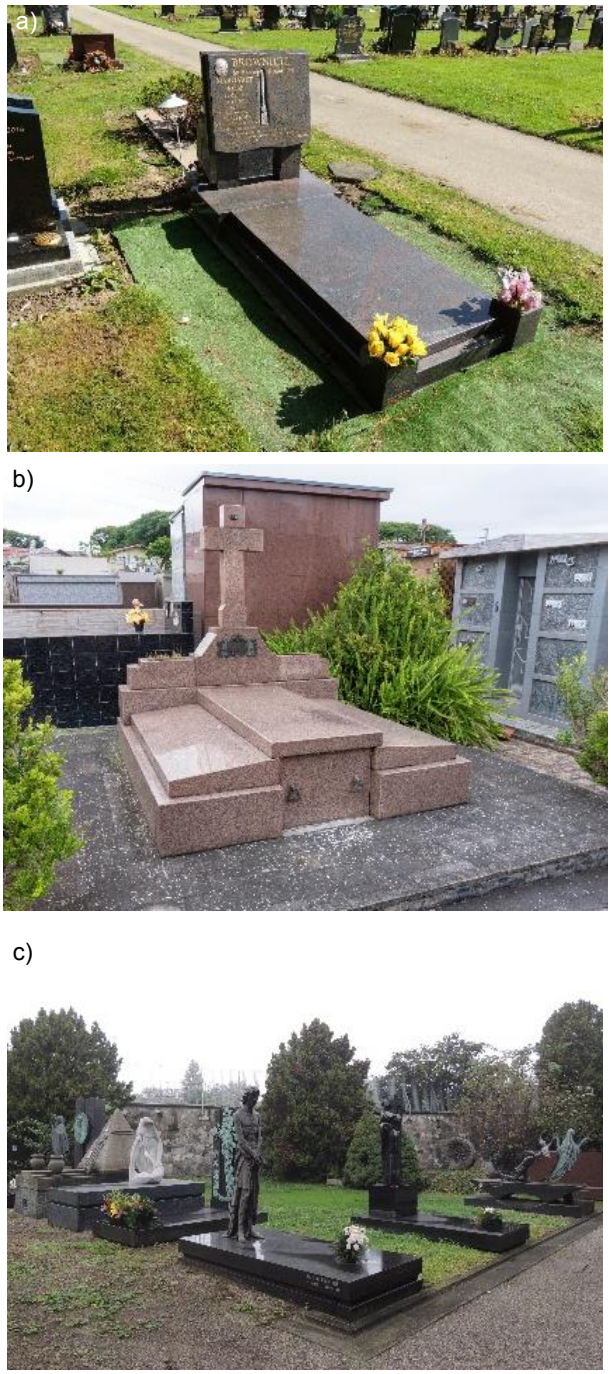


Figure 22 - Examples of graves with a landing stone: a) Abbey Lane Cemetery (Sheffield, UK); b) Cemitério Municipal Água Verde (Curitiba, Brazil)[10]; c) Cimitero Monumentale di Milano (Milan, Italy).

[10] The image source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

The last type of underground burial space is the **natural plot**, a burial focused on nature and not on individual identification. It means that growing plants above the burial is permitted (Clayden et al., 2018), representing a natural monument for the deceased. However, small plaques or decorative items can be placed on stones or trees for the identification of the deceased (Figure 23), the important thing is that it does not disturb the natural cover of the land.

It started with the purpose of burying coffins in a more sustainable way, but with the advancement of cremation, some solutions could be adapted to this type of burial space. Urns with biodegradable material are already available and follow the same principle as the natural burial plot.

Figure 23 - Examples of natural burial plots at the Wisewood Cemetery (Sheffield, UK). To create a meaningful memorial, people place flowers and small objects in correspondence with the natural element that represents the burial space.

Economic conditions often resonate in the cemetery architecture, affecting the materials and design complexity of burial structures, especially with regard to aboveground burial spaces. It does not influence the definition of burial spaces, but it sure contributes for creating an interesting environment within the cemetery. Starting with the **tomb**, culturally it is considered a symbol of prestige and wealth, with a substantial construction, built entirely aboveground.

House-shaped (Figure 24), it is a solid structure that covers the entire surface of the burial space and provides weather protection. Inscriptions with the family's name usually are placed on the outside for the identification of the burial, while detailed information about the deceased is generally, but not exclusively, written on small metal plaques. It can be used for an individual[11] or a group of people. In the first case, the tomb will have room for only one burial, while a family tomb usually accommodates multiple members of a single family (in Figure 24b, from the outside it is possible to see that the tomb has room for six burials).

Figure 24 - Examples of tombs: a) Cimetière du Père-Lachaise (Paris, France); b) Cimitero Monumentale di Milano (Milan, Italy); c) Highgate Cemetery (London, UK); d) Cemitério Municipal Água Verde (Curitiba, Brazil).

[11] One example of a tomb for a single person is the Tomb of Dante, located in the centre of Ravenna, Italy. It was built in honour of Dante Alighieri around 1780 and is where his skeletal remains lie to this day. It is not located inside a cemetery structure, but his remains are buried there and it is a tomb burial type.

Niches started to be used as a way to save space inside the cemetery. It is a hole in a wall that follows the principle of a “drawer” and serves as a compartment for coffins or for containers and/or urns (see examples in Table 5). There are different configurations for this burial space type depending on the management of the cemetery according to the size of the niche and the type of burial management (reused, reclamation or granted in perpetuity).

A **small niche structure** (Figure 25) composes a small vertical element that occupies the whole burial space. It has a reduced number of niches so that each one is sufficiently visible to those who pass without the need for stairs, except for ordinary maintenance (Lopez Duarte & Davoli, 2021). Sometimes a small structure can be used as a family niche, meaning that the owner of the right of burial can decide who will be buried in that space. In other cases, the cemetery will retain the right of burial and unrelated individuals will be buried in one niche close to the other.

Figure 25 - Examples of small niche structures: a and b) Cemitério Municipal Água Verde (Curitiba, Brazil); while c and d) Hutcliffe Wood Garden of Remembrance (Sheffield, UK).

General niche structure composes an entire building with a large number of niches, one above the other, for a more compact and serial storage (Figure 26). It is a significant structure that covers more than the surface of the burial space. Stairs are needed to maintain individual niches and to access the upper floors of the building (see section "*Types of Cemetery Structure*", term "*Vertical Cemetery*"). The difference is that a small niche structure is a single building, while the general niche is part of a complex.

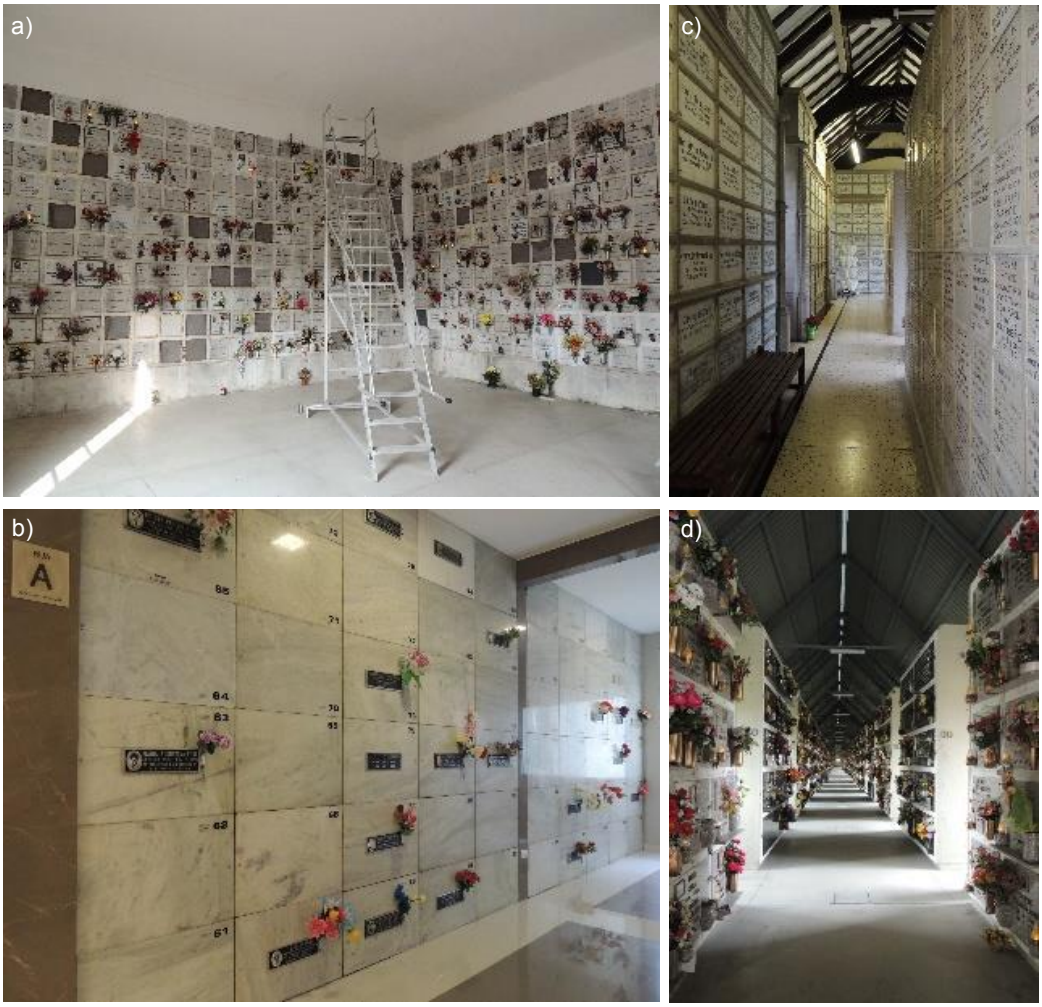


Figure 26 - Examples of general niche structures: a) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); b) Necrópole Ecumênica Vertical Universal (Curitiba, Brazil); c) City Road Cemetery and Crematorium (Sheffield, UK); d) Cimitero di San Cataldo (Modena, Italy).

The last definition is not specifically a burial space because it can be applied to all types described previously. But as the term frequently appears in the cemetery context it will influence further analysis; therefore, its definition is important. Its scale is related to the burial space and for this reason, it has been incorporated into this chapter.

This term is extremely connected to cultural aspects and each cemetery will have its own parameters to decide when a burial space should be considered a **mausoleum** (Figure 27). It is a monument in honour of a person, an entire family or a group of people that were famous or had great social, cultural or economic significance. It can be intended for coffins as well as compartments and urns and is sometimes a stately and impressive building. It can be erected without containing the person's remains, in this case, it is called a "Cenotaph".

Figure 27 - Examples of tombs: a) Lazzarotto Family[12], Cemitério Municipal Água Verde (Curitiba, Brazil); b) Frédéric Chopin, Cimetière du Père-Lachaise[13] (Paris, France); c) Tancredo Neves[14], Cemitério da Ordem Terceira de São Francisco de Assis (São João del-Rei, Brazil); d) John Gray[15], owner of Bobby, Greyfriars Kirkyard (Edinburgh, Scotland).

[12] Napoleon Potyguara Lazzarotto (known as Poty Lazzarotto) was a Brazilian artist with works spread nationally and internationally, which can also be seen in the mural's decorations of his burial. The burials are characterized by the typical drawer shape of the niches and can be classified into different types. As a structure entirely above ground with access to the burials from the outside, it falls into the small niche structure type. But because of Poty's culture significance, his burial is considered also a mausoleum.

[13] The *Cimetière du Père-Lachaise* (Paris, France) houses the burials of celebrities from around the world, such as the grave of Frédéric Chopin, a Polish pianist and composer who died in 1849. His body is buried in Paris, but his heart was taken to Poland and is preserved in alcohol, as requested by him while still alive.

[14] Brazil's first democratically elected president after twenty years of military dictatorship, Tancredo de Almeida Neves. He was buried in his hometown in 1985, in the burial ground located behind the church of which he was an active member. His wife, Risoleta Tolentino Neves, was buried next to him in 2003.

[15] John Gray was the owner of Bobby, a dog that became famous for standing by John's grave for 14 years after he passed away. The story has been the inspiration for many movies and books, including the 1961 Walt Disney film entitled "Greyfriars Bobby: The true story of a dog".

3.2.3. Types of Burial Section

A burial section refers to an area inside the cemetery's perimeter. It is related to the overall layout of the cemetery and includes all of the different burial types present within it. The design of a cemetery is defined before its establishment, many times following some sort of concept (Dow et al., 2005) and it is natural that over time it undergoes changes to incorporate new services and adapt to social needs by introducing new sections.

The main parameter to distinguish these areas is the predominance of one or more types of burial spaces that characterize the physical space. It is important to clear up that they are not always and necessarily "unique", the use of these spaces is often more mixed than it seems. There are separate sections depending on the:

- position of burials (under or above ground level);
- location (outdoor and indoor);
- function[16] (space occupied by coffins, compartments or urns - see "Burial Size" in Subheading 3.2.1)[17].

The burial sections described are existing terms found during the site observations and in some cases adapted to the English language, but new terms were not created. Burial sections will be defined merging all parameters in a singular solution.

The **burial ground** is "any area for the burial of the dead" (Davies & Jokiniemi, 2008) and it can be used as the general term for an outdoor section containing any type of burial space or function. It can represent an area full of one type of burial space, e.g. small niche structure (Figure 28a), graves, tombs, etc, as well as an area with mixed types (Figure 28b and Figure 28c).

[16] The function for which burial spaces are designated highly influences its form, especially what regards its dimension. Another way of dividing the function of burial spaces is by age (baby or adult) and in some cases, cemeteries will dedicate a special section for the burial of children up to a certain age. This was not considered a parameter to frame burial spaces because it is not an international parameter, physically is a matter of size. In some cultures, families will prefer to bury their children in their own family burial space, while the choice of final disposition (burial or cremation are the ones being considered in this research) directly characterize the object to be buried (coffin, compartment and urn). To deal with these methods of disposition that emerged over time, cemeteries created areas specifically for each one of them.

[17] There are two burial moments: primary and secondary. Primary concerns the first stage after death, normally referring to the burial of the coffin containing a dead body. Secondary means the second stage, e.g., when the skeletal remains suffer an inhumation or an entombment process after the time permitted by the law, indicating their removal to another place inside the same burial plot or at another location specifically designed for it, the ossuary. However, there are differences regarding the ashes, sometimes the burial of ashes is considered primary because it is the first time that the remains are being confined. On the other hand, the cremation itself could be considered the primary burial because it is the first process after death, especially if considered that in some countries it is allowed to bring the ashes home or spread them into nature, so there will not be a secondary burial since the urn will not be confined inside a burial space.

Figure 28 - Examples of burial grounds: a) Cemitério Municipal Água Verde (Curitiba, Brazil)[18]; b) Highgate Cemetery (London, UK); c) Cimetière du Montparnasse (Paris, France)[19].

A **gravesite** is an area destined to receive burials, specifically coffins, on different types of graves. It is exclusively an outdoor space due to the technical requirements needed for underground burials. Even if large sections of graves with headstones (Figure 29a) allow a landscape with the presence of a lot of green and graves with landing stones (Figure 29b) give the impression of a more stately space, in most cases both types share the space in harmony (Figure 29c).

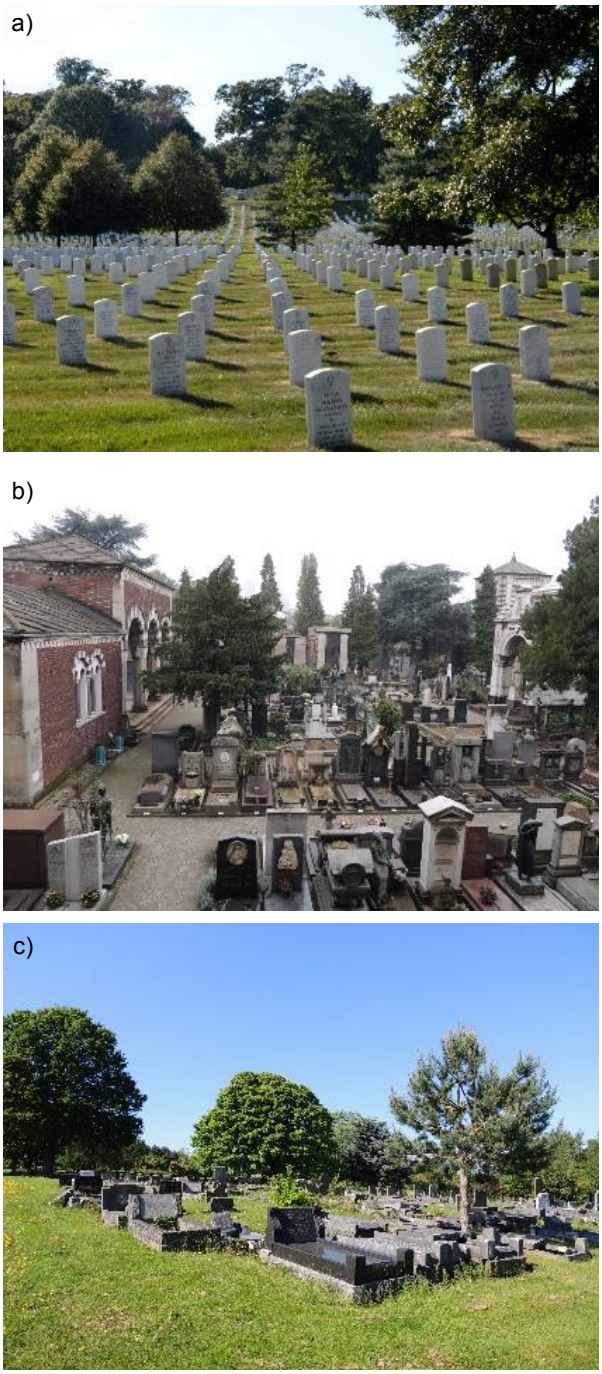


Figure 29 - Examples of gravesites: a) Arlington National Cemetery (Arlington, USA)[20]; b) Cimitero Monumentale di Milano (Milan, Italy); c) Abbey Lane Cemetery (Sheffield, UK).

[20] The image source is: adapted by the author from an original photo courtesy of Marta Calzolari.

Urnfield is an outdoor section similar to a gravesite layout. The difference is that here specifically urns holding the ashes after cremation are buried. In this case, the cinerary urns can be placed in open spaces as underground graves with a stele on top as a monument (Figure 30a) or a traditional headstone in courtyards (Figure 30b and Figure 30c).

Figure 30 - Examples of urnfields: a) Cimitero Monumentale di Milano (Milan, Italy); b) Crookes Cemetery (Sheffield, UK); c) Abbey Lane Cemetery (Sheffield, UK).

The **natural ground** is intended for natural plots (Figure 31). This type of burial section is managed to encourage wildlife and to look as close to a natural meadow or woodland as possible, with individual burial plots being indistinguishable compared to other burial types (Clayden et al., 2018). The deceased remains are buried underground and usually, a tree is planted above as a memorial. This outdoor area can accommodate coffins or urns made with biodegradable material.

Figure 31 - Example of a natural ground at Wisewood Cemetery (Sheffield, UK). The perception of space is that the area is a small woodland, with trees, tall grass, bushes and flowers. When the woodland grows old, it will merge with the existing vegetation at the edge of the cemetery, increasing the green areas of the city.

The last outdoor section is the **memorial garden**, a piece of land dedicated to the dispersion of cremated remains in a natural environment. They can be scattered or buried without the urn in distinct spaces where natural surroundings are predominant. Some cemeteries can make available a delimited space (Figure 32a) or allocate a large open area (Figure 32b and c) for this purpose.

If the cemetery allows, it is possible to place different types of memorials in memory of the deceased. The most common is a small metal plaque with little information like name, date of birth and death. Other materials can be used for the plaque, such as marble for example (Figure 33a). These plaques can be installed on benches, trees, walls (Figure 33b), concrete objects, etc. In alternative people may decide to create little memorials with personal objects, letters, and flowers (Figure 33c).

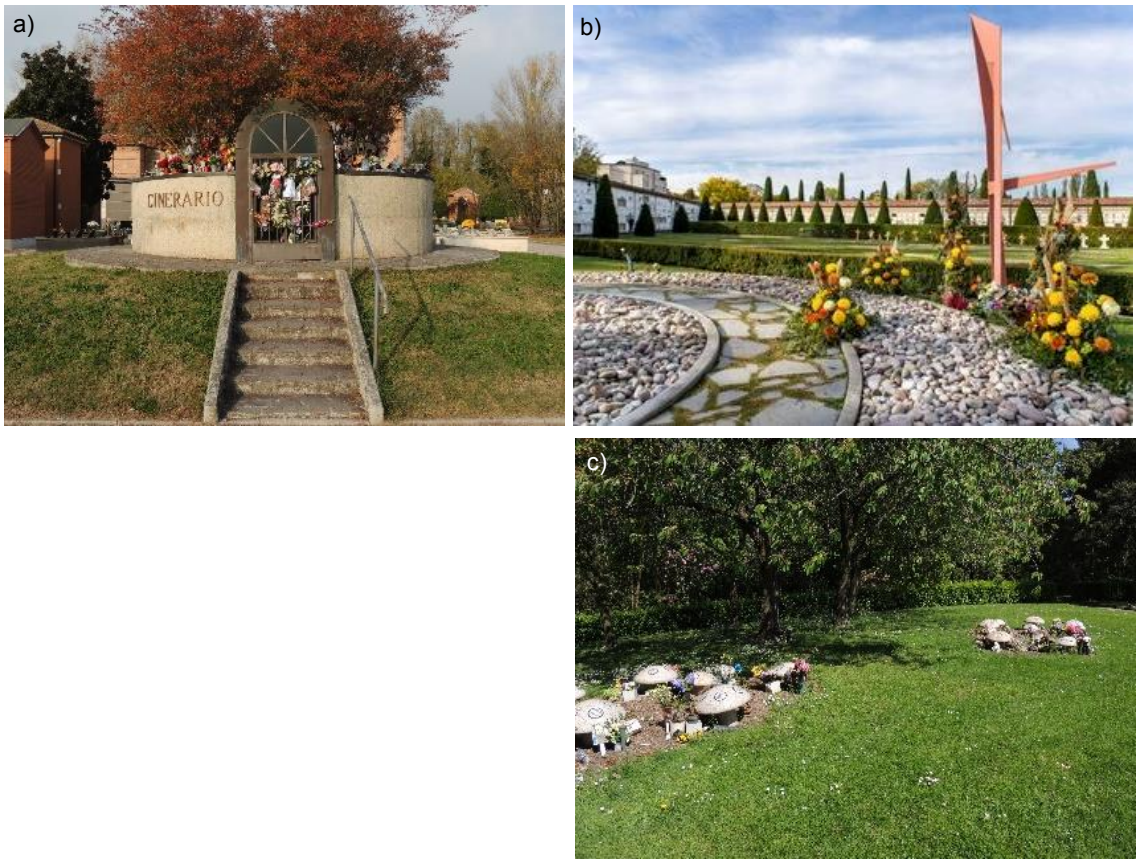


Figure 32 - Examples of memorial gardens: a) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy)[21]; b) Cimitero Monumentale della Certosa di Bologna (Bologna, Italy); c) Hutcliffe Wood Garden of Remembrance (Sheffield, UK).

[21] The image source is: adapted by the author from an original photo from Lopez Duarte & Davoli (2021).

Figure 33 - Examples of memorials: a) marble plaques at York Cemetery (York, UK); b) memorial wall at City Road Cemetery and Crematorium (Sheffield, UK); c) small personal objects at Hutcliffe Wood Garden of Remembrance (Sheffield, UK).

When the recycling of burial spaces is practised in a cemetery, the bones need to be removed to a secondary location to make room for future burials. The body is first buried and, after the time permitted by law, it is exhumated, the remains are kept inside a compartment and moved to the **ossuary**. Depending on the cemetery, the skeletal remains may be left inside the same burial plot (Figure 34a and Figure 34b), when this is not the case, sections are built for this purpose.

The **ossuary below ground** is usually a mass burial grave. It is a communal space, so there are no individual plaques to identify who is buried in this space. On the other side, the **ossuary above ground** is a structure for niches to store the containers (Figure 34c and Figure 34d). Each niche receives a plaque with the identification of the deceased and depending on the cemetery management, flowers, pictures or other decorations may be allowed.

Over time the ossuary was modified to adapt to the cemetery's layout, receiving different shapes and forms. The easiest one to identify as a burial section is a general niche structure built aboveground, usually creating an indoor environment for visitors.

The single niche can be used for public, individual or family burials. In sequence it means that unrelated individuals can be buried in the same burial space, only one individual will occupy the niche, or individuals from the same family are buried together.

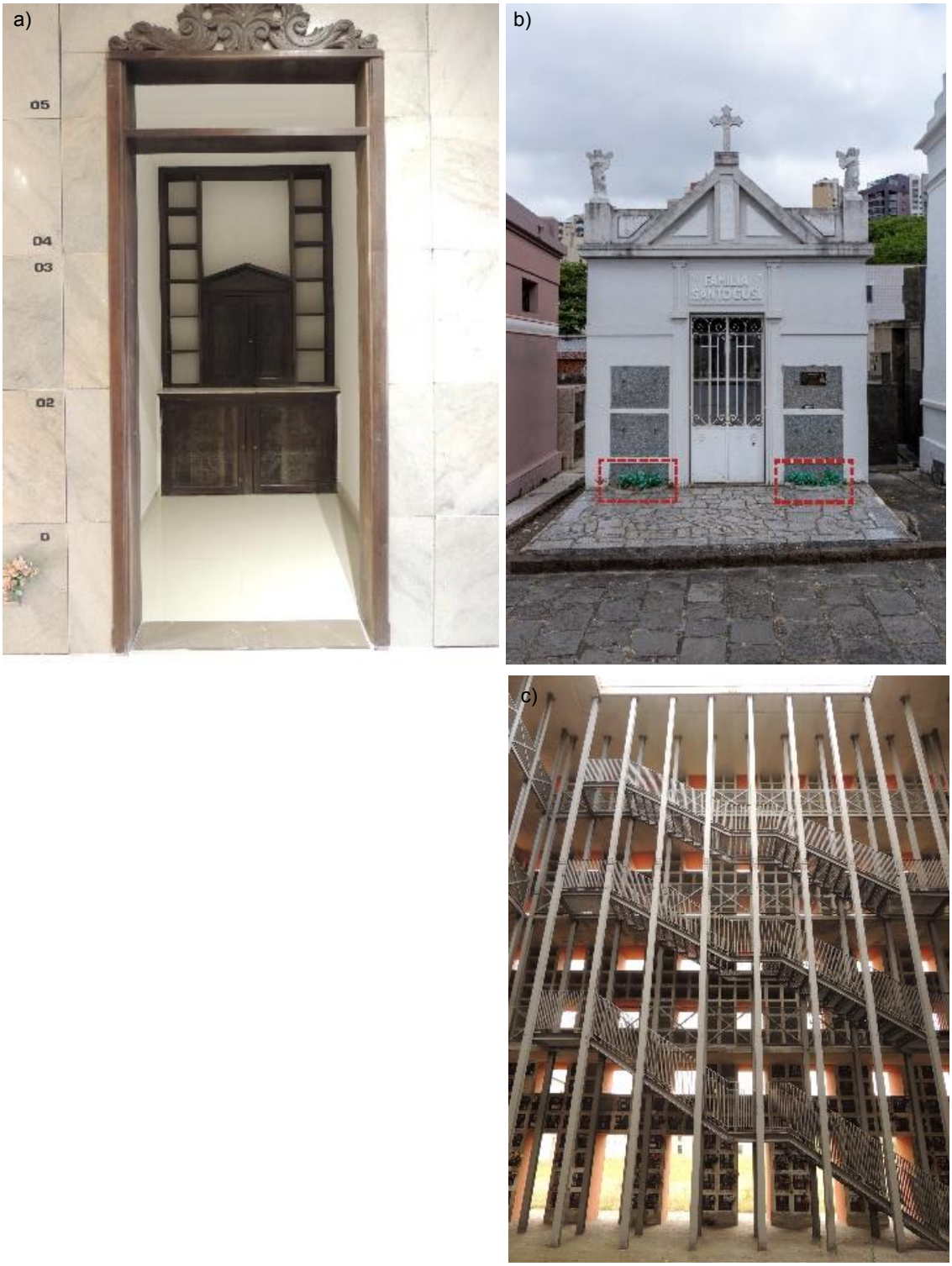


Figure 34 - Examples of ossuary's aboveground: a) Necrópole Ecumênica Vertical Universal (Curitiba, Brazil); b) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); c) Cimitero di San Cataldo (Modena, Italy).

In a similar structure made of general niche structure, the **columbarium** is a structure for individual or family niches designed for sheltering cinerary urns containing cremated remains. It can be located inside a closed room (Figure 35a and Figure 35c) or distributed in a single wall (Figure 35b), in either way it is an aboveground structure.

Figure 35 - Examples of columbariums: a) City Road Cemetery and Crematorium (Sheffield, UK); b) Cimetière du Père-Lachaise (Paris, France); c) Cimitero Monumentale di Milano (Milan, Italy).

Instead, the **catacomb** is a visitable underground space, consisting of tunnels and rooms with general niches dug into the wall or the floor (Figure 36). It is less impacting in terms of land use and yet not so common to be found in contemporary cemeteries. Niches are normally used for coffin burials, but due to the versatility of the space compartments and urns can share the same space.

Figure 36 - Example of a catacomb at the City of London Cemetery & Crematorium (London, UK). The building provides access to two different levels of the terrain, with elegant stairs on both sides. The main doors are the entrance to the catacomb, while the side doors lead to two ossuary's and a room with books of condolences.

Another space often found inside a cemetery is the **arboretum**, an area composed of a great number and a wide variety of tree species (Figure 37). As for the burial space, this term is considered a special term because it is not a place meant to receive burials, but it is possible to find sections inside the cemetery destined to be an arboretum. It is intended as a green sanctuary and a place for quiet walks, remembrance and reflection, sometimes the trees are spread between burial plots over the whole cemetery. The benefit of having tree diversity inside a cemetery is to preserve and enhance areas for wildlife habitat.

Figure 37 - Examples of cemeteries with a recognized arboretum: a) Arlington National Cemetery (Arlington, USA)[22]; b) The Woodlawn Cemetery Arboretum (New York, USA)[23]; c) Woodland Cemetery & Arboretum (Dayton, USA)[24].

3.2.4. Types of Cemetery Structure

Finally, the last scale to be evaluated is the entire cemetery structure, a piece of land located in an urbanized area that has been specifically designated to receive the remains of dead bodies from inhumation or entombment. It includes everything inside the cemetery perimeter, including burial spaces, burial sections and services buildings. The different types of cemetery structures are characterized by the following parameters:

[22] The image source is: adapted by the author from an original photo courtesy of Marta Calzolari.

[23] The image source is: https://www.woodlawn.org/about/history/. Retrieved May 17, 2022.

[24] The image source is: https://woodlandcemetery.org/visitor-photos/. Retrieved May 17, 2022.

- predominance of burial space and/or burial section;
- number of floors (single or multiple);
- function (space occupied by coffins, compartments or urns - see “Burial Size” in Subheading 3.2.1).

Some cemeteries are described based on their religious affiliation (Jewish, Muslim, etc) or by being designed for a specific community (military[25], prison, etc). However, following the same logic applied to previous types, the cemetery structures are analysed according to their physical configuration.

With this in mind, the first type easy to find is the **horizontal cemetery**, where the majority of burial elements are developed over the ground floor. It is possible to find burial sections that are located on buildings with no more than two or three floors above the ground level, living the perception that the structure as a whole is horizontal. This type of cemetery can also be defined as an “extensive cemetery” (Lopez Duarte & Davoli, 2021), because of the amount of land they occupy.

In this group, there are some particular types of cemeteries. The **regular cemetery** (Figure 38) is a general cemetery located in urban or suburban areas containing infinite combinations of different burial spaces and burial sections for all functions. This type of cemetery structure not necessarily is historical or monumental.

Figure 38 - Examples of regular cemeteries: a) Cemitério Municipal Água Verde (Curitiba, Brazil); b) Cimitero Ebraico di Ferrara (Ferrara, Italy); c) Bushey Old Cemetery (London, UK).

[25] *Arlington National Cemetery* (Arlington, USA) is considered also as a military cemetery, for example.

The **monumental cemetery** (Figure 39) initially emerged in France during the 19th century and it is characterized by a predominance of built spaces in relation to nature (see “Overall Visual Characteristics” in Subheading 3.2.1). This type of cemetery counts mainly with upright memorials of different sizes such as tombs, niche structures, mausoleums and graves with landing stones. Some specific burial sections can be located in the burial ground, such as the ossuary and the columbarium. Due to space flexibility, these burial spaces can accommodate all functions.

Figure 39 - Examples of monumental cemeteries: a) Cimetière du Montparnasse (Paris, France)[26]; b) Cimitero Monumentale di Milano (Milan, Italy); c) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy).

The **lawn cemetery** (Figure 40) was popular in the early 1900s and it is also known as “Park Cemetery” or “Memorial Lawn Cemetery”. This type of cemetery structure is an evolution of “Rural Cemeteries” (mid of the 1800s) and “Garden

[26] The image source is: adapted by the author from an original photo courtesy of Pietromaria Davoli.

Cemeteries" (end of the 1800s). It is easy for these cemeteries to receive the arboretum certification because of the large presence of trees.

The main characteristic is the pastoral scenery with a large open lawn setting, formally arranged gravesites and urnfields between green elements rationally placed. The preference is for uniformed graves, but also graves with stunning landing stones or simple niche structures can be found around a lawn cemetery. Some cemeteries started to implement natural plots as an alternative burial space, once it does not disturb the overall landscape.

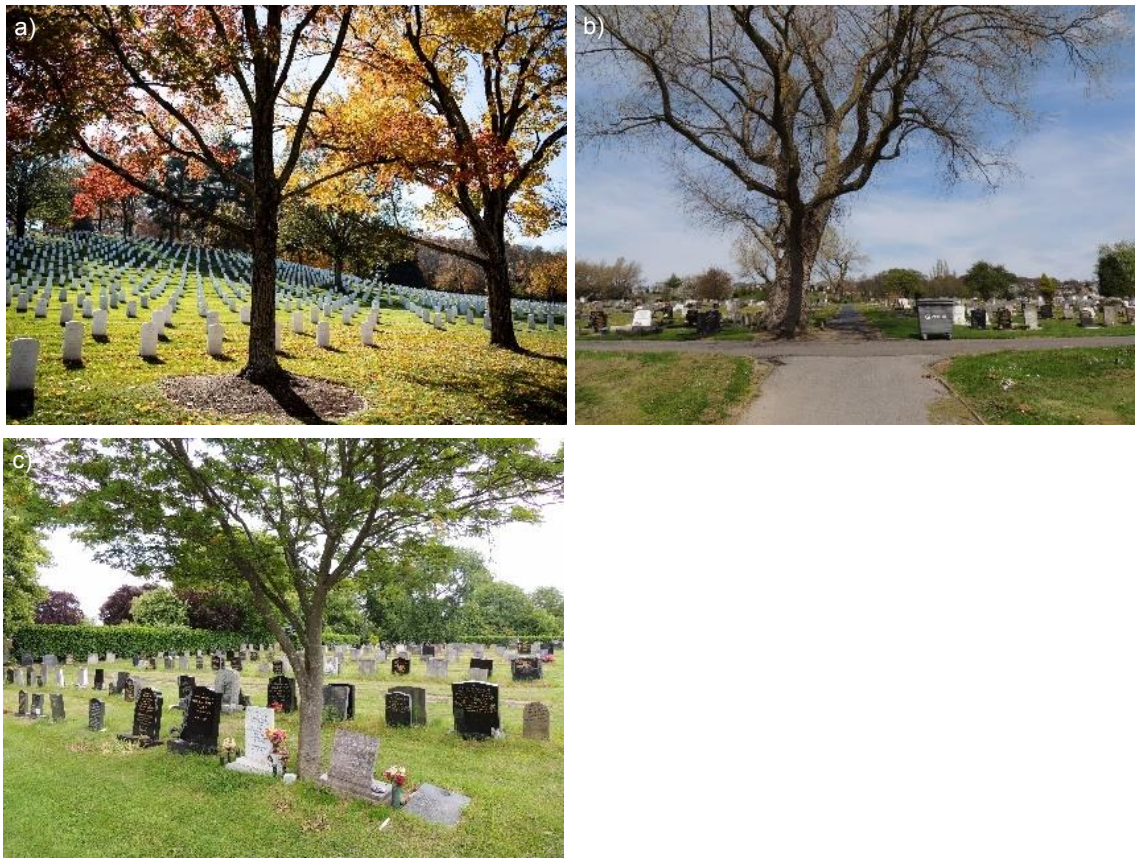


Figure 40 - Examples of lawn cemeteries: a) Arlington National Cemetery (Arlington, USA); b) Wisewood Cemetery (Sheffield, UK); c) York Cemetery (York, UK).

The **garden of remembrance** (Figure 41), also known as "Memorial Cemetery", is a cemetery structure composed mainly of the memorial garden type. It has similar characteristics to the "Lawn Cemetery", large lawn areas with a considerable number of trees and shrubs but without memorials that stand out above the ground. Niche structures and urnfields may also be present in this type of cemetery to accommodate cinerary urns.

It is a space intended for the dispersion of ashes with no defined burial plots, although flat markers made of stone or metal can be placed around the cemetery as a memorial of the deceased. As for the "Lawn Cemetery", these cemeteries are more likely to receive the arboretum title.

Figure 41 - Example of a garden of remembrance, the Hutcliffe Wood Garden of Remembrance (Sheffield, UK). The cemetery provides several different spaces for the scattering of ashes and the installation of memorials.

The **vertical cemetery** (Figure 42) is a contemporary solution for the lack of space in dense urban areas and it can also be defined as a "highly compacted" cemetery (Lopez Duarte & Davoli, 2021). It is a building organized on multiple levels (more than two floors) with a predominance of general niche structures, where for each floor there are batteries of niches arranged one above the other. Its configuration allows to create areas inside the building dedicated to ossuary's and columbarium's.

Figure 42 - Example of a vertical cemetery: a) entrance of the Necrópole Ecumênica Vertical Universal (Curitiba, Brazil); b) internal space for funeral events with an accessible round ramp that gives access to the upper floors; c) each floor has a series of corridors, called also "streets", that gives access to the niche's structures[27].

The **underground cemetery** follows the same principle of the "Vertical Cemetery" about the sparing of urban space. It is an underground building organized on multiple levels, with a predominance of niche structures for catacombs, ossuary's and columbarium's. On the lower level, it can also receive graves, as illustrated in Figure 43. The difficulty of this type of cemetery structure is the construction phase, meaning that it

[27] The images source is: adapted by the author from an original photo from Lopez Duarte (2019).

is complicated to be replicated. Another challenge is to ensure good conditions of accessibility, ventilation and lighting for visitors.

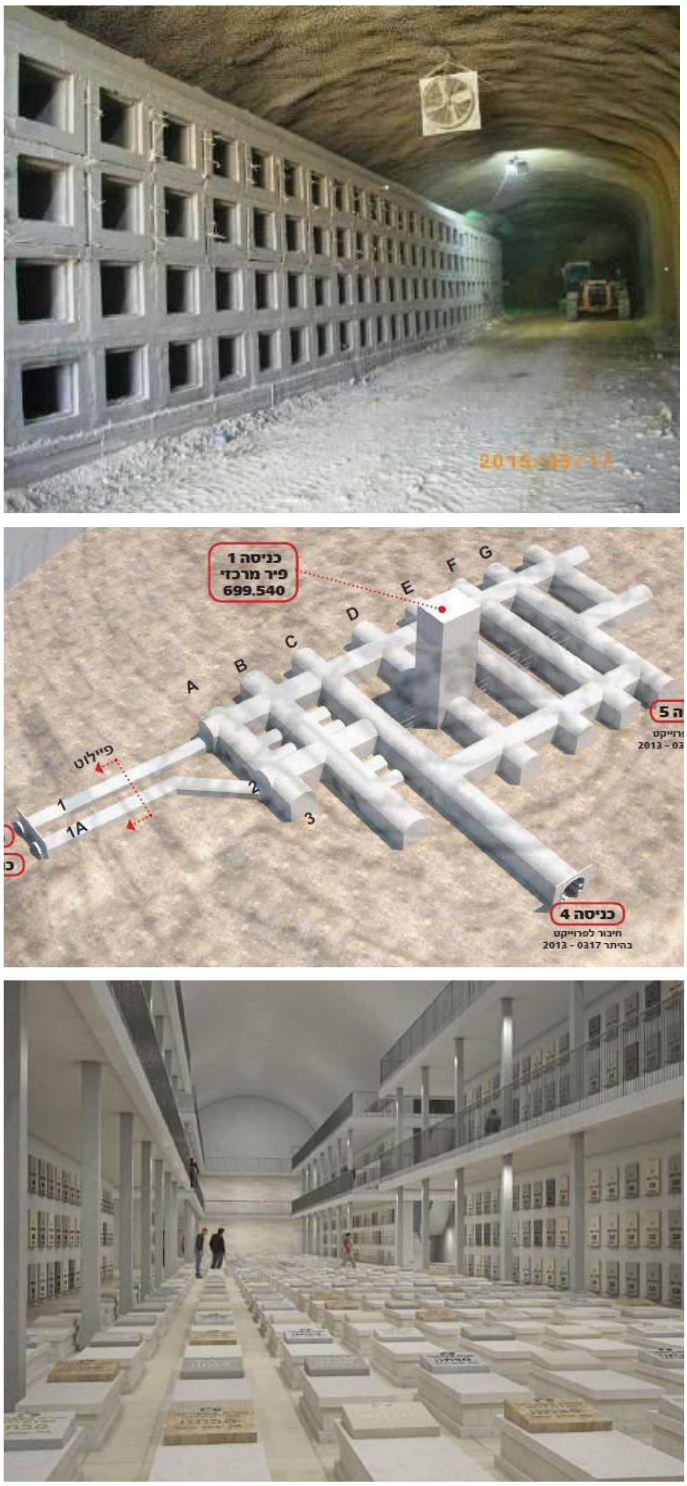


Figure 43 - Example of an underground cemetery, the Minharot Olam (Jerusalem, Israel). The structure was built under the existing cemetery to offer a greater number of burial spaces to the city. Four portals give access to the lower floors, at the same time that a shaft serves as an air plenum and a vertical entrance[28].

[28] The images source is: adapted by the author from an original photo from Glazer (2016).

The **churchyard** (or “Graveyard”) is not considered a cemetery structure. The main difference is that a churchyard contemplates the burial function of a church, but this last one offers also other religious services (weddings, baptisms, ordination of clergy, regular services, etc). Instead, when a chapel is established in a cemetery structure, it serves only for funeral purposes. Therefore, a “Churchyard” is managed by a specific religious affiliation and depending on the country it has more freedom in the decisions to be taken in the burial ground. For these reasons this term was not analysed in depth in this research, but it is important to acknowledge its existence.

Many churches still preserve the burial spaces inside their buildings (Figure 44a) or underground in catacombs (or “Crypts”), marked by wood panels or stone slabs for historical register. This practice is prohibited by most international laws, however, in some countries burials are still performed on the land located around or close to the main building (Figure 44b). Like other terms, it is an area destined for burials that in general can receive any type of burial space (Figure 44c).

Figure 44 - Examples of churchyards: a) Igreja de Nossa Senhora do Rosário dos Pretos (Tiradentes, Brazil); b) St Nicholas' Churchyard (Sheffield, United Kingdom); c) Cemitério da Ordem Terceira de São Francisco de Assis (São João del-Rei, Brazil).

3.2.5. Insights on Individual Types

In order to make a comparative analysis of single types of burial space, burial section and cemetery structure, the “Classification of general cemeteries features” was necessary and will further influence the research. The patterns from Subheading 3.2.1 were very important for the development of the cemetery’s categorization and to initiate a preliminary analysis of the cemetery’s configuration.

A table was created with all the information explained above in a synthetic mode. Each term is characterized by an icon and followed by a small description. They were all based on the parameters determined previously. In the last column, examples using real cases were used to illustrate the concept of the term. The purpose of these definitions is to study un deep specific cemetery elements.

Burial spaces (Table 6) were determined by their position (under or above ground level); the monument or structure over the burial, in terms of material (solid or natural) and dimension (amount of coverage area); and the proportion between the area occupied by the burial space and the burial plot.

The difference between the types of burial spaces, besides their position, is basically the characteristics of the memorial on their top. These elements can cover more or less of the burial plot, which will impact the amount of permeable area. Regarding the proportion of burial space and burial plot, underground burials respect more the relation between the burial space and burial plot, while aboveground burials usually occupy more space.

It is easy to notice these differences between the types of “graves” through the amount of coverage area occupied by the headstones. However, it is more complicated to classify aboveground burial spaces. “Small niche structures” and “General niche structures” have a substantial contrast in the dimension of the entire building that shelter individual niches, varying according to the “Burial Size” and to the “Density of Burials” (Subheading 3.2.1). Although both types allow to access each singular niche from a public pathway, the “tomb” is a type where the access to the singular burial space takes place inside the building itself.

About the burial sections, there is a change in the object of study that is now composed of several elements. For that reason, a section is defined so when a cert amount of area is dominated by one type of burial space. The scale of analysis still allows the classification of burial sections based on their position, the same parameter used for burial spaces. The major transformation is that sections start to create outdoor and indoor areas, together with another relevant attribute, the determination of the use of space.

In most cases, the first step to define a term is to combine the type of burial space with the use of space, which means that the analysis starts to relate the burial space with the final burial technique (see “Burial Size” in Subheading 3.2.1). At the same time, the burial location is related to its position: underground burials are usually located in an outdoor area while aboveground burials create an indoor space, with the only exception being the “catacomb”.

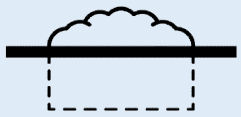
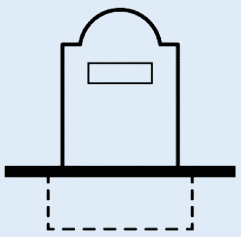
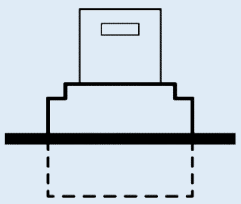
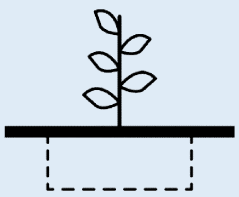
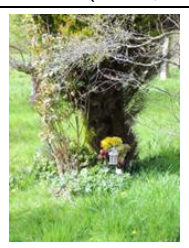
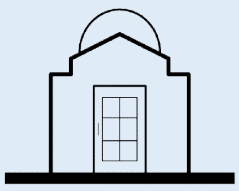
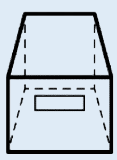
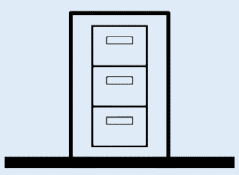
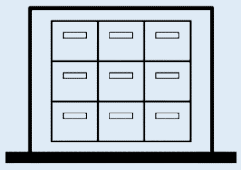
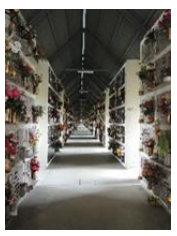
Not all burial spaces are placed in a specific burial section and normally the term “burial ground” tends to be used more generically. This term would refer to any burial areas that were not stipulated by the other terms, e.g., there is not a term that describes a burial section with the predominance of “tombs”. The same thing applies to an area occupied mostly by “small niche structures”.

The last type regards the cemetery structure as a unit composed of burial spaces, burial sections and functional elements. As for burial sections, cemetery structures also consider the use of space as a parameter to define its terms. Most cemetery types accept all uses, except for the “Garden of Remembrance”, which started to limit its burial functions. The evolution in the cemetery structure is the relevance that buildings have on the layout, translated as a parameter based on the number of floors.

Afterwards, planning the sections of a cemetery helps to design the entire burial structure by designating the use of space that the cemetery decides to make available to the public. The cemetery can have a horizontal development, occupying a larger area for the burials, or a vertical development. In the first case, the burial spaces are spread on a ground floor level, being possible to have a few buildings with no more than two or three floors. While underground burials tend to be more streamlined and less disturbing to the landscape, aboveground burials are inclined to have a salient design and dominate the scene.

Table 6 - Synthesis of the burial spaces described in Subheading 3.2.2. The icons and descriptions are based on the parameters defined for each term and real examples were used to illustrate them.

TYPES OF BURIAL SPACE

	TERM	ICON	DESCRIPTION	EXAMPLE
UNDERGROUND	GRAVE		**PUBLIC GRAVE:** • no monument; • surface covered entirely by soil; • no clear distinction between burial space and burial plot.	  General Example
			**GRAVE WITH HEADSTONE:** • solid headstone and/or kerb; • covered by a large permeable area; • burial space similar to a burial plot.	 *York Cemetery* (York, UK)  *Cimitero Monumentale di Milano* (Milan, Italy)
			**GRAVE WITH LANDING STONE:** • solid headstone covering the entire burial area; • covered by a small permeable area; • burial space similar to a burial plot.	 *Cimitero Monumentale di Milano* (Milan, Italy)  *Abbey Lane Cemetery* (Sheffield, UK)
	NATURAL PLOT		• preferably natural elements with the possibility to place small memorials; • entirely natural coverage area; • no clear distinction between burial space and burial plot.	   *Wisewood Cemetery* (Sheffield, UK)
ABOVEGROUND	TOMB		• solid structure house shaped with access to the burials from the inside; • entire surface of the burial is covered by impermeable area; • burial space much smaller than burial plot.	 *Cimitero Monumentale di Milano* (Milan, Italy)  *Cimitero Monumentale della Certosa di Ferrara* (Ferrara, Italy)
	NICHE 		**SMALL NICHE STRUCTURE:** • solid small structure with access to the burials from the outside; • entire surface of the burial is covered by impermeable area; • burial space smaller than burial plot.	  *Cemitério Municipal Água Verde* (Curitiba, Brazil)  *Hutcliffe Wood Garden of Remembrance* (Sheffield, UK)
			**GENERAL NICHE STRUCTURE:** • significant vertical building; • entire building covers more than the burial area; • burial space the same as burial plot.	  *Necrópole Ecumênica Vertical Universal* (Curitiba, Brazil)  *Cimitero di San Cataldo* (Modena, Italy)

SPECIAL TERM

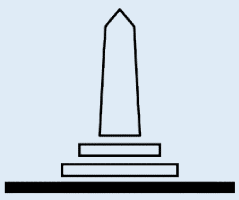
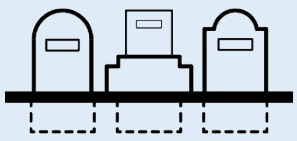
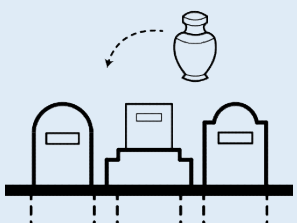
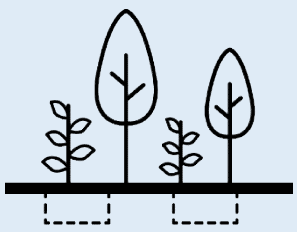
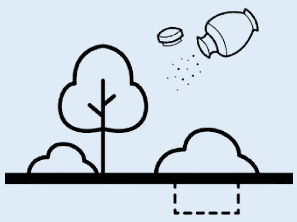
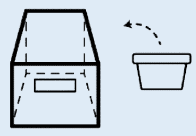
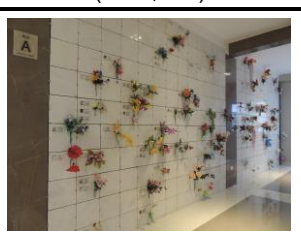
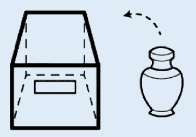
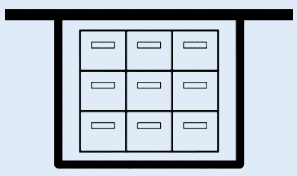
TERM	ICON	DESCRIPTION	EXAMPLE
MAUSOLEUM		• monument in honour of an individual or a group of people for social, cultural or economic reasons; • can be applied to any of the burial space terms described above.	 *Igreja de São Francisco de Assis* (São João del-Rei, Brazil)  *Cimetière du Père-Lachaise* (Paris, France)

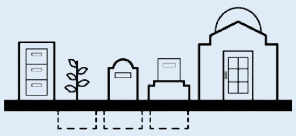
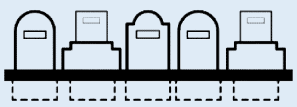
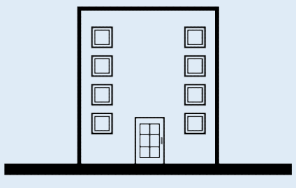
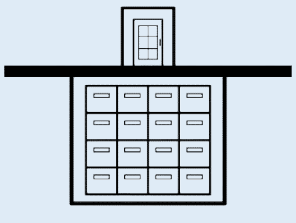
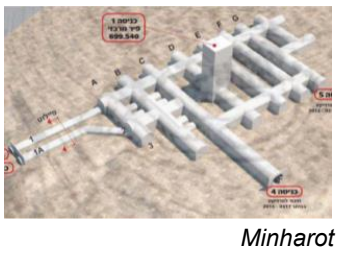
Table 7 - Synthesis of the burial sections described in Subheading 3.2.3. The icons and descriptions are based on the parameters defined for each term and real examples were used to illustrate them.

TYPES OF BURIAL SECTION				
	TERM	ICON	DESCRIPTION	EXAMPLE
OUTDOOR	**BURIAL GROUND**		• any burial space; • under or above ground; • coffins, compartments or urns.	 *Highgate Cemetery* (London, UK)  *Cimetière du Montparnasse* (Paris, France)[29]
	GRAVESITE		• graves; • underground; • coffins.	 *Arlington National Cemetery* (Arlington, USA)[30]  *Cimitero Monumentale di Milano* (Milan, Italy)
	URNFIELD		• graves; • underground; • urns.	 *Cimitero Monumentale di Milano* (Milan, Italy)  *Crookes Cemetery* (Sheffield, UK)
	NATURAL GROUND		• natural plots; • underground; • coffins or urns.	   *Wisewood Cemetery* (Sheffield, UK)
	MEMORIAL GARDEN		• no burial space; • buried or scattered; • ashes.	 *Cimitero Monumentale della Certosa di Bologna* (Bologna, Italy)  *York Cemetery* (York, UK)
INDOOR	**OSSUARY**		• niches; • aboveground; • compartments.	 *Cimitero di San Cataldo* (Modena, Italy)  *Necrópole Ecumênica Vertical Universal* (Curitiba, Brazil)
	COLUMBARIUM		• niches; • aboveground; • urns.	 *City Road Cemetery and Crematorium* (Sheffield, UK)  *Cimetière du Père-Lachaise* (Paris, France)
	CATACOMB		• niches; • underground; • coffins.	*City of London Cemetery & Crematorium* (London, UK) *Highgate Cemetery* (London, UK)

SPECIAL TERM: OTHER AREA INSIDE A CEMETERY				
	TERM	ICON	DESCRIPTION	EXAMPLE
	ARBORETUM		• not meant to receive burials; • a green sanctuary with a wide variety of tree species; • preserve and enhance areas for wildlife habitat.	 *The Woodlawn Cemetery Arboretum* (New York, USA)[31]  *Arlington Nat Cemetery Memorial Arboretum* (Arlington, USA)[32]

[29] The image source is: adapted by the author from an original photo courtesy of Pietromaria Davoli.
[30] The image source is: adapted by the author from an original photo courtesy of Marta Calzolari.
[31] The image source is: https://www.woodlawn.org/about/history/. Retrieved May 17, 2022.
[32] The image source is: adapted by the author from an original photo courtesy of Marta Calzolari.

Table 8 - Synthesis of the cemetery structures described in Subheading 3.2.4. The icons and descriptions are based on the parameters defined for each term and real examples were used to illustrate them.

TYPES OF CEMETERY STRUCTURE				
	TERM	**ICON**	**DESCRIPTION**	**EXAMPLE**
SINGLE FLOOR	**HORIZONTAL CEMETERY**		**REGULAR CEMETERY:** • wide range of burial spaces and burial sections; • all functions; • non-historical and non-monumental.	 *Cemitério Municipal Água Verde* (Curitiba, Brazil)  *Cimitero Ebraico di Ferrara* (Ferrara, Italy)
			**MONUMENTAL CEMETERY:** • tombs, niche structures, mausoleums, graves with landing stone, ossuary and columbarium; • all functions; • predominance of built spaces.	  *Cimitero Monumentale di Milano*[33] (Milan, Italy)[34]  *Cimitero Monumentale della Certosa di Ferrara* (Ferrara, Italy)
			**LAWN CEMETERY:** • gravesites and urnfields combined with simple niche structures and sometimes natural plots; • all functions; • large open lawn setting.	 *Arlington National Cemetery* (Arlington, USA)[35]  *Crookes Cemetery* (Sheffield, UK)
			**GARDEN OF REMEMBRANCE:** • memorial garden, niche structures and urnfields; • urns and ashes; • no memorials above the ground.	  *Hutcliffe Wood Garden of Remembrance* (Sheffield, UK)
MULTIPLE FLOORS	**VERTICAL CEMENTERY**		• general niche structure, ossuary and columbarium; • all functions; • “highly compacted” cemetery.	 *Necrópole Ecumênica Vertical Universal* (Curitiba, Brazil)[36]  *Memorial Necrópole Ecumênica* (Santos, Brazil)[37]
	UNDERGROUND CEMETERY		• general niche structure, catacomb, ossuary and columbarium; • all functions; • underground building.	  *Minharot Olam* (Jerusalem, Israel)[38]

SPECIAL TERM: OTHER TYPE OF BURIAL SITE				
CHURCHYARD or GRAVEYARD		• any burial space; • all functions but mainly coffins; • single floor; • managed by a religion affiliation.	 *St Nicholas' Churchyard* (Sheffield, UK)	 *Cem. da Ordem 3ª de São F. de Assis* (São João del-Rei, Brazil)

[33] The Falck’s family burial space is located in a position of prestige in the *Cimitero Monumentale di Milano* (Milan, Italy). In the shape of an obelisk, it has 19 meters high and is decorated with sculptural elements in honour of Luisa Falck, a little girl that passed away at the age of eight in 1944 (left picture). In the same way was built the tomb of the Bocconi family, an imposing architecture culminating in the monolithic canopy that rises up to 20 meters in height. Starting in 1986 and following the extinction of the Bocconi family, the Bocconi University took over the maintenance of the burial (right picture). Both families were widely respected and admired in Milanese society. These mausoleums are tall as a five-floor building.

[34] The images sources are: https://monumentale.comune.milano.it/monumenti/edicola-falck and https://monumentale.comune.milano.it/monumenti/edicola-bocconi. Both retrieved January 14, 2022.

[35] The image source is: https://www.flickr.com/photos/arlingtonnatl/albums/72157720170770011. Retrieved January 20, 2022.

[36] The image source is: adapted by the author from an original photo from Lopez Duarte & Davoli (2021).

[37] The image source is: adapted by the author from an original photo from Glazer (2016).

[38] The images source is: adapted by the author from an original photo from Glazer (2016).

3.3. INTERPRETATION OF DIFFERENT CONTEXTS OF A CEMETERY

Common themes appearing in the site analysis provided some key observations to the interpretation of different contexts within the cemetery, giving a more systematic approach to understanding the data collected. It also supported the development of the sustainable guidance system because of its greater influence over strategy parameters and decision-making.

The previous analysis allowed the creation of a scale hierarchy for the evaluation of the cemetery contexts. The scale goes from the largest and most broad to the smallest and most specific level of analysis. It is then possible to divide the existing cemetery structures into four contexts: Urban Infrastructure, Outdoor Environment, Built Asset and Cultural Heritage.

Cemeteries are usually large sites located in urban areas or close to them, therefore their implications are not limited to their property lines. The **Urban Infrastructure** regards the relationship between the cemetery structure and its urban context. It looks at the pre-existing conditions around the site and its relationship with the surroundings, meaning that what is being evaluated is the connection of the cemetery with the environment located outside its perimeter.

First of all, it is fundamental for cemeteries to define the scope of the regeneration plan. They can focus on different aims, from social, environmental and economic aspects. Connected to the aim, there are several possible analyses to perform, including patterns related to points of access to the site, accessibility, movement and circulation flow for vehicles and pedestrians, proximity to urban green areas, tourists and educational routes, etc.

All other contexts look at the site conditions. The next one is the **Outdoor Environment**, which refers to the open space of the cemetery and the public-private area (see Subheading 2.7.2) where people have the right of way through the site. This is the most likely feature aspect for “Horizontal Cemeteries”, mainly characterized by the landform of the terrain and its surface form in the landscape

This second context relates to the material conditions of a site, more specifically to the need for the open space to rely on different utilities, e.g., electricity, gas, water, sewer, drainage and telephone services. It includes underground and above-ground structures along with accurate distances, depths and materials.

The **Built Asset** relates to the current context of existing buildings, facilities and any other built items on the site. It needs to be analysed if there are any historical buildings or buildings of particular significance on the site and their state of repair. Even though the burial site is usually located in the open space of the cemetery, it has to follow a construction plan as other built elements.

The last context, the **Cultural Heritage**, includes all the other contexts. It regards the human and cultural aspects of the cemetery, records of people buried, their history, the funerary rituals and everything intangible.

3.4. FUNCTIONAL ELEMENTS OF A CEMETERY STRUCTURE

Finally, the site observation included the identification of several elements considered important to the operation of a cemetery structure. This analysis led to a programming process, which aimed to gather and examine information related to the sustainable management of the site. The outcome is the groundwork for developing solutions later in the guidance system.

Each element is connected to one of the contexts previously described and their influence on the sustainable management will be interpreted in CHAPTER 4. Here, an inventory of functional elements describes how they appear within the cemetery.

3.4.1. Urban Infrastructure

The functional elements of the “Urban Infrastructure” are connected to the urban surroundings. It is about the relation of the internal space with the space just around the cemetery’s boundary (internal x external). Below there is an explanation of the current situation of cemeteries in relation to each element, describing not just the criticalities related to them, but also their potentialities.

Zoning and Land Use planning

This element is related to urban planning while the others are at the cemetery design level. Cemeteries are infrastructures of great impact on the city and are in constant relation with the urban surroundings. Because the cemetery structure is very connected to the structure of the urban fabric, it has to incorporate considered responses to the external conditions. It means that a dialogue between the cemetery and the urban context is fundamental to enhance its value.

As a result, municipalities usually have planning control tools (Zoning and Land Use) to shape the development of the built environment and to trace the city’s growth. These tools consist of the division of the land into sections and the establishment of particular land uses on specific sites. When this planning is done with sustainable goals, it can bring great benefits to the city.

Unfortunately, an overall vision of cemetery structures as a necessary infrastructure is frequently missing during the definition and categorization of land-use policies. So, the intention is to improve the urban environment through the cemetery structures by integrating them into other urban infrastructures during the urban planning process. They can guarantee proper accessibility, support cultural opportunities, promote better connection with the surroundings and provide green spaces for visitors and inhabitants.

Connection with the urban fabric (social aspect)

The urban fabric defines the physical characteristics of the urban space, including components such as streets, roads and circulation spaces, buildings, signage, street

lighting and other infrastructures. In order to improve the “Urban Infrastructure”, it is necessary to analyse the relationship between these components and the structure of the cemetery.

Normally cemeteries are required by law to be fenced for several reasons (Marino, 2014; Sales Machado, 2006), e.g., to protect from sanitary conditions, to preserve a sense of privacy and respect, to mark the sacred ground area, to avoid vandalism and grave robbing, etc. The perimetral wall, characterized by fences or boundary walls that in some cases can reach five meters high (Bazaraite et al., 2014), surrounds the cemetery and separates the burial area from the rest of the city.

Over time, this segregation caused cemeteries to become dead islands within the urban context. Depending on its dimension, it creates a huge barrier that blocks both the transition of people and vehicles, as well as the continuity in the city's morphology. It is possible to see this obstacle in Figure 45, where the cemetery’s wall is a long boundary for road circulation.

The site observation revealed that it is quite useful to have the possibility to access the site through different entrances. Always considering the dimension of the cemetery, the travel time to go around the site would be quite uncomfortable for citizens and visitors. Thus, if people have few options to access the site from different points of the city, it would improve urban circulation.

The cemetery structure also influences the presence of specific buildings and signage in its surroundings. Flower shops, headstones and markers companies and coffee bars are some examples (Figure 46) of commercial activities found around cemeteries during the site observation. On the other hand, it would be better to avoid some functions close to a cemetery for health risks (see Subheading 2.6).

Figure 45 - For security reasons, the Cemitério Municipal Água Verde (Curitiba, Brazil) had to install barbed wire and close the secondary entries to prevent vandalism and grave robbing.[39]

[39] The images source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

Figure 46 - Examples of buildings nearby a cemetery structure: a) flower shop in front of the Cimitero Monumentale di Milano (Milan, Italy); b) company that sells stones for monuments at the City Road Cemetery and Crematorium (Sheffield, UK); c) coffee and snack car bar in front of the Highgate Cemetery (London, UK).

Urban Accessibility (social aspect)

People tend to attend cemeteries to pay tribute to their loved ones that have deceased, spending time decorating and taking care of the burial site. Visits happen more often around the holidays or special days with personal meanings. The number of people visiting the cemetery also increases during funeral services. For these reasons the cemetery needs to have easy connections to public transport and infrastructure services, allowing people to reach them in any possible way.

Existing cemeteries are not always located close to urban centres. The city's growth and the urbanization process moved the cemetery away from visitors, making it necessary for people to travel long distances. Thus, this functional element ensures that the cemetery is connected to the urban system in every possible way, from car parking and public transportation to cycle routes and pedestrian walkways.

Connection with existing urban environmental conditions (environmental aspect)

Although greener planning has a great impact on reducing climate change effects on the urban environment, it is usually missing during the process of urban planning. Despite this factor, the connection of natural spaces (gardens, tree-lined streets, ecological and ventilation corridors, urban woodlands and other green spaces) aims to protect urban natural resources, ensure the continuity of the landscape and improve the urban environment.

Cemeteries can play an important role in this scenario because they are generally a great infrastructure within the municipality's area, allowing a strategic position in relation to urban environmental conditions. This element is related to the "Urban Infrastructure", thus from an operational point of view, it aims to connect the cemetery with structures outside its perimeter. They can be other cemetery structures or even green urban spaces.

Connection with existing educational programmes and tourist routes (cultural aspect)

It is related to the "Cultural Heritage" context.

3.4.2. Outdoor Environment

What regards the "Outdoor Environment", its functional elements are related to the operation of the open space of a cemetery structure. Different from the previous context, this one examines the relationships between components inside the cemetery perimeter (interior x interior). They describe the current scenario of spatial elements within the cemetery, their situation and also the problems related to them.

Site Topography

Cemeteries are large structures with a complex spatial layout that is divided into several burial elements (Figure 47). For this reason, it is directly in contact with the topography and all elements of the landform, it is an element of the topography defined by elements such as changes in level, slope, stratification and soil type. It normally coexists with natural features like vegetation, greenery, lawn, shrubs, trees, animals, etc.

Figure 47 - Examples of the cemetery's landscape: a) the strong relation of the Cemitério Municipal Água Verde (Curitiba, Brazil)[40] with the urban network, having some green elements around its perimeter; b) the expansion area of the City Road Cemetery and Crematorium (Sheffield, UK), spreading towards the boundary with the Manor Fields Park; and c) the alternative landscape at the City of London Cemetery & Crematorium (London, UK) for the disposal of ashes.

[40] The image source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

Logistic Information System (signboards and plaques)

In the cemetery, there are signboards for different uses, such as informational and directional maps and signs, regulations, buildings and section areas identification, street and road signs, and even biodiversity information (Figure 48). Its purpose is to lead visitors, during the difficult time of the loss of a loved one, inside the cemetery through logistics, orientation and educational information.

Figure 48 - Examples of different types of information found during the site observation: a) map at the entrance of the Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); b) historical information about the Cimitero di San Cataldo (Modena, Italy), located between the old and the new part; c) people and wildlife information at the York Cemetery (York, UK); d) car traffic information at the Hutcliffe Wood Garden of Remembrance (Sheffield, UK)

Water Support System

Hydrological objects can be presented in different ways in the cemetery. Water taps (Figure 49) are the first element easy to notice. They can be used by visitors to take care of the burial space of their loved ones by cleaning and watering plants or to support an irrigation system for the site's vegetation maintenance. In addition, rain gardens, water reservoirs, sewerage and other water elements can be present within a cemetery.

Figure 49 - Example of water points found during the site observation: a) Abbey Lane Cemetery (Sheffield, UK); c) Highgate Cemetery (London, UK).

Lighting System and Electrical Support

Lighting and energy are related to many utilities needed for the operation of a cemetery. It is determined by whether electricity, as well as gas, telephone and all other services, are located and connected to the land. In the outdoor environment, a planned lightning system is important to ensure safe mobility around the site. For all that, cemeteries need to rely on power poles.

Some cemeteries do not allow lighting candles close to burial spaces, so to satisfy the visitor's wish, they have installed electrical candles in individual burial spaces.

Security System

As indicated in the element "Connection with the urban fabric" from the "Urban Infrastructure", cemetery structures are susceptible to intrusion, vandalism and grave robbing. To avoid these inconveniences and to ensure protection for visitors, many

cemeteries count with a video surveillance system of their internal space, covering all the indoor and outdoor burial sections. In addition, the entire perimeter and all possible accesses (gates and boundary walls) should be controlled by a security staff.

Another type of security that needs to be considered in a cemetery is that of the burial spaces and its memorials (Figure 50). Some of them are left abandoned and become unstable, presenting a risk to public safety. The cemetery can intervene in public spaces, but when the burial space is privately owned, the cemetery staff is only allowed to lay down the monument to remove the risk. The owner receives a notification about the need to repair the burial space, and failing to do so they may lose the right to burial.

Figure 50 - Examples of risks for public safety: a) monuments laid down to avoid harming someone at the Abbey Lane Cemetery (Sheffield, UK); b) closed area for pedestrian access due to the risk of falling wall covering at the Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); c) danger warning of monument instability at the Highgate Cemetery (London, UK).

Material Waste

The burial area has to deal with organic and compostable waste mixed with not recyclable materials. The waste can vary from flowers, candles, photos, decorations and any other objects that people decided to leave as a memory for the deceased. Therefore, to optimize the maintenance work and to keep the cemetery clean it is normal to see trash cans distributes across the site (Figure 51).

Figure 51 - Examples of treatment of material waste in cemeteries: a) Crookes Cemetery (Sheffield, UK); b) Cemitério Municipal Água Verde (Curitiba, Brazil)[41]; c) Abbey Lane Cemetery (Sheffield, UK).

Use of Materials

This functional element is connected to the topic “Overall Visual Characteristics” in Subheading 3.2.1 and the presence of built-up elements or green elements. Depending on the cemetery’s layout, surfaces and materials around the site will influence the sustainable performance of the cemetery. It is related to the materials used for the construction of the outdoor environment (Figure 52). Areas covered mainly by built-up elements block the soil permeability, while natural elements increase the maintenance work of the site. Another example of this influence is the characteristic of materials to reflect sunlight, which contributes to increasing or decreasing the greenhouse effect.

Figure 52 - Examples of surfaces and materials present in a cemetery structure: a) at the Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy) the overall visual is that of a space with the predominance of built-up elements, but at least the pathways are cover with permeable materials and there is a little presence of green elements; b) instead at the Cemitério Municipal Água Verde (Curitiba, Brazil)[42] the atmosphere is much more impermeable; c) the Abbey Lane Cemetery (Sheffield, UK) has a large green area, which requires a lot of maintenance such as mowing grass, collect leaves that fall from trees and use of pesticides.

Road System

Cemeteries are infrastructures that usually occupy large areas inside the urban area. Exploring all of it may require time and the landscape may prove to be a challenge for some people, with ramps, paths, streets, and avenues across the site (Figure 53). A cemetery is a place where citizens go to visit their loved ones that passed away, and

[42] The images source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

everyone has the right to have access to the burial space. It refers to external areas, including paved and not paved circulation systems.

In some cases, it is possible to access the site with private vehicles, even though the majority of the cemeteries visited allow only staff vehicles to circulate. Depending on the cemetery scale, the only possible mobility is for pedestrian movements. However, regardless of the method of transportation used for movement, in many cases, the current provisions are feasible for disabled access.

Figure 53 - Possible scenarios of a road system in a cemetery structure: a) the best solution for a road system that needs to overcome a sloping ground is an organic layout form, as in the Glasgow Necropolis Glasgow (Scotland); b) it is possible to notice how the ground is sloping at the Cemitério Municipal Água Verde (Curitiba, Brazil)[43]; c) main street that splits into secondary paths at the Highgate Cemetery (London, UK).

Green Element System

Vegetation is normally present inside cemeteries in form of trees, shrubs, climbers, flower meadows, herbs and grassland. Depending on the culture and the morphology it will be present in a large or small amount (Figure 54). The scale of the green element system regards the effects that the outdoor environment of a cemetery may cause on users.

It can have different roles in the composition layout, e.g., decoration, structuring of space, and structuring of landscape, which contributes to sharing the area with different animal species.

[43] The images source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

Figure 54 - Examples of green elements: a) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); b) York Cemetery (York, UK); c) Abney Park Cemetery (London, UK).

3.4.3. Built Asset

The “Built Asset” includes all built elements represented by a building, a single structure or also a burial space. At the site observation, it was found public and religious buildings (funeral parlours, chapels and other ritual facilities), commercial and administrative buildings (offices, florist, coffee shops, memorials store and public information centre), service and technical facilities (toilets, crematoria, mortuary, inhumation services and tanks to store chemicals, water and effluents) that are also considered part of the cemetery.

Heated Buildings

Even if buildings represent only a small portion of a cemetery, it is necessary to acknowledge their existence for a fully sustainable development of these spaces (Figure 55). It is well known that existing buildings are currently largely inefficient, in particular with regard to energy and water wastage. They could reach good environmental performance standards by rethinking the way of using them.

Figure 55 - Examples of heated buildings in a cemetery structure: a) crematoria at the Cimitero Monumentale di Milano (Milan, Italy); b) multi-functional space at the York Cemetery (York, UK); c) at the entrance building of the Highgate Cemetery (London, UK), on the left there are the administrative offices and at the right, there is the chapel and tickets office; d) coffee shop and toilets at the City of London Cemetery & Crematorium (London, UK); e) funeral parlour at the Necrópole Ecumênica Vertical Universal (Curitiba, Brazil); f) Church of San Cristoforo alla Certosa of the Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy).

Unheated Buildings and Construction Structures

It is possible to find a fair amount of unheated buildings in a cemetery (Figure 56). They may be public access used for multiple services, e.g., structures and shelters for funeral events in open spaces. Others can serve for technical purposes, being accessed only by members of the staff to undergo maintenance work. Those constructions can contribute to the sustainable scenario of the cemetery with similar guidelines applied for heated buildings.

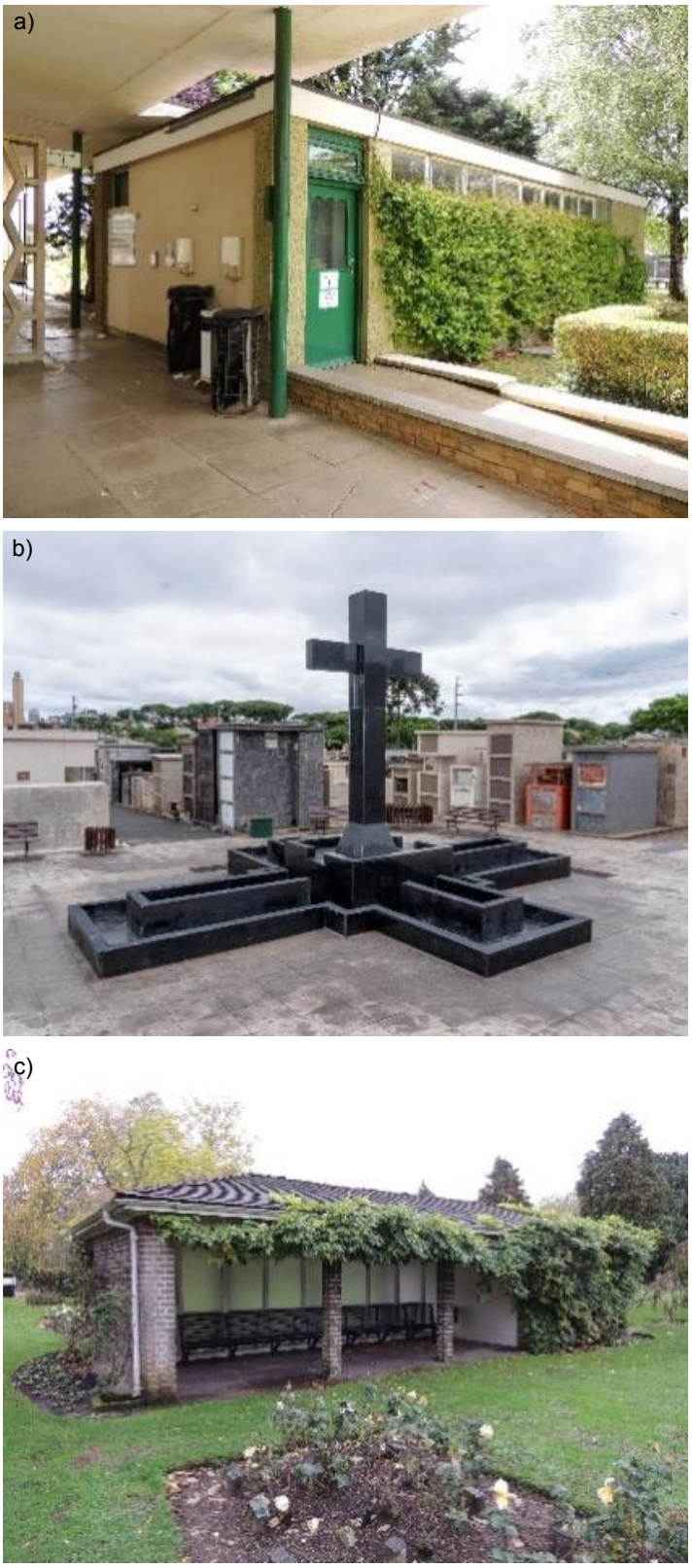


Figure 56 - Examples of unheated buildings and construction structures found at the site observation: a) toilets at the Bushey Old Cemetery (London, UK); b) religious sign at the Cemitério Municipal Água Verde (Curitiba, Brazil)[44], where visitors can light candles instead of close to the burial space; c) sitting area within the City of London Cemetery & Crematorium (London, UK).

[44] The images source is: adapted by the author from an original photo courtesy of Fillipe Duarte.

Accessibility

Everyone has the right to have access to all the facilities of a cemetery structure, whether they are staff members or visitors. Therefore, it is necessary to ensure a walkable system (Figure 57) for pedestrians within the buildings that is safe and accessible for all ages, with disabilities or baby carriages, etc.

Figure 57 - Examples of accessible entrances: a) ramp and stairs of access at the Hall of Remembrance and Toilets at the Hutcliffe Wood Garden of Remembrance (Sheffield, UK); b) toilets and baby changing room fully equipped for disable accessibility at the City of London Cemetery & Crematorium (London, UK); c) the historical character of the cemetery makes it difficult to install a disabled lift, leaving stairs as the only access the ossuary at the Cimitero Monumentale di Milano (Milan, Italy), but the handrail serves as a support for children, elderly any other person.

Burial Components

Burial components are built structures classified in Subheading 3.2.5 and extremely related to the “Outdoor Environment” (Figure 58). They are a symbol of family, culture and history. In some cemeteries there are only a few types of burials available, not giving the possibility to choose and use specific types.

Figure 58 - Examples of burial components: a) Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy); b) City Road Cemetery and Crematorium (Sheffield, UK); c) Cimitero Monumentale di Milano (Milan, Italy).

3.4.4. Cultural Heritage

This context is related to intangible elements such as sentiments, memory, history and culture. These elements may become tangible information when they are communicated to others. There is a first step of collecting data, to then proceed to decisions about communication strategies. All these elements compose a cemetery.

Historical Wealth and Identity Value

Compared to local and recent history, burial spaces are places of emotional ties between the living and the dead. They are evidence of historical-civil values (Figure 59) that reveals a love of the country, glory and heroism as an act of personal history. The person who goes to the cemetery and recognizes that space as theirs, defines the identity aspect of those who visit and use the space frequently. The “Monumental Cemetery” is usually recognized by its Historical Wealth and Identity Value.

Figure 59 - Cemeteries are characterized by a lot of history, for example: a) the Cimitero di San Cataldo (Modena, Italy) is an extension of the old part, the Cimitero Monumentale Costa, built in 1971 by Aldo Rossi and Gianni Braghieri; b) the Cimetière du Père-Lachaise (Paris, France), the largest cemetery in Paris and internationally recognized; c) also cemeteries located in small urban areas may be largely known, e.g. the Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy).

Cultural Wealth

Cemeteries usually have landmarks located across the site (Figure 60), a representation of cultural and societal beliefs. They can have local, national or even international significance, leading to different management strategies.

Figure 60 - Examples of burial Spaces with a cultural value that influence the cemetery structure: a) people leave coins and notes on the Karl Marx burial space at the Highgate Cemetery (London, UK); b) Giorgio Bassani is a well-known character at the Cimitero Ebraico di Ferrara (Ferrara, Italy), where people place stones at his burial space as cultural respect; c) the Tomb of Dante (Ravenna, Italy) is a tomb with international cultural influence;

Information Exchange System

All the previous information, from history, identity and cultural aspects, should be transmitted to visitors in any form (Figure 61). It regards the “Logistic Information System”

in the “Outdoor Environment” (Subheading 3.4.2), but it includes also educational programmes such as school tours or tourist activities.

Figure 61 - Examples of possible information systems within a cemetery structure: a) the management office of the York Cemetery (York, UK) provides several information about cemetery activities and urgent contacts; b) information at the Bushey Old Cemetery (London, UK) about the Jewish tradition of washing hands in a cemetery next to available Notes for the Guidance of Persons Visiting Graves; c) history data at the Abney Park Cemetery (London, UK).

3.5. CONCLUSION OF CHAPTER 3

The CHAPTER 3 analyses specific characteristics of a cemetery structure and its actual situation within different international realities. Site observations revealed their selves to be a great methodology for this study. It made it possible to understand how a cemetery structure operates and gave some insights for a comprehensive but not exhaustive definition of burial terms.

The result is a list of terms to manage the language issue that arise during the research, classified in the following way: seven types of burial spaces, eight types of burial sections and six types of cemetery structures. The list is not exhaustive and further terms should be added in the future to create a richer set of definitions, as long as they follow the parameters. In case a term is strictly related to variable and intangible elements (culture, religion or legal requirements), they should be included as a “Special Term”.

It was not possible to cover a wider range of cemeteries, so the focus was mainly on cemeteries related to a Christian culture that are still receiving burials, proving also the possibility to extend the analysis to Jewish cemeteries. It means that most of the structures are in Europe and America, dating from the end of the 18th century to the present day.

After all, the combined analysis of the categorization of cemeteries, the interpretation of different contexts and the evaluation of its functional elements were the difficult part due to having many countries with multiple variables. Tables and diagrams were of great support to organise de data collected. Once it was done, it was easy to form the analysis of the composition of a cemetery configuration.

In the end, the four contexts within different scales will be deeper evaluated during the construction of the guidance system in CHAPTER 4. Both the literature review and the site observations were useful by providing an understanding of what impacts a cemetery may cause. Specific sustainable strategies will be associated with them in further analysis.

CHAPTER 4: ANALYSIS AND PROPOSAL OF A SUSTAINABLE GUIDANCE SYSTEM FOR CEMETERIES

Figure Cover Chapter 4: Register book from the City of London Cemetery & Crematorium (London, UK).

4.1. METHODOLOGY FOR THE DEVELOPMENT OF THE SUSTAINABLE GUIDANCE SYSTEM

The object of analysis were sustainability certifications, specifically certifications for different industries, issues and disciplines. They encourage sustainable practices by rewarding companies and organisations that follow a certain number of requirements and are in line with government regulations and priorities.

The guidance system aims to address the renovation process of operating cemeteries not only to transform them into environmentally sustainable structures but also to keep the cultural heritage memory for future generations. In this matter, green building certifications were found to be the most compatible certification to analyse in the cemetery case. These types of certificates concern the dynamic relations between the built space and its external environmental conditions, considering also factors for a healthy indoor environment. The previous analysis from CHAPTER 2 and CHAPTER 3 revealed specific characteristics of the cemetery structure that needed to be included in the certification processes. For this reason, "geographical situation and culture were determined and integrated into the process of design" (Tebbouche et al., 2017).

According to the World Green Building Council, "sustainable building certifications - also known as green building rating tools - are used to assess and recognise buildings which meet certain sustainability requirements or standards". There are a huge variety of green building certification standards at the international level Figure 62, each one with its own approach to achieve sustainability in the built environment. The most common sustainable topics are lower carbon emissions, resources conservation, efficiency improvement, operating costs reduction, sustainable practices priority and creation of a healthier environment.

The World Green Building Council is responsible for a significant number of building certifications and claims to be the largest sustainable action network. They state that "by 2021, 4.2 billion square metres of green building space had been certified around the world through member Green Building Councils"[45]. One of them, the Leadership in Energy and Environmental Design (LEED) green building rating system developed by the U.S. Green Building Council (USGBC), is an international symbol of professional credentialing and project certification.

This certification process is designed to attend to several building types with strategies related to any stage of the development process, from design and construction to operation and maintenance. It is a flexible and articulated system that provides different formulations for new constructions, existing buildings and urban areas. Because

[45] Information extracted from the World Green Building Council's official website: https://worldgbc.org/sustainable-building-certifications/. Retrieved February 10, 2023

of its international popularity, many other rating systems use LEED certificate parameters as reference and adapted when necessary to local requirements and legislation.

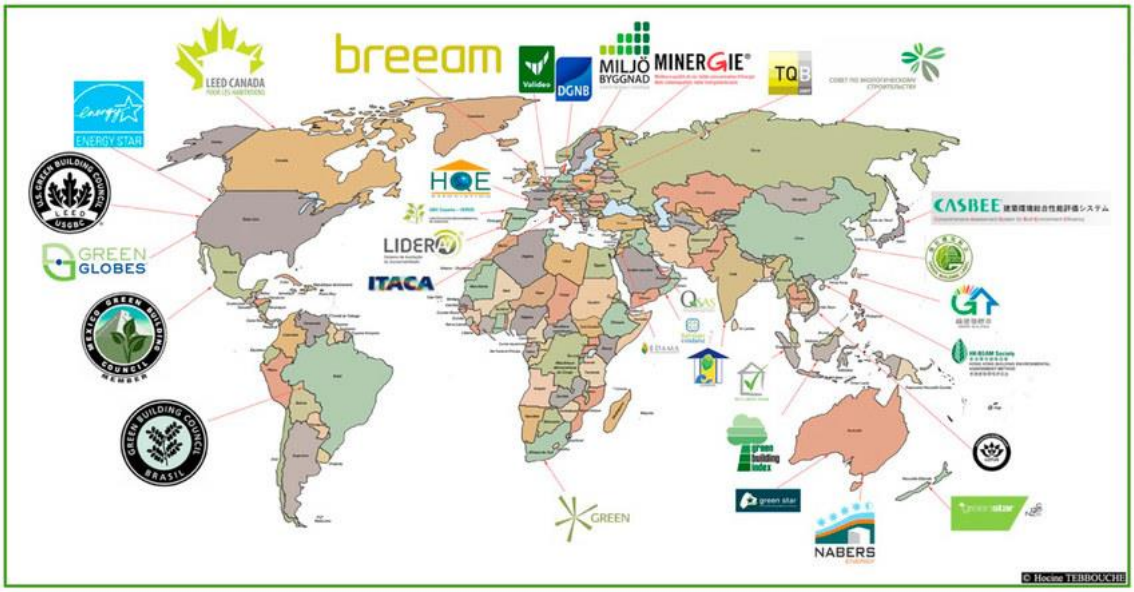


Figure 62 - Example of international green building certifications and their worldwide geographical location of influence (Tebbouche et al., 2017)*. Each country has specific sustainable certifications that are adequate to local characteristics and legislation.*

The **GBC Historic Building (GBC HB)**, designed by the Green Building Council Italia (GBC Italy), is one example of a certification adjustment to the local needs regarding the conservation, redevelopment, recovery and integration of Italian historic buildings with different uses. The categories are organized into environmental, artistical, well-being and sustainable efficiency assessments. The intent is to be used on:

> "(…) construction that are worthy of consideration as "material witness having the force of civilization". Buildings that may fall within the scope of application of the GBC Historic Building protocol must be built before 1945 with artisanal and preindustrial techniques or after 1945 if a pre-industrial building process is detached and there are historical and cultural recognized features. It applies to conservation, rehabilitation or recovery/integration processes, which must implicate major renovations, defined as actions that involve significant elements of HVAC systems and the renewal or functional reorganization of interior spaces, evaluating the possibility of the building envelope performance improvement, consistent with preservation of the typological and construction features of the existing building." (Green Building Council Italia, 2016a, p. 2).

Since many existing cemeteries that are still operational infrastructures were built before 1945, this tool seems to be suitable for this evaluation. However, this certificate includes many principles from the LEED Building Design and Construction (LEED BD+C) rating system as well as several that focus on the realities of existing buildings.

Therefore, further analysis considered also strategies for new constructions that may be necessary during the regeneration planning or cemeteries that were built after that time[46].

Another sustainable certification useful for the evaluation of cemetery structures is the **Sustainable SITES Initiative (SITES)**, a complement to the LEED rating system. It promotes the development or redevelopment projects of the land, its resources and communities, of sites that may or may not contain buildings. Land represents an important component of horizontal cemeteries, the most common type of cemetery structure, so it is appropriate to analyse a specific certification for the maintenance of the landscapes and outdoor spaces.

The SITES Rating System, administered by Green Business Certification Inc. (GBCI), has a similar structure as the LEED rating system, but it focuses on measuring landscape performance with operational and environmental criteria. It contributes to the overall sustainability efforts of the Built Asset and increases those from the Outdoor Environment by reducing urban heat island effects, controlling erosion, reducing flooding and increasing green areas.

> "SITES allows projects to benchmark against performance criteria that protect and restore ecosystem services and support green business practices. The four overarching goals of the rating system are to create regenerative systems and foster resiliency; ensure future resource supply and mitigate climate change; transform the market through design, development and maintenance practices; and enhance human wellbeing and strengthen the community." (Green Business Certification Inc., 2020, pp. 2–3).

The sustainable certifications analysed (GBC HB and SITES) focus on the evaluation of the overall efficiency of a building and its site. The aim is to minimize the environmental impact of the built environment with several mandatory prerequisites and facultative credits to be achieved according to the project's objectives. Both operates in the same way, based on a points system which depend on the credits acquired, the certificates structures can be found in Appendix B: GBC Historic Building Check List and Appendix C: Sustainable SITES Initiative Rating System Scorecard.

> "It is important to note, that existing environmental approaches to the sustainability of buildings in different countries do not respond to sustainable architecture requirements, given the fact that their environmental assessment systems put much more emphasis on environmental performance, whereas socio-cultural and economic parameters are given less consideration." (Tebbouche et al., 2017, p. 102).

The requirements from GBC HB are grouped into six categories: Historic Value, Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources and

[46] Indeed, time frame is not one of the limitations of the research described on Subheading 1.3.4.

Indoor Environmental Quality. There are two separate categories, Innovation in Design and Regional Priority, that aim to encourage the improvement of the building's general operation and to focus on local environmental priorities.

As for the SITES certification, there are nine categories: Site Context, Pre-Design Assessment and Planning, Water, Soil and Vegetation, Materials Selection, Human Health and Well-Being, Construction, Operations and Maintenance, and Education and Performance Monitoring. There is also an extra category for Innovation or Exemplary Performance.

Therefore, after an extensive study of the structure of these two sustainable certification protocols and their parameters to measure sustainability, they were used to carry out a comprehensive analysis of the cemetery's characteristics. The first stage of analysis was the identification of indicators of sustainability in Subheading 4.2, specific to the cemetery structures. Further investigation on the specific research topic, using the cemetery context described in Subheading 3.3 and matching with individual functional elements from Subheading 3.4, revealed an extended number of strategies to be implemented in cemeteries, described in Subheading 4.3. However, a particular analysis related to different types of cemetery structures (Subheading 3.2.4) was fundamental to guarantee the best outcome and presented in Subheading 4.4.

4.2. DESCRIPTION OF THE SUSTAINABLE INDICATORS

A building or construction is normally damaged by the force of time or by natural causes (rain, cold, heat, earthquake, etc), and cemetery structures demonstrate this phenomenon. Considering regeneration tools coordinated with an interpretation key of burial spaces, an analysis of different sources was used to identify the indicators that demonstrate virtuous impacts from a sustainable point of view. Table 9 resumes the data collected and the sustainable indicators established for cemetery structures.

Starting with the previous study of the sustainable certifications, the contribution was a formal structure for the cemetery indicators similar to the macro areas of the rating systems. Information has been integrated and excluded according to a critical analysis of what is related to the cemetery and topics of interest in this analysis. Followed by a literature review on social and economic aspects that were found to be missing in traditional building certification, and finally, management information was collected through interviews during some of the site observations.

The indicators are separated following the three dimensions of sustainability (environmental, social and economic), which helps to acknowledge and compare existing practices. The indicators are connected with more than one dimension to "consider the impact of resource consumption and the value creation in terms of integration among the three dimensions, assuming that each of them is equally important" (Bernardi et al., 2017). Therefore, even if the majority of the parameters regard the environmental and social aspects, some of them have an effect on economic factors. The prerequisites and credits from GBC HB and SITES protocols were analysed following this new systematization of sustainable indicators.

Table 9 - Relation between the sustainable indicators established for cemetery structures and the three dimensions of sustainability.

Environmental	Social	Economic	Sustainable Indicators	
●		x	Water Assessment	Operation
●		x	Energy and Emission	
●		x	Land Management*	
x	●		Comfort and Well-being	
	●		Safety	
	●	x	Functional & Adaptability	
x	●		Heritage Conservation and Valorisation*	
●	x	x	Material and Waste Management	
x	x	●	Processes Management*	
x	x	●	Innovative Design Approach	
x	x	x	Construction Site (water + energy + material and waste management + comfort and wellbeing)	Temporary

The use of "●" indicated that the indicator is directly related to the sustainable dimension, while "x" means that the indicator can influence the sustainable dimension. The "Construction Site" indicator is analysed in Subheading 4.3.5. The indicators marked with "*" are specifically connected to the operation of cemetery structures described in Subheading 4.2.4. Because of their significant impact on the guidance system, the symbol will be maintained in future analyses as a reminder.

4.2.1. Environmental Indicators

This section investigates different environmental aspects associated with the cemetery's building and site, with the goal to limit the construction impact, reduce consumption and minimize the use of raw materials. Apart from reducing, other concepts and tools from the circular economy are promoted in this category, such as increasing the reuse and recycling actions (Lopez Duarte, 2021). In this area the environmental actions are:

- use, management and disposal of water;
- improvement of energy performance and control, together with the use of renewable sources;
- conserve habitats and increase biodiversity;
- accurate selection of materials, considering also the impact from transportation;
- management of waste disposal.

Therefore, the indicators determine for the regeneration of cemetery structures are directly related to environmental aspects are Water Assessment, Energy and Emission, Land Management and Material and Waste Management.

4.2.2. Social Indicators

The subjects considered in this section cover aspects from healthiness, well-being and comfort from visitors and staff, as well as the communication of cultural heritage information and the integration of the cemetery with its surroundings from a social perspective. It takes into account:

- indoor environmental quality and comfort, including monitoring and control of pollution;
- provide accessibility and safety;
- protect cultural and historic values;
- engage citizens, workers and stakeholders in the regeneration process;
- support social connections and coordinate educational initiatives.

In this case, the indicators with a predominant social point of view are Comfort and Well-being, Safety, Functional & Adaptability, and Heritage Conservation and Valorisation.

4.2.3. Economic and Management Indicators

Increasing the efficiency of the cemetery will reduce costs of maintenance and consumption, at the same time that the use of local, certificated and sustainable products contributes to the local economy. Considering that cemeteries can occupy a significant amount of land, interventions can be integrated with the public system (regarding for example indicators such as Water Assessment, Energy and Emission, Heritage Conservation and Valorisation, Materials & Resources and Processes Management).

The Life Cycle Assessment (LCA) tools is suitable for this indicator because it gives a broad perspective of the site in all its aspects, calculating and evaluating the environmental impact of buildings from cradle to grave. These impacts can be related to the consumption of energy and materials, the production of waste and pollutants, the emission of greenhouse gases, etc., depending on the goal of the assessment. Therefore, it is a rigorous environmental balance of the entire building process including the management and end of life of the building. Thus, this indicator has the aim to:

- identify improvements in the sustainability management of the cemetery structure;
- encourage to contemplate local characteristics and priorities.

To achieve these aims, two indicators have been defined, Processes Management and Innovative Design Approach.

4.2.4. Indicators Specific to the Cemeteries Structure

While the previous indicators were supported by the rating system protocols, specific indicators for cemetery structures were identified during the literature review (Subheading 2.1), the mobility program and the consultations with managers. They revealed aspects that are essential for the operation of a cemetery structure and that, unfortunately, are not directly contemplated by the certifications.

Horizontal Cemeteries have to manage their functions spread all over their perimeter, meaning that one of the most important indicators is the Land Management. The most important aspect to consider within this indicator is the Burial Components (Subheading 3.4.3), a function element that affects all of the sustainable environments, from the risk of environmental contamination to the preservation of the cultural heritage, and also the primary source of income (sale of burial spaces). Vertical Cemeteries have everything located inside one or several building complexes so, in this case, strategies must be adapted to the building context in order to minimize the same risks from the Horizontal Cemetery.

This next indicator, the Heritage Conservation and Valorisation, is present in all cemetery types. It is connected to elements such as buildings, natural areas, history and culture, or any other intangible aspects that may or may not be translated into tangible aspects. Particular elements are related to land development and Burial Components.

The Processes Management is another indicator that must be considered during the regeneration process from all cemetery types. It requires a Cemetery Management and Maintenance Plans that incorporate all four cemetery contexts, aiming to achieve the best performance, especially regarding the burial space but not exclusively. Beyond the distribution of the burial spaces on site, the management and maintenance of a cemetery have to decide, among other issues, about the appropriate burial method, the preservation and restoration of individual burial spaces, the monitoring of environmental contamination, and maintaining the organization of the site.

4.3. EXPLANATION OF THE GUIDANCE SYSTEM

After identifying the indicators to be evaluated on a cemetery structure in Subheading 4.2 Description of the Sustainable Indicators, it is possible to analyse their applications to the four contexts interpreted in Subheading 3.3 Interpretation of Different Contexts of a Cemetery). When an indicator is connected to a functional element for one specific context, it creates a sustainable principle. It consists of a first explanation of the relation between the indicator and the cemetery structure, followed by examples of strategies that could be applied to achieve a sustainable level. In the end, when feasible, it is possible to find an example of the strategy applied in a real case. Therefore, the indicators of the guidance system are defined as follows:

1- **Indicator + Strategy:** two analyses are provided in this phase: first the explanation of the relationship between the indicator and the cemetery for each context (the indicator focused on the cemetery); followed by the description of applicable strategies that highlight functional elements to be addressed on the regeneration process along with suggestions on how to implement the strategies;

3- **Sustainable Parameters:** list of credits extracted from GBC HB and SITES;

4- **Best Practice Example:** existing cemetery structures that were identified during the research as being of extremely positive behaviour for further study of the theme.

All the principles together compose the operational actions of the guidance system for a sustainable regeneration of cemetery structures. It represents the minimum

requirements that this type of infrastructure should follow to achieve high levels of sustainability in the urban space.

4.3.1. Urban Infrastructure

UI1) Land Management

INDICATOR + STRATEGY:

The aim of the strategy related to the “Land Management” indicator is to include, when possible, cemeteries in the municipality’s natural system to improve the city’s ecological condition (see “Connection with existing urban environmental conditions” in Subheading 3.4.1). It is fundamental to allocate specific burial land uses far from natural sources (wellspring water, river, etc.) to avoid environmental contamination. Even if natural sources are located outside the cemetery’s area, they must also be considered during the cemetery analysis for this indicator.

The process to ensure the inclusion of cemeteries in the greening planning of urban areas can be:

1. analyse the structure of the city;
2. map existing green areas and cemetery structures to analyse their situation in relation to the urban context;
3. create green areas and corridors to connect fragmented natural areas to the cemetery and other green areas (through tree-lined streets, ecological corridors, and other types of green connections).

A second stage to increase the amount of urban green area can be through the increase of vegetation inside the cemetery (see "Outdoor Environment" in Subheading 4.3.2). Regarding the two main categories of cemeteries, those with a predominance of built-up elements and those with a predominance of green elements (see “Overall Visual Characteristics” Subheading 3.2.1), the idea is to increase the amount of vegetation in those cemeteries that lack on green elements and to enhance the existing vegetation in those that already have it.

SUSTAINABLE PARAMETERS:

Sustainable SITES Initiative® Rating System:

Site Context:

- Conserve aquatic ecosystems (Prerequisite 1.3);
- Conserve habitats for threatened and endangered species (Prerequisite 1.4).

Pre-Design Assessment + Planning:

- Designate and communicate Vegetation and Soil Protection Zones (Prerequisite 2.3).

BEST PRACTICE EXAMPLE:

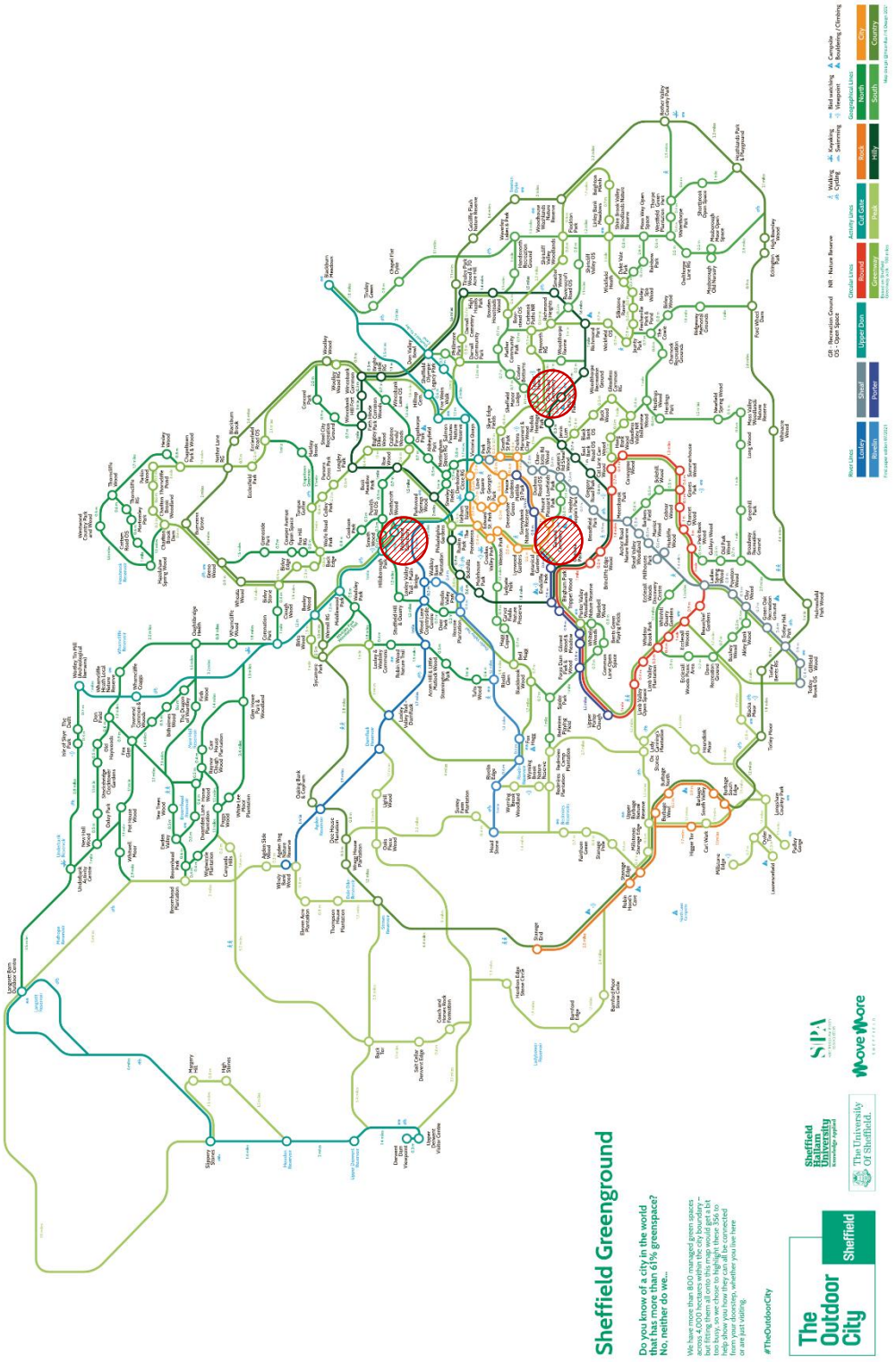


Figure 63 - A Greenground Map of Sheffield[47], a city in the United Kingdom that manages more than 800 green spaces and that encourages people to live the outdoor city. The red circles indicate the location of the three cemetery structures on the map: the General Cemetery, the Wardsend Cemetery and the City Road Cemetery and Crematorium.

[47] The image source is: https://www.welcometosheffield.co.uk/content/articles/a-greenground-map-of-sheffield/. Retrieved April 22, 2022.

The city of Sheffield, in the United Kingdom, has more than 60% of its area destined for green spaces. To make these spaces accessible and stimulate citizens and visitors to spend time in open and green spaces, the local authority commissioned a green map of the city connecting the most important areas with different thematic lines. In total there are 356 different places on the map, from woodlands and public parks to a national park, including three cemetery structures (Figure 63). The General Cemetery and the Wardsend Cemetery are both currently managed as a park and stop receiving new burials in the late 1900s. Instead, the City Road Cemetery and Crematorium is still an operating cemetery managed by the city council, and because of its significant green areas, the cemetery is also considered a public green space.

UI2) Comfort and Wellbeing

INDICATOR + STRATEGY:

The circulation flow of people in a cemetery is continuous during the day with daily visitors and may increase during funeral services. In many cases, people have difficulty accessing the cemetery so their life should be made easier at this moment. Strategies are related to the transport and accessibility to the cemetery or with different options to access the cemetery (see “Urban Accessibility” in Subheading 3.4.1).

When referring to transportation access, cemeteries located in dense urban areas should prioritize the connections with public transportation, cycle/walking paths and other routes. Another possibility is to provide bike racks on-site, storage rooms, preferential parking spaces and alternative fuelling stations may also promote the use of low-emission and alternative-fuel vehicles.

The use of alternative transportation to access the cemetery should be encouraged not only for visitors but also for staff members. However, to be able to promote the use of alternative and more eco-sustainable vehicles it is necessary to minimize the parking areas for ordinary private vehicles. Some possibilities are to give preferential parking spaces for alternative transportation or to not exceed the minimum parking capacity established by local planning instruments. The aim is to help reduce environmental impacts caused by car traffic (pollution, use of land, security, etc).

It is known that cemeteries located in less dense areas have different priorities, regarding the management of their function, than urban cemeteries (Neckel et al., 2017). From the accessibility point of view, suburban cemeteries are more likely to receive visitors in their own private vehicles. Thus, the strategy is about the promotion of a new planning to expand the public transportation and create a local transport network even outside the city. It will contribute to limit the use of cars and to increase the accessibility of the cemetery. Moreover, this indicator can be linked to social aspects because public transport even outside the city would be useful for the elderly, people who do not have a car or any other with mobility issues.

This strategy intends to ensure the widest possible range of transport options to reach the cemetery: public transportation systems (train, metro, bus, tram, subway, etc), sharing transportation service (bicycles, scooters, cars, etc), bicycles, parking lots, etc. The following steps are a suggestion on how to improve the accessibility in cemeteries:

1. analyse the traffic flow (pedestrians and vehicles) to or near the site and which transport options are available in the city;

2. analyse which transport options are already located close to the site, and which lack access;

3. create new accesses routes to the cemetery and improve existing ones if necessary.

Private cemeteries will be able to intervene only inside the project areas by creating parking lots for different types of vehicles. While cemeteries managed by the local authorities can plan changes to public transportation modes if stations or stops are not located close to the cemetery. For this reason, a specialist in urbanism is necessary during the renovation process of a cemetery, and when possible, working together with the local authorities should be pursued (see “Processes Management”).

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Sustainable Sites:

- Alternative transportation: public transportation access (Credit 2.1)*;

- Alternative transportation: bicycle storage and changing rooms (Credit 2.2);

- Alternative transportation: low-emitting and fuel-efficient vehicles (Credit 2.3);

- Alternative transportation: parking capacity (Credit 2.4).

* The protocol talks about the proximity of the cemetery to existing transportation nodes, but in this case, because the participation of authorities responsible for cemetery management is encouraged, if this proximity does not exist, new transportation modes can be planned.

Sustainable SITES Initiative® Rating System:

Site Context:

- Connect to multi-modal transit networks (Credit 1.5);

Site Design - Human Health + Well-Being:

- Encourage fuel efficient and multi-modal transportation (Credit 6.9).

UI3) Heritage Conservation and Valorisation

As for the previous strategies, the UF3 is related to the connection of the cemetery with existing scientific interests, recreation, educational programmes and tourist routes (see “Connection with existing tourist routes” in Subheading 3.4.1). Cemeteries can merge with other urban sites, as a place of leisure, biodiversity

interesting, green spaces, and intangible identity, instead of only a space for the interment of dead bodies. The aim of this indicator is to promote burial spaces in the city as a shared space with urban meaning.

The meaning of this indicator is to enhance the cemetery structure on aspects related to cultural heritage. These spaces can be connected to the urban area in different ways, including a public cityscape with particular interesting in its cultural and social significance. Many activities could be allowed inside the cemetery, requiring only an extra attention to respect the atmosphere of the place. For example, activities such as walking the dog, birdwatching, running or simply walking home, could take place in a park or in a cemetery. But in this last one, the individual space of reflection is the focus of attention, communicating social behaviours as to avoid loud noises, keep animals on a leash, playing games is forbidden as well as other activities that the cemetery management may consider disrespectful.

At the Urban Infrastructure scale, projects should ensure accessibility with balanced mobility (public and private), facilitate tourism and promote educational programmes. The possibility for strategies in this matter are endless, needing to adapt to each specific context. However, the aim is always to enhance the interest of citizens to visit the cemetery (increasing also social awareness, see "Cultural Heritage" in Subheading 3.3). The indicators from the “Cultural Heritage” (Subheading 4.3.4) are closely related to the UF3 indicator.

UI4) Processes Management

INDICATOR + STRATEGY:

Planning control tools (see “Zoning and Land Use Planning” in Subheading 3.4.1) can help to create an integrated planning for the regeneration of several cemetery structures located within the same municipality. The integration of the renovation process of cemeteries with local authorities will be necessary to achieve the best outcome, especially if the cemetery is under public management.

This indicator collects the strategies aimed at bringing the management of the cemetery back into an efficient and controlled process so that the proposals listed above can be applied effectively. A preliminary analysis must focus on the relationship of the cemetery with the urban context, concentrating on potentialities to be developed and weaknesses to be improved. In this analysis, all the cemeteries within the same urban area must be evaluated together to achieve the best outcome.

Strategies can be related to the creation of ecological corridors to connect cemetery structures and other green infrastructures, a transportation system that makes it easy for people to move from one structure to another, the inclusion of tour visits and educational programmes inside cemeteries in the city’s agenda, etc. The implementation of the strategies in fact has a similar sequence to the previous ones, but here the analysis is about the urban space, and this must be considered a priority:

1. study the Zoning and Land Use of the city;
2. evaluate which aspect (environmental, social, cultural) to enhance in the city and selected cemeteries;

3. connect existing cemeteries with other cemeteries or other structures with similar characteristics that are being evaluated.

It is important for the design team to have a member that is a specialist in urban planning or is in possession of a sustainable qualification to support the application and integration of sustainable strategies. This figure can be represented by the municipality cemetery manager or similar if there is one.

The type of intervention suggested for the “Urban Infrastructure” is almost restricted to cemeteries managed by the local authorities. Private management cemeteries are encouraged to dialogue with the local authorities to find solutions for the problems found in the preliminary analysis.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Preliminary analysis*;

- Specialist in restoration of architectural heritage and landscape (Credit 6)**.

Innovation in Design:

- GBC Accredited Professional (Credit 2).

* The protocol should also consider aspects related to the urban context during the preliminary analysis of the historic value (the research suggests to consider this aspect during the preliminary analysis of existing protocols).

** Adapted from the protocol to consider an urbanism specialist to be part of the design team or to seek to propose a connection with local authorities.

Sustainable SITES Initiative® Rating System:

Site Context:

- Limit development on farmland (Prerequisite 1.1);

- Protect floodplain functions (Prerequisite 1.2);

- Locate projects within existing developed areas (Credit 1.6).

UI5) Innovative Design Approach*

INDICATOR + STRATEGY:

Cemeteries have different realities depending on where they are located. The environmental characteristics are unique and specific to the cemetery subject to intervention and the surroundings. It means that each cemetery presents different needs regarding the relation to the urban context and distinct local characteristics (see “Connection with the urban fabric” in Subheading 3.4.1). In any case, the aim is to connect the cemetery to the territory and include them in the urban system.

Since cemeteries are often very large and closed spaces, this characteristic implies the obligation of having to get around them when it would often be more

convenient to be able to cross them, at least during the daytime. Thus, creating connections with the urban fabric may allow different parts of the city to be accessible without significant interruptions. One strategy can be to guarantee different access to the cemetery and tolerate the transitions of pedestrians and vehicles through the circulation system of the cemetery (with respect to the internal rules).

Besides the physical problem of not being able to cross the cemetery structure, there is also the perceptive problem of not seeing through the cemetery's perimeter. It creates a clear separation between the cemetery and the life of the city, which can generate the feeling of insecurity and the segregation of the urban space. Another strategy can be the creation of a permeable vision of the surrounding environment of the cemetery. A possible intervention is:

1. study the condition of the cemetery's boundaries and the existing movement and circulation system within and around the site (internal and external);
2. create a hierarchy among paths/streets, and locate the areas where the cemetery can dialogue more with its surroundings;
3. evaluate improvements on the cemetery structure (which paths are important to keep interrupted regarding the municipality's grid plan, the need to open new accesses inside the cemetery, improvements on the existing boundaries, etc).

Another aspect that can be the focus of attention is the integration with existing local priorities. Discussion with the local authorities can support the decision regarding improvements in the "Urban Infrastructure" context. In this way, cemeteries can contribute to projects planned for an urban scale with environmental, social, economic or cultural importance. Professionals must be encouraged to find innovative solutions and achieve excellent performance for issues that were not previously mentioned.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Innovation in Design:

- Innovation in design (Credit 1 - Option 2*).

Regional Priority:

- Regional priority (Credit 1).

* Adapted to the "Urban Infrastructure": for the protocol to achieve an "exceptional performance" it needs to exceed "by more than double the parameters required by the requirements and/or reaching the incremental threshold", but in a cemetery it should be "encouraged to find innovative solutions and achieve excellent performance for issues that were not previously mentioned".

Sustainable SITES Initiative® Rating System:

Site Context:

- Redevelop degraded sites (Credit 1.5).

Innovation or exemplary performance:

- Innovation or exemplary performance (Credit 10.1).

BEST PRACTICE EXAMPLE:

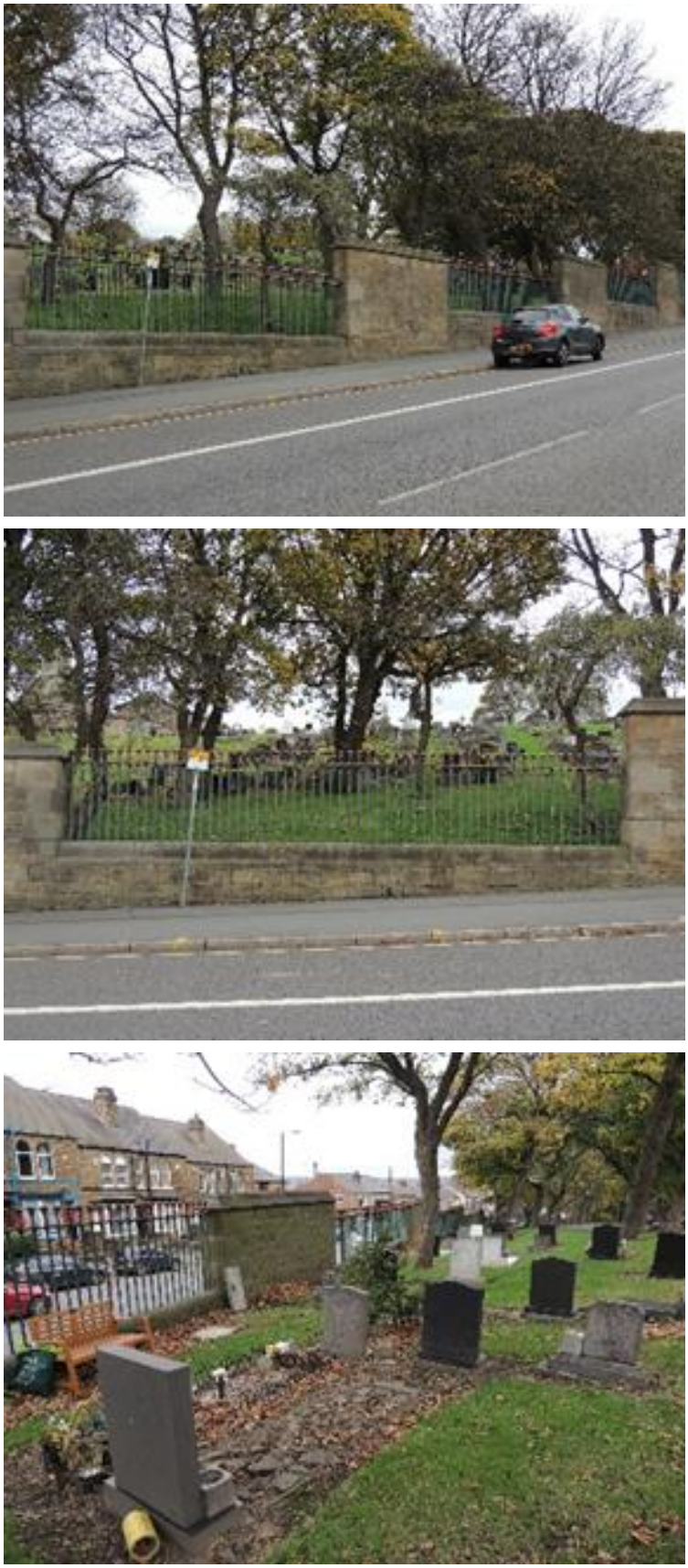


Figure 64 - The perimetral wall of the City Road Cemetery and Crematorium (Sheffield, UK) allows a visual permeability between the burial area and the urban area.

The boundary of the City Road Cemetery and Crematorium is fenced with metal vertical posts inserted in the middle of brick walls (Figure 64). The cemetery controls the public access by having only one entrance for vehicles and pedestrians, but at the same time, it allows visual permeability between the cemetery and the city. It gives a sense of security to those inside and encourages pedestrians to walk near the cemetery. The benefit of this strategy is more on the area outside the cemetery because it creates a pleasant space around the cemetery. Another positive aspect is the connection of the cemetery with the society, by increasing the relationship of the city with the cemetery and making it normal to see burial spaces in everyday life.

4.3.2. Outdoor Environment

OE1) Water Assessment

INDICATOR + STRATEGY:

Horizontal cemeteries usually are composed of a large area of Outdoor Environment, meaning that a few spatial elements are needed for the operation of the cemetery. In this case, water points spread around the cemetery (see “Water Support System” in Subheading 3.4.2) must be available for staff work and for visitors to clean the memorials or to water the plants placed on top of the burial space.

Different from the Built Asset, the Outdoor Environment of horizontal cemeteries has a great consumption of water for irrigation systems, management operations or ornamental purposes. The installation of meters to measure the amount of water used may support the assessment of adding recycled water or other systems to improve the water management of cemeteries. The external uses that should be measured are irrigation, fountains and water features, recycled water and any other water system.

Besides that, the outdoor environment suffers all kinds of environmental impacts, one of which is rainfall. Due to the site’s dimension, it is important to increase the loss of precipitation and to guarantee a stable flow of water through drainage structures. Site levels may affect the design of the cemetery, so it should be evaluated how the site drainage work and any potential problems with it. It regards both permeable and impermeable surfaces (burial sections use a large number of waterproof materials). Avoiding large amounts of waterproof surfaces (see “Use of Materials” in Subheading 3.4.2) is important to guarantee a stable flow of water and avoid surface runoff. It could carry pollutants into bodies of water or they could infiltrate into the soil and reach the groundwater.

The use of specific strategies may help to guarantee the quality of the water and increase the loss of precipitation. The development of a *Rainwater Management Plan* is needed in this case to control the hydrological cycle of the site and help manage the rainwater runoff. This plan should determine the proper treatment of rainwater runoff to

reduce the number of contaminants. An alternative is to increase the infiltration into the soil by reducing the amount of impermeable surfaces.

Other actions can take place to increase water efficiency, such as the collection of rainwater through special systems, the recovery and recycling of greywater, the use of permeable surfaces, the installation of plants that do not require permanent irrigation, etc. The vegetation (see “Green Element System” in Subheading 3.4.2) density and the microclimate may also be factors that will influence the irrigation quantity.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Sustainable Sites:

- Stormwater design: quantity and quality control (Credit 4).

Water Efficiency:

- Water efficient landscaping (Credit 1);
- Water metering (Credit 3).

Sustainable SITES Initiative® Rating System:

Site Context:

- Protect floodplain functions (Prerequisite 1.2).

Site Design - Water:

- Manage precipitation on site (Prerequisite 3.1);
- Reduce water use for landscape irrigation (Prerequisite 3.2);
- Manage precipitation beyond baseline (Credit 3.3);
- Reduce outdoor water use (Credit 3.4);
- Design functional stormwater features as amenities (Credit 3.5).

OE2) Energy and Emission

INDICATOR + STRATEGY:

The consumption of energy in the Outdoor Environment for the operation of a cemetery is basically for the illumination of the site[48]. Another use found during the site observation was that of electrical candles (see “Lighting System and Electrical Support” in Subheading 3.4.2). After analysing the site, it could be evaluated the application of smart facilities in the Outdoor Environment.

To increase the overall energy efficiency of a cemetery structure, energy audits should be performed considering the Outdoor Environment and the Built Asset together. It could be an opportunity to optimize the implementation of renewable energy sources and to provide an accounting of the energy consumed over time. Even if the Outdoor Environment does not include heating, the major consumption of energy from the Built

[48] In the GBC Historic Building® Rating System, the supply of outdoor lighting systems is considered in the process power supply.

Asset, depending on the cemetery size the outdoor energy consumption can have a relevant impact on the sustainable management over time.

It is important to evaluate the reduction of the light dispersion generated by outdoor lighting on site overnight. It will minimize the negative impact and will increase the night visibility of the celestial vault. Some strategies that can be applied are the use of luminaires that emit light downward; installation of a lighting system that produces low illuminance value; replacement of obsolete systems with new generation low-consumption LED that consume less; restriction of illumination to paths (see "Road System" in Subheading 3.4.2), building facades (see "Cultural Wealth" in Subheading 3.4.4) and areas to guarantee safety (see "Security System" in Subheading 3.4.2), enhance the architectural value or increase visual comfort. The illumination system must also allow an independent night-time control or include motion sensors to switch on only when needed.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Advanced analysis: energy audit (Credit 1.1 - Option 1).

Sustainable Sites:

- Light pollution reduction (Credit 6 - Case 2).

Energy & Atmosphere:

- Minimum energy performance (Prerequisite 2);
- Optimize energy performance (Credit 1);
- Renewable energies (Credit 2);
- Measurement and verification (Credit 5).

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Reduce light pollution (Credit 6.8).

Operations + Maintenance:

- Reduce outdoor energy consumption (Credit 8.5);
- Use renewable sources for landscape electricity needs (Credit 8.6).

OE3) Land Management

INDICATOR + STRATEGY:

Existing cemeteries are already well established, but to get more burial space, expansion plans may be needed. In this case, the site must have a composition layout that adjusts to abiotic conditions, having special attention to the soil and the underground water. The cemetery needs to adapt to the existing conditions, with minimum soil

movements (Figure 65) to disturb the less possible the biodiversity of the site. Vegetation and wildlife habitats should also be analysed before making changes to the topography.

Cemeteries deal with the decomposition of organic matter, which can end up polluting the air, the soil, the subsoil and the groundwater. It varies according to the "Site Topography" (Subheading 3.4.2) and climate factors (see Subheading 2.6.1). Exposure to these substances can be hazardous to human health and by performing laboratory analysis it will be possible to verify if the cemetery site is degraded. If the results are positive, the consequent step is to understand whether the contaminant elements are strict to the landform (from the grave's type) or if they are also present in the built elements (aboveground burial space types). In both cases, there will be the need to plan remediation interventions to restore the health and safety of the site. In Subheading 2.7.3, the example of *Necrópole Ecumênica Vertical Universal* (Curitiba, Brazil) shows that construction decisions and an appropriate "Use of Materials" (Subheading 3.4.2) can contribute to minimize the environmental impact of the cemetery structure.

A positive impact is the recovery of original ecological communities (native plants and natural habitats) by restoring the "Green Element System" (Subheading 3.4.2) and the surface water bodies present on the site. Cemeteries are sites in constant change with areas altered by human activity over time, making it difficult to preserve the historical configuration. But the integration of green areas with the architectural design of the cemetery has to be strongly considered.

Depending on the condition of the cemetery, strategies related to green elements are to design with an adequate diversity of vegetation types and vegetation stratification (low, medium and high vegetation), as well as deep analysis on the correct use plants (perennials, native and non-native species, etc). The aim is to recover the existing habitat as well as the cultural heritage. As a consequence, it ends by "promoting the collective use of open green spaces and providing spaces for socialization"[49] (Green Building Council Italia, 2016b, p. 193).

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Sustainable Sites:

- Brownfield redevelopment (Credit 1);
- Site development: open spaces recovery (Credit 3).

Sustainable SITES Initiative® Rating System:

Site Design - Water:

- Restore aquatic ecosystems (Credit 3.6).

Site Design - Soil + Vegetation:

- Create and communicate a soil management plan (Prerequisite 4.1);
- Control and manage invasive plants (Prerequisite 4.2);
- Use appropriate plants (Prerequisite 4.3);
- Conserve healthy soils and appropriate vegetation (Credit 4.4);

[49] Translated by the author from Green Building Council Italia (2016b, p. 193).

- Conserve special status vegetation (Credit 4.5);
- Conserve and use native plants (Credit 4.6);
- Conserve and restore native plant communities (Credit 4.7);
- Reduce the risk of catastrophic wildfire (Credit 4.11).

Operations + Maintenance:

- Minimize pesticide and fertilizer use (Credit 8.4).

BEST PRACTICE EXAMPLE:

Figure 65 - The Highgate Cemetery (London, UK) faces many problems with the lack of space for new burial spaces. To make space available, the cemetery decided to cover an old burial section with soil. In this way, the burial spaces underneath were kept in place, while the space above started to be used for new burials. The negative point is that the neighbours lost their traditional and characteristic view of the cemetery ground.

OE4) Comfort and Wellbeing

INDICATOR + STRATEGY:

The cemetery needs to offer good health conditions and to be accessible for all visitors (see “Site Topography”, “Logistic Information System”, “Security System”, “Road System” and “Green Element System” in Subheading 3.4.2), so it is important to plan and organize the cemetery in a way that is easy to people to move around. Ensuring available accessibility and diversity in the internal mobility of the cemetery increases the

interest and care of visitors and encourages citizens to use the space more often. The benefit is that people with mobility disadvantages (children, elderly, people with disabilities, baby carriages, etc) will be able to move more easily, while for visitors it will optimize their time. They are all strategies related to usability and universal design

The planning of the spatial distribution of the cemetery needs to ensure a road system within the cemetery that is safe and accessible for all, to facilitate the mobility of people inside the cemetery. It must include gently sloping paths and in cases where it is possible, it should be planned an internal transportation system with electric or autonomous vehicles, ensuring at least one type of transport other than on foot. Some examples of transportation accessibility are bicycles, scooters, mini-cars, etc. Another strategy is the installation of tactile pavement for visually impaired people.

Together with the accessibility, there is also the use of effective signage, where its function is to communicate historical, directional, regulation, identification, traffic information or any other site characteristics to visitors. Accurate signboards are useful tools for the well-being of visitors, when strategically placed (with proper colour and lighting) they can easily communicate and convey a concise message that looks elegant and provides clear direction. Quality signboards are enough to drive attention as well as embellish the overall appearance of the place and its surroundings.

They should include all kinds of barriers and disabilities as possible. The installation of alarm devices depends on proper planning to not disturb the tranquillity of the place. They need little maintenance and their design should integrate with the site landscape. Besides that, this strategy can intersect the “Material and Waste Management” strategies, requiring signboards to be made from eco-friendly materials (recycled plastic, wood, glass, aluminium, etc) suitable for outdoor and/or indoor environments. They also need to be durable and not fade, chip or crack easily.

Outdoor air influences the health and well-being of the entire cemetery environment, so particular attention should be taken to burial spaces, especially those located in open spaces but not limited to. The environmental monitoring is intended to guarantee that chemical elements, originating from the decomposition process, do not represent a danger to visitors (see Subheading 2.6).

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Indoor Environmental Quality:

- Environmental Tobacco Smoke (ETS) control (Prerequisite 2 - Case 1);
- Outdoor air delivery monitoring (Credit 2).

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Provide optimum site accessibility, safety, and wayfinding (Credit 6.2);
- Support mental restoration (Credit 6.4);
- Minimize exposure to environmental tobacco smoke (Credit 6.10).

Operations + Maintenance:

- Protect air quality during landscape maintenance (Credit 8.7).

OE5) Safety

INDICATOR + STRATEGY:

The “Security System” can include a video surveillance system to avoid vandalism and robbery, guaranteeing a safe environment for visitors. “Logistic Information System” can provide important information on unstable areas and prohibited accesses. Areas with different priority access (spaces with opening and closing times, others with full access even at night) can contribute to the connection of the cemetery with the “Urban Environment”.

SUSTAINABLE PARAMETERS:

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Provide optimum site accessibility, safety, and wayfinding (Credit 6.2).

OE6) Functional & Adaptability

INDICATOR + STRATEGY:

Land uses are quite important to be defined in a cemetery and proposing new uses, even if they are compatible with the cemetery function, is difficult. The “Site Topography” (Subheading 3.4.2) characterizes which type of burial spaces will be placed in specific areas based on geographic characteristics, but even within this limitation a number of uses within the cemetery “Outdoor Environment” are possible. It refers to the establishment of new burial sections, the creation of new green areas and the introduction of compatible natural uses. An analysis of the urban surroundings and local culture will help to propose collective or public functions that will integrate the cemetery with the local community.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Compatible end-use (Credit 3.1).

Sustainable SITES Initiative® Rating System:

Site Design - Materials Selection:

Design for adaptability and disassembly (Credit 5.3).

BEST PRACTICE EXAMPLE:

Figure 66 - The York Cemetery (UK) has incorporated some new uses within the cemetery structure.

Besides all the different types of burial sections (memorial garden, memorial wall plaques and graves for coffins or urns), the York Cemetery decided to reserve a piece of land for a herb garden, an orchard and the position of beehives (Figure 66). They are managed by volunteers from The Friends of York Cemetery charity. Although these functions are questioned by academics about being located inside a cemetery, it is an interesting way to integrate the community and the cemetery, being an opportunity to let people enter the cemetery.

OE7) Heritage Conservation and Valorisation

INDICATOR + STRATEGY:

This strategy is mainly for the identification of historic buildings (being directly related to the "Built Asset"), but it is possible to be adapted to the outdoor environment. It is related to anything that was part of the original concept of the cemetery. Interventions on the landform can be to improve services and technical systems, optimize space, and add structures or facilities, however, in any of them, it is necessary to guarantee the reversibility to the original conditions of the site. This procedure will allow the identification of the areas subject to conservation and those subject to renovation.

It may focus on the historic landform of the cemetery, streets or pathways, vegetation, and their historical materials (see "Site Topography", "Road System", "Green Element System" and "Use of Materials" in Subheading 3.4.2). The "Logistic Information System" (Subheading 3.4.2) and the "Information Exchange System" (Subheading 3.4.4) can give support to the Heritage Conservation and Valorisation indicator.

Finally, the safety of the cultural heritage needs to be ensured, avoiding the loss of monuments because they were abandoned ("Security System", Subheading 3.4.2). Strategies to maintain the built heritage can be performed in different ways, according to the cemetery management plan. Their conservation will protect the "Historic Wealth and Identity Value" and the "Cultural Wealth" (Subheading 3.4.4) of the cemetery.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Preliminary analysis (Prerequisite 1);
- Project reversibility (Credit 2).

BEST PRACTICE EXAMPLE:

Figure 67 - Buildings from Bushey New Cemetery (London, UK) used for prayer halls and administrative offices and built with local sustainable materials.

The new buildings of the Bushey New Cemetery[50] (Figure 67) were "constructed from solid rammed earth walls - an ancient building method that is at once natural and sustainable and durable and strong"[51]. The Jewish culture does not allow human remains to be disturbed for any reason (burial for perpetuity), meaning that one day the cemetery will be fully occupied. Anticipating this moment, the project of the extension of the Bushey Cemetery provided for buildings to return to the earth with little intervention, and for the site to be part of London's green belt. The use of organic and local materials allows the buildings to be part of their setting and brings several benefits to reduce environmental impacts. Even if this project is about new buildings, it is an interesting example that shows the connection of the built environment with the landscape design process.

Figure 68 - Maintenance of the York Cemetery (UK), preserving local heritage and facilitating the cemetery accessibility.

The focus of York Cemetery management is the preservation of its natural landscape and the enhancement of biodiversity. For this reason, older sections of the cemetery were kept untouched, allowing

[50] Project from Waugh Thistleton Architects.

[51] Information extracted from the cemetery's official website: https://waughthistleton.com/bushey-cemetery/

the vegetation to grow. Under request, specific burial spaces will be maintained clean by the landscape staff, allowing a more personal conservation of the burial ground (Figure 68). Mowing the lawn in strategic places allows the creation of natural pathways for pedestrians to access particular sections of the cemetery.

OE8) Material and Waste Management

INDICATOR + STRATEGY:

The elements that are evaluated by the Material Management strategy[52] are "Use of Materials", "Road System" and "Green Element System" (Subheading 3.4.2). With an adequate design that balances the morphology of the existing buildings with the outdoor space, the strategy can contribute to reducing the local effects of heat islands (differences in thermal gradient between urbanized areas and green areas) and improving the environmental quality and comfort. Another benefit is from using local materials, reducing environmental impacts and enhancing local communities.

In this case, it is important to perform a degradation diagnostic on these elements to identify any problem. Interventions need to respect the historical heritage of the site but they can be designed as a reinterpretation of the elements object of renovation. Some examples of outdoor interventions to absorb the heat caused by solar radiation are shading exterior surfaces with live plant elements or architectural elements, using materials with a high solar reflectance index, and designing paved exterior surfaces using permeable and light-coloured materials.

Otherwise, interventions using an accurate selection of materials, "either because they are already present and therefore [need replacement] recognized by the analyses or because their compatibility with the existing ones can be assessed"[53] (Green Building Council Italia, 2016b, p. 33), are recommended to be performed as much as possible during the regeneration process[54].

The Waste Management strategy instead evaluates "Material Waste" and "Green Element System". A heterogeneous amount of waste is produced in the outdoor environment from mourning objects and materials/vegetation that needs to be constantly changed. Waste disposal management is intended to optimize the life cycle of these materials. Promoting the use of biodegradable materials for ornaments, controlling the process of plants and landscape waste, encouraging the use of certified products from a sustainable point of view, and instructing visitors and staff about their recycling or reuse, will help to reduce the transportation and disposal in landfills.

For cemeteries with mixed structures (vertical and horizontal), the Material and Waste Management strategy needs to be performed for both the Outdoor Environment and the Built Asset. Vertical and Underground Cemeteries can consider this indicator only for the Built Asset.

[52] The burial site is considered on the Built Asset.

[53] Translated by the author from Green Building Council Italia (2016b, p. 33).

[54] Translated by the author from HB Manual.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Advanced analysis: diagnostic tests on materials and degradation (Credit 1.2).

Sustainable Sites:

- Heat island effect: non-roof and roof (Credit 5 - Option 1 and 5).

Materials & Resources:

- Storage and collection of recyclables (Prerequisite 1);
- Materials reuse (Credit 3);
- Building product environmental optimization (Credit 4);
- Regional materials (Credit 5).

Sustainable SITES Initiative® Rating System:

Site Design - Soil + Vegetation:

- Optimize biomass (Credit 4.8);
- Reduce urban heat island effects (Credit 4.9).

Site Design - Materials Selection:

- Eliminate the use of wood from threatened tree species (Prerequisite 5.1);
- Reuse salvaged materials and plants (Credit 5.4);
- Use recycled content materials (Credit 5.5);
- Use regional materials (Credit 5.6);
- Support responsible extraction of raw materials (Credit 5.7);
- Support transparency and safer chemistry (Credit 5.8);
- Support sustainability in materials manufacturing (Credit 5.9).

Operations + Maintenance:

- Provide for storage and collection of recyclables (Prerequisite 8.2);
- Recycle organic matter (Credit 8.3).

OE9) Processes Management

INDICATOR + STRATEGY:

The Cemetery Management and Maintenance Plans should include also environmental inspections for the Outdoor Environment to ensure that air, soil and underground water are not being contaminated by chemical components (the Brazilian's law is an example). A predicted diagnostic to analyse when the cemetery will get fully occupied is strongly recommended to be performed, together with a site's transformation plan for when it will run off space.

The context with more relevance in Horizontal Cemeteries is the Outdoor Environment, thus at least one member of the design team has to be represented by a landscape specialist. It is fundamental to ensure the preservation of the environment, enhance biodiversity and manage the landscape properly.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Scheduled maintenance plan (Credit 5);

- Specialist in restoration of architectural heritage and landscape (Credit 6)*.

Innovation in design:

- GBC Accredited Professional (Credit 2).

* Adapted from the protocol to consider a landscape specialist to be part of the design team.

Sustainable SITES Initiative® Rating System:

Site Design - Materials Selection:

- Support sustainability in plant production (Credit 5.10).

Operations + Maintenance:

- Plan for sustainable site maintenance (Prerequisite 8.1).

Education + Performance Monitoring:

- Plan to monitor and report site performance (Credit 9.3).

OE10) Innovative Design Approach

INDICATOR + STRATEGY:

Each cemetery presents different characteristics and needs, and specific strategies may be planned. Professionals must be encouraged to find innovative solutions and achieve excellent performance in the areas of sustainability. Another aspect that can be the focus of attention is the integration with existing local priorities, especially what regards the environment based on the importance of the area where the project is located. The “Outdoor Environment” has a significant influence on the “Urban Infrastructure” context. In this way, cemeteries can contribute to projects planned for an urban scale with environmental, social, economic or cultural importance.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Innovation in design:

- Innovation in design (Credit 1 - Option 2).

Regional priority:

- Regional priority (Credit 1).

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Support physical activity (Credit 6.5);
- Support social connection (Credit 6.6);
- Provide on-site food production (Credit 6.7).

Innovation or exemplary performance:

- Innovation or exemplary performance (Credit 10.1).

4.3.3. Built Asset

BA1) Water Assessment

INDICATOR + STRATEGY:

Cemeteries depend on a water system on their buildings to supply toilets for staff and visitors (usually they are separated), sinks and pre-wash spray taps used for mortuary services and some structures may also make showers available for workers. Therefore, this indicator aimed at implementing strategies to increase water use efficiency in buildings (they can be present on “Heated Buildings” or “Unheated Buildings and Construction Structures” from Subheading 3.4.3) and ensure water saving.

Some examples of water management techniques to decrease the dependence on municipal water supply and wastewater systems regard the processing to collect, purify and reuse water from the built environment. In processes that do not require drinking water, it can be the use of devices to reduce the consumption of water; the design of a recycling system for greywater; the harvest of rainwater that falls on catchment surfaces and rooftops, etc.

Each functional unit present within the cemetery should have a meter installed to support the measuring of water consumption and identify additional water-saving opportunities. In the case of Horizontal Cemeteries, the water assessment has to be performed considering the Built Asset and the Outdoor Environment together, because it can also contribute to the pollution of the open spaces. Landscapes and buildings are supposed to be included during the development and implementation of the water management plan.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Sustainable Sites:

- Stormwater design: quantity and quality control (Credit 4)*.

Water Efficiency:

- Water use reduction (Prerequisite 1);

- Water use reduction (Credit 2);
- Water metering (Credit 3).

* Although better applicable to the Outdoor Environment because of its extension, the Built Asset can contribute to the pollution of stormwater.

Sustainable SITES Initiative® Rating System:

Site Design - Water:

- Manage precipitation on site (Prerequisite 3.1);
- Manage precipitation beyond baseline (Credit 3.3);

BA2) Energy and Emission

INDICATOR + STRATEGY:

Cemeteries use energy mainly for lighting and heating, such as the supply of internal lighting and heating systems, production of hot water, and general power supply. In this manner, to transform existing heated buildings into carbon zero and Nzeb buildings, it is important to consider that each individual building consists of different layers[55] (Salama, 2017), and in this indicator the ones analysed are skin, structure, services and space plan. Focusing on improving the efficiency of the envelope for existing buildings the "technical composition" (Durmisevic & Yeang, 2009) is summarized into the following subdivision:

- "structure" (composed of frame, floor, roof, stairs, etc);
- infill walls with openings (infill, windows, doors, etc) intended as the "skin";
- technological systems, e.g., water (plumbing, reservoirs), electricity (lighting, energy), ventilation, heating and cooling, as the "services";
- indoor space, as human health and well-being, for the "space plan".

Depending on the type of cemetery (horizontal or vertical), the amount of the Built Asset will change considerably. The Vertical Cemetery had all functions located inside the same building ("Heated Buildings" in Subheading 3.4.3); thus, it may be convenient to improve energy efficiency, provide greater comfort for workers and visitors and reduce the consumption of natural sources. On the other hand, the buildings of a Horizontal Cemetery are diffused in the landscape ("Unheated Buildings and Construction Structures" in Subheading 3.4.3), meaning that the heating spaces will be limited, and the consumption of energy will be mainly from lightning.

Before planning the intervention strategies, it is necessary to know the energy consumption of the buildings through energy audits to be able to find solutions that will focus on the specific situation and increase occupants' comfort. During its operation, measure the building's energy consumption and implement a *Measurement and*

[55] There are two other layers, site and stuff. For this analysis, the "site" layer is considered as the "Outdoor Environment", see Subheading 3.3 for more information. The "stuff" layer is related to the sustainable strategies of space settings and furnishings. It is an added value to the overall sustainability of the building, but it is not directly associated with the subject of study. Therefore, it is not considered in this research.

Verification Plan. Energy consumption from the Outdoor Environment should be considered in this planning when the cemetery type requires so.

Strategies for the efficient use of energy should be promoted with the scope of minimising the light dispersion from indoor lighting of the buildings, integrating renewable sources (green energy) in the cemetery, use low environmental impact technologies. The contribution of this indicator is the reduction of economic and environmental impacts of cemeteries and greenhouse gas emissions.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Advanced analysis: energy audit (Credit 1.1).

Sustainable Sites:

- Light pollution reduction (Credit 6 - Case 1).

Energy & Atmosphere:

- Minimum energy performance (Prerequisite 2);
- Fundamental refrigerant management (Prerequisite 3);
- Optimize energy performance (Credit 1);
- Renewable energies (Credit 2);
- Enhanced refrigerant management (Credit 4);
- Measurement and verification (Credit 5).

Sustainable SITES Initiative® Rating System:

Site Design - Soil + Vegetation:

- Use vegetation to minimize building energy use (Credit 4.10).

Operations + Maintenance:

- Use renewable sources for landscape electricity needs (Credit 8.6).

BEST PRACTICE EXAMPLE:

Figure 69 - The crematoria from the City of London Cemetery & Crematorium (London, UK) has solar panels installed on the rooftop, generating energy for the internal consumption of the cemetery.

An example of a cemetery that manages its energy consumption using a production system from renewable sources is the City of London Cemetery & Crematorium (Figure 69). Solar panels were installed on the rooftop of the crematoria for the generation of green energy. Even if it is not enough to cover the entire cemetery's energy consumption, because the crematoria consume an excessive amount of energy, it helps compensate for the cemetery's primary energy needs. Therefore, energy analysis should be one of the priorities in cases of existing crematoria or in the effort to install one.

BA3) Comfort and Wellbeing

INDICATOR + STRATEGY:

This indicator aims to increase the well-being and protect the health of staff and visitors, being related to the indoor air quality, use of non-toxic materials, as well as adequate thermal comfort, ventilation system and lighting system. It is important to guarantee a monitoring system that ensures the maintenance of the minimum requirements defined by law (in the absence of the latter, consider the requirements defined by the project) and to reduce contaminants.

Horizontal cemeteries are normally composed by a small amount of buildings, usually being used by staff from the cemetery and representing a minor level of concern in this matter. Particular attention should be taken to burial spaces, especially those located in confined spaces but not limited to (e.g. columbaria, ossuary and catacombs). This monitoring is intended to guarantee that chemical elements from the decomposition process do not represent a danger for the indoor environment of the cemetery.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

- Minimum indoor air quality performance (IAQ) (Prereq. 1);
- Air monitoring (Credit 1);
- Outdoor air delivery monitoring (Credit 2);
- Low-emitting materials: adhesives and sealants (Credit 4.1);
- Low-emitting materials: paints and coatings (Credit 4.2);
- Low-emitting materials: flooring systems (Credit 4.3);
- Low-emitting materials: composite wood and agrifiber products (Credit 4.4);
- Indoor chemical and pollutant source control (Credit 5);
- Controllability of systems: lighting (Credit 6.1);
- Controllability of systems: thermal comfort (Credit 6.2);
- Thermal comfort: design (Credit 7.1);
- Thermal comfort: verification (Credit 7.2).

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Provide optimum site accessibility, safety, and wayfinding (Credit 6.2).

BA4) Functional & Adaptability

INDICATOR + STRATEGY:

Cemeteries have a wide typology of buildings to manage, some of them older than others. The first step is to describe what should be considered historic, because its concept may be different depending on country, culture and education. This definition is part of the preliminary analysis (see "BA5) Heritage Conservation and Valorisation") and will guide the design team through the decision-making process.

Considering the preliminary analysis results, the design process should evaluate a varied use of individual spaces. It will contribute to extend the life cycle of the built heritage because the longer duration of the interventions supports the preservation of existing structures and reduce the consume of new materials. It helps preserve natural resources, reduce waste production and mitigate environmental impacts.

The cemetery functions have to be compatible with the characteristics of the building's typology and the evolution of the construction phases. This indicator is related to "Heated Buildings" and "Unheated Buildings and Construction Structures", supporting the preservation of existing buildings in all their components. It is especially connected to the "Burial Components" (Subheading 3.4.3), where it can be implemented with new burial spaces or burial sections within the existing configuration.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Compatible end-use (Credit 3.1).

Materials & Resources:

- Building reuse (Prerequisite 3);
- Building reuse: maintaining existing technical element and finishing (Credit 1).

Sustainable SITES Initiative® Rating System:

Site Design - Materials Selection:

- Design for adaptability and disassembly (Credit 5.3).

BEST PRACTICE EXAMPLE:

Figure 70 - The multifunctional chapel of the York Cemetery (UK).

The York Cemetery's chapel (Figure 70) is used for funeral services but can also be hired for concerts, art exhibitions, meetings, lectures and other events[56]. The cemetery counts also with a workshop space, the Harriet Centre, used for meetings or coffee breaks after tours. The indoor space is versatile, ample, has natural light, good acoustics and can accommodate 140 seats, counting with a heating system that helps to improve the comfort of occupants on cold days, typical of the United Kingdom. The Office Administrator is responsible for managing the use of the chapel and the management of the check deposits. This promotion of the cemetery creates spaces for the community and aims to ensure good conservation from social, cultural and economic aspects over time.

BA5) Heritage Conservation and Valorisation

INDICATOR + STRATEGY:

Sometimes regeneration interventions are needed to ensure that buildings still fit their original functions (see "Heated Buildings", "Unheated Buildings and Construction

[56] Information extracted from the cemetery's official website: https://www.yorkcemetery.org.uk/

Structures" and "Burial Components" in Subheading 3.4.3). This research deals with existing cemeteries, so it is fundamental to do a preliminary analysis of the site before start planning the interventions, including the definition of historic buildings once countries have their own legislation on the matter. With this definition, it will be possible to evaluate which interventions can be made on the buildings to best fit their existing function or to propose new ones (see "BA4) Functional & Adaptability").

This indicator aims to analyse the condition of the cemetery structure and to recognize the value of existing buildings and constructions based on their construction technologies, materials and structures. The preliminary analysis needs to consider every building located inside the cemetery, heated or unheated, different types of constructions and also the burial space. For this last one, it is important to identify the condition of existing burial spaces (safety) as well as their characteristics (materials, location, personal data of the deceased, etc).

The conservation of the testimonial value is guaranteed when a project respects the integrity of the building and allows for future restoration of its previous condition. Another advantage is that it will also reduce the demolition work both during the construction site and in the future of the additional parts. It means that any intervention (insertions, replacements or additions) can be removed in the future without damaging the existing structure. This procedure will allow the identification of the areas subject to conservation and those subject to renovation.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Preliminary analysis (Prerequisite 1);
- Project reversibility (Credit 2).

Sustainable SITES Initiative® Rating System:

Site Design - Materials Selection:

- Maintain on-site structures and paving (Credit 5.2).

BA6) Material and Waste Management

INDICATOR + STRATEGY:

Constructions located in different countries, with specific geographical and climate aspects, are compatible with a variety of materials. Therefore, the advanced analysis must include the diagnostic of restoration materials based on technical decisions and on the historical characteristics of existing buildings. Analyses of materials are performed for the recognition and characterization of their nature and the identification of the causes of the degradation processes. This process ensures that buildings have good quality materials and efficient global behaviour.

The combination of the Built Asset with nature-based strategies can help to reduce the local heat island effects through the implementation of strategies for

ecological architecture and sustainable constructions. Some examples are the use of materials with high solar reflectance index, installation of green roof systems and green walls on building facades.

Another important aspect to be evaluated is the waste produced by the occupants of the building, and in vertical structures, it includes also the waste from the burial space. Strategies examples are the collection and storage of recyclable materials, the reuse of materials and products, the use of recovered and certified materials, and so many others. To guarantee safety and indoor comfort in the Built Asset, especially including the burial space, it is fundamental for this indicator to interact with the Outdoor Environment.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Advanced analysis: diagnostic tests on materials and degradation (Credit 1.2);
- Advanced analysis: diagnostic tests on structures and structural monitoring (Credit 1.3);
- Chemical and physical compatibility of integrated materials (Credit 3.2);
- Structural compatibility (Credit 3.3).

Sustainable Sites:

- Heat island effect: non-roof and roof (Credit 5 - Option from 2 to 5).

Materials & Resources:

- Storage and collection of recyclables (Prerequisite 1);
- Materials reuse (Credit 3);
- Building product environmental optimization (Credit 4);
- Regional materials (Credit 5).

Sustainable SITES Initiative® Rating System:

Site Design - Soil + Vegetation:

- Reduce urban heat island effects (Credit 4.9).

Site Design - Materials Selection:

- Eliminate the use of wood from threatened tree species (Prerequisite 5.1);
- Reuse salvaged materials and plants (Credit 5.4);
- Use recycled content materials (Credit 5.5);
- Use regional materials (Credit 5.6);
- Support responsible extraction of raw materials (Credit 5.7);
- Support transparency and safer chemistry (Credit 5.8);
- Support sustainability in materials manufacturing (Credit 5.9).

BA7) Processes Management

INDICATOR + STRATEGY:

Making a renovation project of cemetery structures, especially ensuring the sustainability of these sites, is a complicated task of teamwork and must depend on different professionals. When the Built Asset is the predominant context of a cemetery structure, one of the members should be a specialist in the restoration of architectural heritage. It will guarantee the preservation of the testimonial characteristics of the built heritage and the optimization of the design and construction phases.

Continuous inspections over time ensure the conservation of the asset, therefore a Cemetery Management and Maintenance Plans must define and organize small maintenance interventions. It will reduce management costs in the long term by avoiding incisive interventions, especially on the “Burial Components” (Subheading 3.4.3). The aim is to maintain the performance and durability of each building present in the cemetery (functionality, quality, efficiency and economic value).

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Scheduled maintenance plan (Credit 5);
- Specialist in restoration of architectural heritage and landscape (Credit 6).

Innovation in design:

- GBC Accredited Professional (Credit 2).

Sustainable SITES Initiative® Rating System:

Education + Performance Monitoring:

- Plan to monitor and report site performance (Credit 9.3).

BA8) Innovative Design Approach

INDICATOR + STRATEGY:

Each cemetery has different characteristics and needs and specific strategies may be planned. Professionals must be encouraged to find innovative solutions and achieve excellent performance in the areas of sustainability. Another aspect that can be the focus of attention is the integration with existing local priorities, especially what regards the environment. In this way, cemeteries can contribute to projects planned for an urban scale with environmental, social, economic or cultural importance.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Innovation in design:

- Innovation in design (Credit 1).

Regional priority:

- Regional priority (Credit 1).

Sustainable SITES Initiative® Rating System:

Innovation or exemplary performance:

- Innovation or exemplary performance (Credit 10.1).

4.3.4. Cultural Heritage

CH1) Functional & Adaptability

INDICATOR + STRATEGY:

A cemetery has a well-defined function as a community landscape, being difficult and frequently impossible to propose new and eccentric uses. However, in some countries, cemeteries are part of the local community, with a wider role (civic memory, secular institution, sacred place, park, green infrastructure) and spaces that promote collective uses (events, competitions[57], tourism, etc.). In these cases the cemeteries are considered multifunctional landscapes, where different uses take place simultaneously in harmony.

This transformation is possible because the population accept behaviours that can equally coexist with a burial site and remembrance. When their interpretation of the cemetery change, cemeteries become a shared space with different meanings among visitors and represent the identity of that particular place. The result is the development of the cemetery into a place with a cultural and symbolic role, but that needs practical strategies to manage the multifunctionality.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Compatible end-use (Credit 3.1).

[57] Competitions reunite people with the same interesting's, in this case, cemetery and burial topics. They can promote local history, built heritage, tourism, maintenance, biodiversity, and many others. In United Kingdom there are some example applied on cemetery structures, such as the "Green Flag" award, "friend's" groups.

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Promote equitable site use (Credit 6.3);
- Support physical activity (Credit 6.5);
- Support social connection (Credit 6.6).

CH2) Heritage Conservation and Valorisation

INDICATOR + STRATEGY:

Cemeteries are places historically attached to the local community where they are located, with ancient burial practices and personal memories that are translated into funerary monuments. These symbolic expressions are marked with architectural components, such as areas reserved for specific traditions and social events. In multi-ethnic, or multiculture, cemeteries these expression are present in form of religious symbols and must be consider part of the cultural heritage.

There are also cultural beliefs that are expressed in cemeteries. Gravestones communicate the history and memories from a specific period of time to date, with private records (names, dates, personal statements transcript in stones, portraits) and artistic value (materials, sculptures, paintings, etc.). Many families and native cultures are still remembered in cemeteries even if they no longer exist, through individual stories that were conservated over time. Besides that, the cemetery layout, as well as historical and architectural features, are also important elements to preserve.

The preliminary analysis must evaluate the testimonial value of buildings and constructions, their historic value ("Historic Wealth and Identity Value", Subheading 3.4.4) and cultural heritage aspect ("Cultural Wealth", Subheading 3.4.4) of the Outdoor Environment and Built Asset. A complete analysis takes into consideration facts that happened during the cemetery development to understand why certain transformations happened and evaluates the importance of each one. The aim is to conservate the testimonial value of buildings, constructions and the site with interventions that respect the original condition of the space and do not damage their integrity.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Preliminary analysis (Prerequisite 1);
- Project reversibility (Credit 2).

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Protect and maintain cultural and historic places (Credit 6.1);
- Support mental restoration (Credit 6.4).

Education + Performance Monitoring:

- Promote sustainability awareness and education (Credit 9.1);
- Develop and communicate a case study (Credit 9.2).

CH3) Processes Management

INDICATOR + STRATEGY:

In a cemetery structure, it is important to preserve the "historical matter" as an environmental, social and cultural resource, enhancing the historic building existing within the project in its complexity. “To highlight directions for future inquiry, for example, it is necessary to understand to what extent different burial customs can coexist or how they can coexist by planning for commonalities that build coherence” (Scalenghe & Pantani, 2019). It means that the Cemetery Management and Maintenance Plans must also deal with cultural and historical value during the regeneration of burial spaces.

The aim is to preserve the identity of the cemetery and its local culture, while pursuing sustainable strategies and meeting licensing criteria during the cemetery operation. The relationship with experts in cemetery studies is important during the design phase to guarantee the respect of cultural aspects strictly related to the cemetery and its history. Each cemetery will need to relate to the local community differently, and these professionals can suggest the best way to do it. Therefore, this indicator promotes the integration with the other contexts by ensuring that at least one professional with a qualification in cultural heritage studies will participate on the design team.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Specialist in restoration of architectural heritage and landscape (Credit 6).

Innovation in design:

- GBC Accredited Professional (Credit 2).

Sustainable SITES Initiative® Rating System:

Pre-Design Assessment + Planning:

- Engage users and stakeholders (Credit 2.4).

Education + Performance Monitoring:

- Plan to monitor and report site performance (Credit 9.3).

CH4) Innovative Design Approach

INDICATOR + STRATEGY:

Each cemetery has different characteristics and needs, and specific strategies may be planned. Professionals must be encouraged to find innovative solutions and achieve excellent performance in the areas of sustainability. Another aspect that can be the focus of attention is the integration with existing local priorities, especially from cultural aspects, based on the importance of the area where the project is located. The "Cultural Heritage" is influenced by all the other contexts. In this way, cemeteries can contribute to projects planned for an urban scale with environmental, social, economic and cultural importance.

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Innovation in design:

- Innovation in design (Credit 1 - Option 2).

Regional priority:

- Regional priority (Credit 1).

Sustainable SITES Initiative® Rating System:

Site Design - Human Health + Well-Being:

- Provide on-site food production (Credit 6.7);
- Support local economy (Credit 6.11).

4.3.5. Construction Site

INDICATOR + STRATEGY:

The construction site during the renovation process of a cemetery is considered by this research as an independent indicator of sustainability because it is a process that has a short period of time and the activities performed are specific to the construction process, meaning that during the operation of the cemetery these elements will not be present. It is related to water, energy, material and waste management, comfort and well-being of the construction site and its surroundings.

This indicator aims to reduce the negative impacts on the environment created by construction activities. These impacts can be related to soil, water, noise and air pollution, use of non-renewable resources, waste production, etc. It will also enhance the well-being of those in contact with the construction site, including workers, cemetery staff, close inhabitants and species particularly sensitive to human presence. Strategies should consider sustainability for a variety of phenomena, such as the control of soil erosion and soil sedimentation, the flow of pollutants into the sewer system or onto the ground, the production of dust and acoustic discomfort; water and energy consumption; and the replacement of chemical materials with natural ones to facilitate their disposal.

A construction site is not restricted to the Built Asset, especially in a cemetery where several of its functions are spread over the landscape. The burial site can be seen as a continuous construction site that will influence the entire landform and Built Asset, with constant work on the landscape and waste from the landscape maintenance.

Depending on the burial types present within the cemetery, cemeteries should give preference to machinery and equipment with reduced noise and high energy efficiency. Therefore, the construction site needs to consider both contexts, the Outdoor Environment and the Built Asset, as a single element in order to achieve the aim of reducing its environmental impacts.

Specific documentation must be prepared to register the implementation of these strategies, along with describing the strategy's methods. It is important to communicate it to operators involved in the activities as well as to the external public. The last activity is the verification that technological and energy systems were correctly installed in accordance to the project documents. The construction site indicator regards mainly the Outdoor Environment and the Built Asset, and their relations to the rating systems are:

SUSTAINABLE PARAMETERS:

GBC Historic Building® Rating System:

Historic Value:

- Sustainable restoration site (Credit 4).

Sustainable Sites:

- Construction activity pollution prevention (Prerequisite 1).

Energy & Atmosphere:

- Fundamental commissioning of building energy systems (Prerequisite 1);
- Enhanced commissioning (Credit 3).

Materials & Resources:

- Demolition and construction waste management (Prerequisite 2);
- Demolition and construction waste management (Credit 2).

Indoor Environmental Quality:

- Construction IAQ management plan: during construction (Credit 3.1);
- Construction IAQ management plan: before occupancy (Credit 3.2).

Sustainable SITES Initiative® Rating System:

Construction:

- Communicate and verify sustainable construction practices (Prerequisite 7.1);
- Control and retain construction pollutants (Prerequisite 7.2);
- Restore soils disturbed during construction (Prerequisite 7.3);
- Restore soils disturbed by previous development (Credit 7.4);
- Divert construction and demolition materials from disposal (Credit 7.5);
- Divert reusable vegetation, rocks, and soil from disposal (Credit 7.6);
- Protect air quality during construction (Credit 7.7).

4.3.6. Synoptic overview of operational strategies

The operational guidance system is synthesised in Table 10 for the “Urban Infrastructure, Table 11 for the “Outdoor Environment”, Table 12 for the “Built Asset” and Table 13 for the “Cultural Heritage”. These tables illustrate some interesting facts about the distribution of sustainable strategies within the cemetery context. It shows how the cemetery’s characteristics influence the indicators and allows comparison between two international rating systems.

The tables have all indicators described in Subheading 4.2 listed by cemetery contexts (Subheading 3.3), allowing the analysis of the predominance of indicators for each individual context. On the left side, there is a code for every indicator used, which is composed of the abbreviation of the context and a sequence number, while on the right there is an explanation of the relation of the indicator with the cemetery structure. First, the explanation is through the association of the indicator with functional elements from Subheading 3.4, followed by a brief description. Functional elements can be related to more than one indicator.

In the last two columns, there are the credits extracted from GBC HB and SITES rating systems. The entire certifications were analysed and all the credits were associated with one indicator from one of the contexts. A credit may appear in more contexts or it may not be associated with a particular context. The GBC HB have a clear focus on the credit’s aims, so they appear only one time within a context, but SITES have a couple of credits with broad aims and they may appear in more than one indicator within a context.

For example, the credit *Heat island effect: non-roof and roof* from GBC HB appears only once on the Outdoor Environment and the Built Asset, but does not appear on the Urban Infrastructure or the Cultural Heritage. Looking into more details, it appears inside the *Material and Waste Management* indicator, the same for both contexts (OE8 and BA6). It also shows that are missing credits for some of the sustainable indicators, for example, the *Safety* indicator from the Outdoor Environment has no match with the GBC HB credits, and with one from SITES.

Table 10 - Synoptic table of sustainable strategies for cemetery structures, focused on the "Urban Infrastructure" context.

URBAN INFRASTRUCTURE					
CODE	**SUSTAINABLE INDICATOR**	**FUNCTIONAL ELEMENTS OF A CEMETERY**	**RELATION TO CEMETERY** (text from Subheading 4.3.1)	**TOOLS**	
				GBC Historic Building® Rating System	**Sustainable SITES Initiative®**
-	Water Assessment	-	-	-	-
-	Energy and Emission	-	-	-	-
UI1	Land Management*	Connection with existing urban environmental conditions Connection with the urban fabric	Include cemeteries in the municipality's natural system to improve the city's ecological condition.	-	**Site Context** - Conserve aquatic ecosystems (Prereq. 1.3) + Conserve habitats for threatened and endangered species (Prereq. 1.4)
					Pre-Design Assessment + Planning - Designate and communicate Vegetation and Soil Protection Zones (Prereq. 2.3)
UI2	Comfort and Well-being	Urban Accessibility Connection with the urban fabric	Guarantee public and alternative transportation to access the cemetery.	**Sustainable Sites** - Alternative transportation: public transportation access (Credit 2.1) + Alternative transportation: bicycle storage and changing rooms (Credit 2.2) + Alternative transportation: low-emitting and fuel-efficient vehicles (Credit 2.3) + Alternative transportation: parking capacity (Credit 2.4)	**Site Context** - Connect to multi-modal transit networks (Credit 1.5)
					Site Design - Human Health + Well-Being - Encourage fuel efficient and multi-modal transportation (Credit 6.9)
-	Safety	-	-	-	-
-	Functional & Adaptability	-	-	-	-
UI3	Heritage Conservation and Valorisation*	Connection with existing educational programmes and tourist routes	Connect the cemetery with existing scientific interests, educational programmes and tourist routes.	-	-
-	Material and Waste Management	-	-	-	-
UI4	Processes Management*	Zoning and Land Use planning Connection with the urban fabric	Create an integrated planning for the regeneration of several cemetery structures located within the same municipality.	**Historic Value** - Specialist in restoration of architectural heritage and landscape (Credit 6 - *urbanism specialist or connection to local authorities*)	**Site Context** – Limit development on farmland (Prereq. 1.1) + Protect floodplain functions (Prereq. 1.2) + Locate projects within existing developed areas (Credit 1.6)
				Innovation in Design - GBC Accredited Professional (Credit 2)	
UI5	Innovative Design Approach	Connection with the urban fabric	Connect the cemetery to the territory and include them in the urban system.	**Innovation in Design** - Innovation in design (Credit 1 - Option 2)	**Site Context** - Redevelop degraded sites (Credit 1.5)
				Regional Priority - Regional priority (Credit 1)	**Innovation or exemplary performance** - Innovation or exemplary performance (Credit 10.1)
-	~~Construction Site~~	Not applicable in "Urban Infrastructure"		-	-

Table 11 - Synoptic table of sustainable strategies for cemetery structures, focused on the "Outdoor Environment" context.

OUTDOOR ENVIRONMENT					
CODE	**SUSTAINABLE INDICATOR**	**FUNCTIONAL ELEMENTS OF A CEMETERY**	**RELATION TO CEMETERY** (text from Subheading 4.3.2)	**TOOLS**	
				GBC Historic Building® Rating System	**Sustainable SITES Initiative®**
OE1	Water Assessment	Site Topography Water Support System Use of Materials Green Element System	Increase water efficiency used in irrigation systems, management operations and ornamental purposes.	**Sustainable Sites** - Stormwater design: quantity and quality control (Credit 4)	**Site Context** - Protect floodplain functions (Prereq. 1.2)
				Water Efficiency - Water efficient landscaping (Credit 1) + Water metering (Credit 3)	**Site Design - Water** - Manage precipitation on site (Prereq. 3.1) + Reduce water use for landscape irrigation (Prereq. 3.2) + Manage precipitation beyond baseline (Credit 3.3) + Reduce outdoor water use (Credit 3.4) + Design functional stormwater features as amenities (Credit 3.5)
OE2	Energy and Emission	Lighting System and Electrical Support Road System Cultural Wealth Security System	Increase energy efficiency used to illuminate the site and individual burial spaces.	**Historic Value** - Advanced analysis: energy audit (Credit 1.1 - Option 1)	**Site Design - Human Health + Well-Being** - Reduce light pollution (Credit 6.8)
				Sustainable Sites - Light pollution reduction (Credit 6 - Case 2)	
				Energy & Atmosphere - Minimum energy performance (Prereq. 2) + Optimize energy performance (Credit 1) + Renewable energies (Credit 2) + Measurement and verification (Credit 5)	**Operations + Maintenance** - Reduce outdoor energy consumption (Credit 8.5) + Use renewable sources for landscape electricity needs (Credit 8.6)
OE3	Land Management*	Site Topography Use of Materials Green Element System	Adjust composition layout to abiotic conditions, having special attention to the soil, the underground water and green elements.	**Sustainable Sites** - Brownfield redevelopment (Credit 1) + Site development: open spaces recovery (Credit 3)	**Site Design - Water** - Restore aquatic ecosystems (Credit 3.6)
					Site Design - Soil + Vegetation - Create and communicate a soil management plan (Prereq. 4.1) + Control and manage invasive plants (Prereq. 4.2) + Use appropriate plants (Prereq. 4.3) + Conserve healthy soils and appropriate vegetation (Credit 4.4) + Conserve special status vegetation (Credit 4.5) + Conserve and use native plants (Credit 4.6) + Conserve and restore native plant communities (Credit 4.7) + Reduce the risk of catastrophic wildfire (Credit 4.11)
					Operations + Maintenance - Minimize pesticide and fertilizer use (Credit 8.4)
OE4	Comfort and Well-being	Site Topography Logistic Information System Security System Road System Green Element System	Ensure available accessibility, diversity in the internal mobility of the cemetery, effective signage, etc.	**Indoor Environmental Quality** - Environmental Tobacco Smoke (ETS) control (Prereq. 2 - Case 1) + Outdoor air delivery monitoring (Credit 2)	**Site Design - Human Health + Well-Being** - Provide optimum site accessibility, safety, and wayfinding (Credit 6.2) + Support mental restoration (Credit 6.4) + Minimize exposure to environmental tobacco smoke (Credit 6.10)
					Operations + Maintenance - Protect air quality during landscape maintenance (Credit 8.7)
OE5	Safety	Security System Logistic Information System	Install a video surveillance system to guaranteeing a safe environment for visitors.	-	**Site Design - Human Health + Well-Being** - Provide optimum site accessibility, safety, and wayfinding (Credit 6.2)
OE6	Functional & Adaptability	Site Topography	Establish new burial sections, green areas and compatible natural uses.	**Historic Value** - Compatible end-use (Credit 3.1)	**Site Design - Materials Selection** - Design for adaptability and disassembly (Credit 5.3)

OE7	Heritage Conservation and Valorisation*	Green Element System Site Topography Use of Materials Road System Security System	Guarantee the reversibility of the interventions to the original conditions of the site.	**Historic Value** - Preliminary analysis (Prereq. 1) + Project reversibility (Credit 2)	-
OE8	Material and Waste Management	Material Waste Use of Materials Road System Green Element System	Use an accurate selection of materials and optimize their life cycle.	**Historic Value** - Advanced analysis: diagnostic tests on materials and degradation (Credit 1.2)	**Site Design - Soil + Vegetation** - Optimize biomass (Credit 4.8) + Reduce urban heat island effects (Credit 4.9)
				Sustainable Sites - Heat island effect: non-roof and roof (Credit 5 - Option 1 and 5)	**Site Design - Materials Selection** - Eliminate the use of wood from threatened tree species (Prereq. 5.1) + Reuse salvaged materials and plants (Credit 5.4) + Use recycled content materials (Credit 5.5) + Use regional materials (Credit 5.6) + Support responsible extraction of raw materials (Credit 5.7) + Support transparency and safer chemistry (Credit 5.8) + Support sustainability in materials manufacturing (Credit 5.9)
				Materials & Resources - Storage and collection of recyclables (Prereq. 1) + Materials reuse (Credit 3) + Building product environmental optimization (Credit 4) + Regional materials (Credit 5)	**Operations + Maintenance** - Provide for storage and collection of recyclables (Prereq. 8.2) + Recycle organic matter (Credit 8.3)
OE9	Processes Management*	Logistic Information System Security System Material Waste Road System Green Element System	Include in the Cemetery Management and Maintenance Plans environmental inspections, a plan for the occupation of the burial spaces and a site's transformation plan for future development of the cemetery.	**Historic Value** - Scheduled maintenance plan (Credit 5) + Specialist in restoration of architectural heritage and landscape (Credit 6 - *landscape specialist*)	**Site Design - Materials Selection** - Support sustainability in plant production (Credit 5.10)
					Operations + Maintenance - Plan for sustainable site maintenance (Prereq. 8.1)
				Innovation in design - GBC Accredited Professional (Credit 2)	**Education + Performance Monitoring** - Plan to monitor and report site performance (Credit 9.3)
OE10	Innovative Design Approach	General	Use innovative solutions to achieve excellent performance in the areas of sustainability.	**Innovation in design** - Innovation in design (Credit 1 - Option 2)	**Site Design - Human Health + Well-Being** - Support physical activity (Credit 6.5) + Support social connection (Credit 6.6) + Provide on-site food production (Credit 6.7)
				Regional priority - Regional priority (Credit 1)	**Innovation or exemplary performance** - Innovation or exemplary performance (Credit 10.1)
OE-CS	Construction Site	General	Reduce the negative impacts on the environment created by construction activities and enhance the well-being of those in contact with the construction site.	**Historic Value** - Sustainable restoration site (Credit 4)	**Construction** - Communicate and verify sustainable construction practices (Prereq. 7.1) + Control and retain construction pollutants (Prereq. 7.2) + Restore soils disturbed during construction (Prereq. 7.3) + Restore soils disturbed by previous development (Credit 7.4) + Divert construction and demolition materials from disposal (Credit 7.5) + Divert reusable vegetation, rocks, and soil from disposal (Credit 7.6) + Protect air quality during construction (Credit 7.7)
				Sustainable Sites - Construction activity pollution prevention (Prereq. 1)	
				Energy & Atmosphere - Fundamental commissioning of building energy systems (Prereq. 1) + Enhanced commissioning (Credit 3)	
				Materials & Resources - Demolition and construction waste management (Prereq. 2) + Demolition and construction waste management (Credit 2)	

Table 12 - Synoptic table of sustainable strategies for cemetery structures, focused on the "Built Asset" context.

BUILT ASSET					
CODE	**SUSTAINABLE INDICATOR**	**FUNCTIONAL ELEMENTS OF A CEMETERY**	**RELATION TO CEMETERY** (text from Subheading 4.3.3)	**TOOLS**	
				GBC Historic Building® Rating System	**Sustainable SITES Initiative®**
BA1	Water Assessment	Heated Buildings Unheated Buildings and Construction Structures	Increase water efficiency used inside buildings for toilets and mortuary services.	**Sustainable Sites** - Stormwater design: quantity and quality control (Credit 4) **Water Efficiency** - Water use reduction (Prereq. 1) + Water use reduction (Credit 2) + Water metering (Credit 3)	**Site Design - Water** - Manage precipitation on site (Prereq. 3.1) + Manage precipitation beyond baseline (Credit 3.3)
BA2	Energy and Emission	Heated Buildings Unheated Buildings and Construction Structures Burial Components	Increase energy efficiency used for lighting and heating in the built asset.	**Historic Value** - Advanced analysis: energy audit (Credit 1.1) **Sustainable Sites** - Light pollution reduction (Credit 6 - Case 1) **Energy & Atmosphere** - Minimum energy performance (Prereq. 2) + Fundamental refrigerant management (Prereq. 3) + Optimize energy performance (Credit 1) + Renewable energies (Credit 2) + Enhanced refrigerant management (Credit 4) + Measurement and verification (Credit 5)	**Site Design - Soil + Vegetation** - Use vegetation to minimize building energy use (Credit 4.10) **Operations + Maintenance** - Use renewable sources for landscape electricity needs (Credit 8.6)
-	Land Management*	-	-	-	-
BA3	Comfort and Well-being	Heated Buildings Unheated Buildings and Construction Structures Accessibility Burial Components	Increase the well-being and protect the health of staff and visitors.		**Site Design - Human Health + Well-Being** - Provide optimum site accessibility, safety, and wayfinding (Credit 6.2)
-	Safety	-	-	-	-
BA4	Functional & Adaptability	Heated Buildings Unheated Buildings and Construction Structures Burial Components	Identify cemetery functions that are compatible with the characteristics of the building's typology.	**Historic Value** - Compatible end-use (Credit 3.1) **Materials & Resources** - Building reuse (Prereq. 3) + Building reuse: maintaining existing technical element and finishing (Credit 1)	**Site Design - Materials Selection** - Design for adaptability and disassembly (Credit 5.3)
BA5	Heritage Conservation and Valorisation*	Heated Buildings Unheated Buildings and Construction Structures Burial Components	Recognize the value of existing buildings and constructions based on their construction technologies, materials and structures.	**Historic Value** - Preliminary analysis (Prereq. 1) + Project reversibility (Credit 2)	**Site Design - Materials Selection** - Maintain on-site structures and paving (Credit 5.2)

BA6	Material and Waste Management	Heated Buildings Unheated Buildings and Construction Structures Burial Components	Ensures that buildings have good quality materials for an efficient global behaviour and optimize their life cycle.	**Historic Value** - Advanced analysis: diagnostic tests on materials and degradation (Credit 1.2) + Advanced analysis: diagnostic tests on structures and structural monitoring (Credit 1.3) + Chemical and physical compatibility of integrated materials (Credit 3.2) + Structural compatibility (Credit 3.3)	**Site Design - Soil + Vegetation** - Optimize biomass (Credit 4.8) + Reduce urban heat island effects (Credit 4.9)
				Sustainable Sites - Heat island effect: non-roof and roof (Credit 5 - Option from 2 to 5)	**Site Design - Materials Selection** - Eliminate the use of wood from threatened tree species (Prereq. 5.1) + Reuse salvaged materials and plants (Credit 5.4) + Use recycled content materials (Credit 5.5) + Use regional materials (Credit 5.6) + Support responsible extraction of raw materials (Credit 5.7) + Support transparency and safer chemistry (Credit 5.8) + Support sustainability in materials manufacturing (Credit 5.9)
				Materials & Resources - Storage and collection of recyclables (Prereq. 1) + Materials reuse (Credit 3) + Building product environmental optimization (Credit 4) + Regional materials (Credit 5)	**Operations + Maintenance** - Provide for storage and collection of recyclables (Prereq. 8.2) + Recycle organic matter (Credit 8.3)
BA7	Processes Management*	Heated Buildings Unheated Buildings and Construction Structures Burial Components	Organize small maintenance interventions according to the Cemetery Management and Maintenance Plans.	**Historic Value** - Scheduled maintenance plan (Credit 5) + Specialist in restoration of architectural heritage and landscape (Credit 6).	**Education + Performance Monitoring** - Plan to monitor and report site performance (Credit 9.3)
				Innovation in design - GBC Accredited Professional (Credit 2)	
BA8	Innovative Design Approach	Heated Buildings Unheated Buildings and Construction Structures Accessibility Burial Components	Encouraged to find innovative solutions and achieve excellent performance in the areas of sustainability.	**Innovation in design** - Innovation in design (Credit 1)	**Innovation or exemplary performance** - Innovation or exemplary performance (Credit 10.1)
				Regional priority - Regional priority (Credit 1)	
BA-CS	Construction Site	General	Reduce the negative impacts on the environment created by construction activities and enhance the well-being of those in contact with the construction site.	**Historic Value** - Sustainable restoration site (Credit 4)	**Construction** - Communicate and verify sustainable construction practices (Prereq. 7.1) + Control and retain construction pollutants (Prereq. 7.2) + Divert construction and demolition materials from disposal (Credit 7.5) + Protect air quality during construction (Credit 7.7)
				Sustainable Sites -Construction activity pollution prevention (Prereq. 1)	
				Energy & Atmosphere - Fundamental commissioning of building energy systems (Prereq. 1) + Enhanced commissioning (Credit 3)	
				Materials & Resources - Demolition and construction waste management (Prereq. 2) + Demolition and construction waste management (Credit 2)	

Table 13 - Synoptic table of sustainable strategies for cemetery structures, focused on the "Cultural Heritage" context.

CULTURAL HERITAGE					
CODE	**SUSTAINABLE INDICATOR**	**FUNCTIONAL ELEMENTS OF A CEMETERY**	**RELATION TO CEMETERY** (text from Subheading 4.3.4)	**TOOLS**	
				GBC Historic Building® Rating System	**Sustainable SITES Initiative®**
-	Water Assessment	-	-	-	-
-	Energy and Emission	-	-	-	-
-	Land Management*	-	-	-	-
-	Comfort and Well-being	-	-	-	-
-	Safety	-	-	-	-
CH1	Functional & Adaptability	Cultural Wealth	Encourage multifunctional cemeteries with different uses that takes place simultaneously in harmony.	**Historic Value** - Compatible end-use (Credit 3.1)	**Site Design - Human Health + Well-Being** - Promote equitable site use (Credit 6.3) + Support physical activity (Credit 6.5) + Support social connection (Credit 6.6)
CH2	Heritage Conservation and Valorisation*	Historic Wealth and Identity Value Cultural Wealth	Conservate the testimonial value of buildings, constructions and the site, with interventions that respect the original condition of the space and do not damage their integrity.	**Historic Value** - Preliminary analysis (Prereq. 1) + Project reversibility (Credit 2)	**Site Design - Human Health + Well-Being** - Protect and maintain cultural and historic places (Credit 6.1) + Support mental restoration (Credit 6.4) **Education + Performance Monitoring** - Promote sustainability awareness and education (Credit 9.1) + Develop and communicate a case study (Credit 9.2)
-	Material and Waste Management	-	-	-	-
CH3	Processes Management*	Historic Wealth and Identity Value Cultural Wealth Information Exchange System	Preserve the identity of the cemetery and its local culture, while pursuing sustainable strategies and meeting licensing criteria during the cemetery operation.	**Historic Value** - Specialist in restoration of architectural heritage and landscape (Credit 6 - *specialist in cultural heritage*) **Innovation in design** - GBC Accredited Professional (Credit 2)	**Pre-Design Assessment + Planning** - Engage users and stakeholders (Credit 2.4) **Education + Performance Monitoring** - Plan to monitor and report site performance (Credit 9.3)
CH4	Innovative Design Approach	Historic Wealth and Identity Value Cultural Wealth Information Exchange System	Encouraged to find innovative solutions and achieve excellent performance in the areas of sustainability.	**Innovation in design** - Innovation in design (Credit 1 - Option 2) **Regional priority** - Regional priority (Credit 1)	**Site Design - Human Health + Well-Being** - Provide on-site food production (Credit 6.7) + Support local economy (Credit 6.11)
-	~~Construction Site~~	Not applicable in "Cultural Heritage"		-	-

4.4. INDICATORS IN RELATION TO DIFFERENT TYPES OF CEMETERY STRUCTURE

Planning proper interventions is important to reduce the use of resources and maintenance costs over time. The guidance system evaluates cemeteries using sustainable indicators represented by functional elements connected to sustainable strategies. These indicators are described for each cemetery's contexts explaining why the strategy is important for the cemetery structure and its contribution to urban sustainability. However, each cemetery have its own features, meaning that before operating the guidance system, it is necessary to evaluate specific aspects of the cemetery structure that will be regenerated.

After defining the indicators necessary to assess the sustainability of cemetery structures, the procedure to achieve a positive impact balance from buildings should consist of four steps. First the definition of the purpose and scope of the regeneration project will give a clearer idea about which indicator to give preference during the decision-making process. Many indicators will benefit from information obtained from the whole life cycle of the building and measurement of environmental impact, thus a database with this information should be developed during the regeneration planning of the cemetery. This information is also required to proceed to the next step, which is the impact assessment of alternative scenarios. Finally, the design team must interpret the results obtained in order to define the interventions to be implemented.

In order to decide the indicators to apply on the cemetery structure in study, it is necessary to evaluate two factors that will influence on the decision-making process. First cemeteries can be influenced by their management type (private or public) and their location (urban or suburban). Thus, the strategies described for the "Urban Infrastructure" are listed in Table 14, showing the influence of the two characteristics over the cemetery structure management.

Table 14 - Urban Infrastructure Indicators listed and classified with different weights for Management Type (private and public) and the Location of Cemetery Structure (urban or suburban). A single "X" means the indicator should be considered, two "XX" means the priority should be taken, and a "-" means the indicator does not apply.

Indicators	Management Type		Location	
	Private	Public	Urban	Suburban
UI1 - Land Management	-*	XX	XX	X
UI2 - Comfort and Wellbeing	X **	XX	X	XX
UI3 - Heritage Conservation and Valorisation	X	X	X	X
UI4 - Processes Management	-***	XX	XX	XX
UI5 - Innovative Design Approach	XX	XX	XX	X

* a private cemetery can ensure greener areas on the cemetery's perimeter, which will help to connect it with other urban green areas.
** a private cemetery has to ensure the maximum possibilities of accessibility transportation as possible (with parking lots for as many types of transportation as possible, locate entrances close to public transportation stops, etc).
*** the private sector should be stimulated to participate in urban regeneration planning.

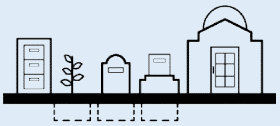
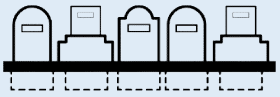
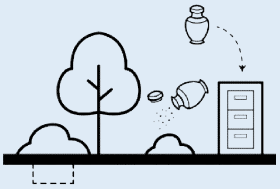
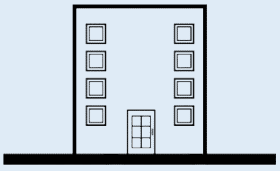
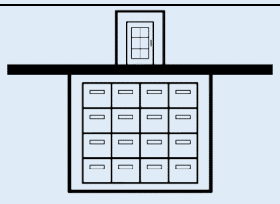
Public cemeteries are more likely to contribute to strategies in the urban context once they are managed by the local authority (see Subheading 2.7.2), but nothing interferes with private cemeteries pursuing strategies to contribute to local priorities. The research identified three indicators, out of five, where the private cemetery can actively contribute to the sustainable management of the urban infrastructure (UI2, UI3 and UI5).

The difference between urban and suburban cemeteries is the location regarding the urban context, which can be measured by the number of urban boundaries. Urban cemetery faces all sides with the city, in other words, it is surrounded by the urban area. While suburban cemetery faces on one side the city and the other side the rural area.

Besides the urban characteristics, cemeteries have different features inside their perimeter, therefore the Outdoor Environment, the Built Asset and the Cultural Heritage indicators will have different priorities for each case. Some indicators are related to fundamental aspects of a cemetery, such as UI2, UI4 and OE5, and should be mandatory to all types of cemeteries. Other indicators will have different priorities depending on the type of cemetery and the aim of the regeneration planning (e.g. heritage conservation, landscape renovation, improvement of management processes, incentive technical and cultural innovations, etc), and were individuate in Table 15. It is important to highlight that this is a general division of the indicators, interventions can and must adapt the implementation of the guidance system to specific cases.

Indicators related to the conservation and enhancement of the cultural heritage are better related to Monumental Cemeteries, because of the predominance of monuments with a great social and cultural value. Landscape indicators should be prioritized in Lawn Cemeteries or Gardens of Remembrance, once they are composed of a big amount of green and open areas. These indicators are very important to contribute to urban resilience and should be pursued by all types of cemetery, but it may be difficult to implement strategies on cemeteries that are almost entirely occupied by burial spaces and monument of different forms. Finally, single floor cemeteries share similar physical characteristics between them, as well multi floor cemeteries, which means that they share the same indicators necessary to improve management and introduce innovations.

Table 15 - Different types of cemetery structure are listed and classified with different priorities for each sustainable indicators. A "-" means there are no indicators that apply to that regeneration purpose.

<table>
<tr><th rowspan="2">TYPES OF CEMETERY STRUCTURE</th><th colspan="4">PURPOSE OF REGENERATION INTERVENTION</th></tr>
<tr><th>HERITAGE CONSERVATION</th><th>LANDSCAPE RENOVATION</th><th>IMPROVE MANAGEMENT</th><th>INCENTIVATE INNOVATION</th></tr>
<tr><td> 
REGULAR CEMETERY</td><td>CH3</td><td>OE4 + OE6</td><td rowspan="4">OE1 + OE2 + OE8 + OE9</td><td rowspan="4">UI5
OE10
CH1 + CH4</td></tr>
<tr><td> 
MONUMENTAL CEMETERY</td><td>UI3
OE7
CH2</td><td>OE4</td></tr>
<tr><td> 
LAWN CEMETERY</td><td>OE7
CH2</td><td>UI1
OE3</td></tr>
<tr><td> 
GARDEN OF REMEMBRANCE</td><td>CH3</td><td>UI1
OE3 + OE6</td></tr>
<tr><td> 
VERTICAL CEMETERY</td><td>BA5 + BA7</td><td>UI1</td><td rowspan="2">BA1 + BA2 + BA3 + BA6</td><td rowspan="2">UI5
BA4 + BA8
CH1 + CH4</td></tr>
<tr><td> 
UNDERGROUND CEMETERY</td><td>BA7
CH3</td><td>-</td></tr>
</table>

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Figure Cover Chapter 5: Burial landscape at the Abbey Lane Cemetery (Sheffield, UK).

5.1. EVALUATION AND OBSERVATIONS OF THE RESULTS OBTAINED

The promotion of actions aimed at the sustainable redevelopment of cemetery structures is still a relatively unexplored area for the scientific community and citizens. The cemetery is associated with the external and the internal environment, making the redevelopment action complex since there are many interlocutors and constraints. In this context, it was revealed a **widespread need phenomenon for the redevelopment** of cemetery structures. This statement is driven by multiple reasons, in particular:

- to avoid environmental contamination and public health problems from the decomposition of organic matter, improper disposal of material waste and unstable memorials;
- to improve the quality of urban living by reducing the segregation between the cemetery structure and the urban context, responding to climatic and environmental characteristics;
- to enhance the cultural value and the historical materials within the cemetery by increasing the inclusion of the cemetery as a multifunctional public space for the local community;

The analysis of the assessment of cemetery structures from an integrated perspective demonstrates that these infrastructures can contribute significantly to the sustainable scenario.

The research framework is based on field investigations and meetings with managers, counting also with the involvement of experts on the topic during an international mobility programme. The experiences and observations gathered during this process allowed the **emergence of some observations** about conditions that can affect the implementation of the guidance system.

Complexity of the topic. It is not possible to talk only about environmental and energy efficiency in the regeneration of cemetery structures due to the vast number of aspects required to cover the operation of the burial area. The topics of expertise associated with this particular sector are social dimension and environmental systems. To achieve sustainability in cemetery structures, the management aspect is decisive, especially as regards the integration of the various aspects.

Technological upgrading. The awareness of the need for technological updating has recently increased in cemetery structures and some managers are already applying sustainable strategies. In certain cases, the renewal of structures and the expansion or construction of a new building are already considering sustainable improvements.

Optimization of the burial area. The greater frequency of interventions is attributable to actions aimed at optimizing the use of space for burials. This attitude includes an interpretation of the life cycle of the same and the benefits deriving from the possibility of having an integrated and more effective system. Other interventions aimed at improving the burial performance also include actions for measuring social aspects, adapting new technics and updating equipment.

Design support. A few specific technical guides have been developed for cemetery structures to support the designer in the preliminary and inherent phases of the design. Even if they are valuable indicators and an integrated tool for this research, it was noticed that they lack on guidelines for aspects related to management strategies and cultural heritage.

Given the observations regarding the panorama of prevailing actions, some **criticalities have also been identified**. Factors that increase the level of complexity seem to hinder technological implementation in this sense.

Economic private and public resources. The management of the economic relationships that exist between managers and owners of a cemetery in the case of redevelopment appears to be particularly problematic. In the public sector, managers may claim the need to carry out improvements, but they operate on a tight budget and have to wait until public funding becomes available. Private cemeteries are more independent from this point of view, where the will of the owners regarding redevelopment depends on the relationship between benefits and profits. Except in the case of specific funding, actions not strictly related to emergency interventions for regulatory compliance appear rather rare.

Difficulty accessing the site. Because it is a complicated topic to interfere on a burial site, it increases the level of isolation. Few authorities are willing to intervene in legal matters, but when it happens there are interesting proposals for environmental indicators for this sector. Thus, to avoid further disturbance and also to respect the bound is funeral services, the quickest planning actions are favoured.

5.1.1. Verification between purposes and results obtained

The achieved results of the research was that of sorting interdisciplinary topic in order to arrange the overall concept of cemetery, giving a new vision and knowledge on the subject. The combined methodology support specifically the classification of different cemetery elements (Burial Space, Burial Section and Cemetery Structure), the identification of functional elements necessary for the operation of a cemetery and the determination of the cemetery environment into four contexts (Urban Infrastructure, Outdoor Environment, Built Asset and Cultural Heritage).

The final result was that of a guidance system with new operating concepts that an infrastructure characterized by open spaces should consider for sustainable management. Besides that, the literature review was fundamental to establish which gaps are still present and which areas need to be deeply investigated, while the site observation provided a deep analysis of the criticalities and potentialities of specific cemetery features in different locations.

Considering the field limitation to operating cemeteries, located in urban cities from the Western world influenced by European culture, it was very difficult to dissociate from religious practices and focus on cultural dynamics. Another constraint is the legal factor, which potential to contribute to the sustainable transition is not explored and often represents a barrier.

Given the complexity and specificity of the cemetery, some considerations can be extended to cases with similar contexts. The tool is structured on the characteristics of a cemetery structure, thus the considerations regarding managing the site, the environment and the social interactions may remain valid. Anyway, appropriate adaptation to the guidance system needs to be carried out for different types of cemeteries, not only in terms of the strategies to be implemented but also in the determination of the indicators that best suit the type of cemetery to be regenerated.

Operational planning and strategies for the regeneration of cemeteries.

Cemeteries have been built over time as a response to the need for an indispensable infrastructure, what has not simultaneously evolved was a definition of valid operational trends for the achievement of sustainable performances. It was noticed that interventions carried out are often a consequence of the desire to extend the operation of the cemetery over time instead of aiming to improve the space. This phenomenon generated different space and cultural requirements but allowed the identification of important aspects.

A guidance system has been made explicit which integrates the specific aspects developed in the various parts of the research. It provides the answers to questions surrounding sustainability in the urban environment through the regeneration of cemetery structures. In particular, it defines an interdisciplinary framework of cemetery aspects, indicates operational strategies, and creates a simplified decision and behavioural support tool.

The burial space and the management of the structure concentrate the major efforts to satisfy the burial request and maintain a balanced operation system, representing the main feature of concern of the tool. The difficulty of intervening in the regeneration process of cemeteries is associated with the complexity of the intersections of various interdisciplinary aspects and the impossibility of bringing innovative solutions without going through a long bureaucratic process.

Definition of the state of the art.

There was some lack of reference data that impacted the development of the research. There are few data on guidelines, mandatory indications or incentives aimed at improving the cemetery structures and territorial protection. The research revealed that the “Built Asset” and “Urban Infrastructure” receive support from existing literature, on the other hand, references to the “Outdoor Environment” are a handful of and to the “Cultural Heritage” are almost none.

The guidance tool aims to integrate different aspects directly related to the cemetery structure, even those that are not usually considered during a sustainable planning. It identifies the positive interactions between the various aspects, highlighting topics that need to act synergistically to achieve the research aim. In addition, it also illustrates the extent and type of constraints before the implementation of specific

regeneration actions. This stage demonstrates the complexity of the theme and the real need to intervene in these spaces. International studies demonstrate that the concerns present in this research are extensible to other contexts.

Characterization of the cemetery.

From the observation of the selected sites for the identification of particular cemetery characteristics, some tendencies were identified. Through the assessment and examination of the parts of which the cemetery is composed, the following basic principles emerged in the current state of these assets.

Breakdowns and malfunctions of the burials, which have to be restored by the owner of the burial space, cause the safety of the space to be compromised. Intervention for the restoration is guaranteed by the cemetery staff only after a long bureaucratic process. It is appropriate to highlight the impossibility of activating instantaneous deviations of people flows within the cemetery.

Applicability of existing sustainable certifications in the cemetery.

Specific reference data are useful to express considerations and identify measurable margins for improvements. The interaction and comparison of these values would allow greater precision to estimate the benefits of certain interventions. In the absence of parameterisation references the intervention can implement targeted but uncoordinated actions, which can bring unsatisfactory results. The variety of cemetery types complicates the organization of the guidance tool, but it can be solved if some cemeteries followed an existing rating system adding a “Pilot Credit” specific to the sector, while other types analysed each indicator individually.

From a quantitative perspective, the indicators that are mostly covered by the existing rating systems analysed are the environmental parameters, such as energy performance, as well as waste, material, and water management. The indicators that are less considered are related to social (Cultural Heritage context) and urban parameters (Urban Infrastructure context) on both certifications, while economic parameters are affected by existing credits but are not the aim of the certification.

Another observation is that GBC HB regards mainly historic buildings from the Built Asset, but with some small changes, it can also be adapted to the Outdoor Environment. It happens the opposite with SITES, which focuses much more on the Outdoor Environment and only a few credits consider the Built Asset. Therefore, if the cemetery management aims to achieve sustainable levels through existing rating systems, nowadays it would not be possible to apply only one certification and integrated planning will be needed.

5.1.2. Open issues and suggestions for future developments

Although the management for the redevelopment of a cemetery was complex, the proposal of a simplified tool to support the planning process was considered indispensable. In the phases of evaluating the feasibility and opportunity for the requalification of cemetery structures, it was recognized the need to integrate other

factors that do not directly fall within the intentions and areas investigated by the proposed decision-making process support tool.

The present research has a wide margin for improvement and provides important input in setting directions for future research. Although the applicability of the concept has been shown by this research, future work can be done on specifying, extending and validating the categorization of elements of a cemetery structure as well as the development of sustainability indicators.

Users and visitors may be engaged in the evaluation phases, integrating the observations and feedback collected with the monitored and parameterised data. In the case of continuation and refinement of the work, it will be a priority to acquire and analyse data on specifically identified case studies, data as the functional interactions and the distribution criteria. A further aspect of analysis, only partially addressed in the research, could concern the benefits of an energy and environmental quality certification system for cemeteries. The collection of precise data and subsequent verification of the procedure during construction contribute to obtaining environmental well-being.

Definition of parameters that interacts with cultural value. There are some examples in the literature of ways to monitor the Outdoor Environment, but for the Cultural Heritage, there are not sufficiently significant data. The attention needed for the implementation of a cultural indicator, therefore, concerns the tangible and intangible aspects of a cemetery structure. It can be achieved through the collection of data relating to the morphological, technological, constructive and distributive characteristics of the cemetery.

Start the development of experimentation methodologies. One way to implement the results of the research would be the experimentation and optimization of the procedure during the project, on a sample case. Specific areas of analysis can be developed in order to generate guidelines, useful for the development of specific legislation or the definition of qualitative regulations on a voluntary basis.

Assist with the operational and legislative process. A proposal for renovation of the legislation associated with the urban scale usually happens every 10 years. It is time enough to evaluate if the proposal is working properly and if there are interventions to be made. Some countries use it as a routine procedure, while other follows the current needs. There are cases where the legislation related to cemetery issues is about to expire or it is already expired.

The administrative and territorial fields are in many cases overlapping in terms of competencies, in particular regions, provinces, municipalities and associations. It represents a great opportunity to incorporate all these competencies with sustainable concepts and to encourage a tight interaction of the organizational management system.

GLOSSARY

Figure Cover Glossary: Crematoria at the Cimitero Monumentale della Certosa di Ferrara (Ferrara, Italy).

The following terms were extracted from the literature review, websites, interviews and other sources of information coming from the scientific community and sources related to the theme in study. They refer to specific concepts related to cemetery structures and their definition are important to understand how a burial space works.

CEMETERY: a place where dead bodies and cremated remains are buried; a place where “bodies decompose after burial in open fields termed cemeteries” (Neckel et al., 2017, p. 217).

BURIAL TECHNIQUES: description of the methods of final disposition or manners of dealing with a dead body.

INHUMATION or INTERMENT: the coffin is placed under the ground, leaving the degradable elements in contact with the environment; this method usually puts the coffin inside a grave.

ENTOMBMENT: the coffin is placed inside a concrete or a brick manufacture, isolating the decomposable elements from the external environment; it may use graves, tombs or niches to place the coffin.

MUMMIFICATION or EMBALMING: the preservation of a dead body, whereby it does not occur the decomposition of the organic matter; it may be intentional (embalming) or accidental (mummification) through the exposure to chemicals, extreme cold, very low humidity or lack of air; if the method is intentional, it normally uses the mausoleum to place the coffin, on the other side, the accidental preservation of the corpse may occur in any type of burial.

CREMATION: involves the incineration of the corpse through combustion and the subsequent transformation of the mineral residues into ashes; the ashes are storage inside a special urn; it is an alternative to traditional burial (inhumation or entombment), “recognized by researchers as an ecological solution” (Anna and Ewa, 2020).

EXHUMATION: the process of taken out the remains of a dead body from where it is buried so that it can be examined in order to find out the identity of the person buried or the cause of death.

NATURAL BURIAL PROCESS: an eco-friendly burial that aims to do have a minimum impact on the environment.

BURIAL TYPE: description of the single element or place where the dead body or the coffin may be storage.

TOMB: a burial element built above ground level, it may be half buried or entirely above ground; it uses tombstones for the identification of the dead body, typical element of traditional burial; type of building often used for European-style burials of family tombs.

GRAVE: a burial element entirely below ground level with only a gravestone that emerges above ground for the necessary identification of the dead body; depending on the depth of the hole dug below ground level, it may be left uncovered or it may be shaped with a concrete or a brick structure; because they are covered with lawn, it allows a vegetal composition on the cemetery space (Anna and Ewa, 2020).

MAUSOLEUM: a monument which contains a person or an entire family that is famous or have a great social, cultural or economic significance.

NICHE: a compartment (a cavity “built further back than the rest of the wall”) intended for a single burial (Neckel et al., 2017) that follows the principle of a “drawer”; it may compose a vertical element with a small number of vaults or it may compose an entire building for a more serial and compacted storage; it may also be located under the floor and inside walls in certain places (cemeteries, churches).

BURIAL GROUNDS TYPE: description of a space within the cemetery based on the burial type present inside that particular area.

GRAVESITE: an area of land destined to receive burials, specifically graves; a “grass buried field” (Anna and Ewa, 2020).

URN FIELD: it allows unified headstone inscriptions and larger areas covered with lawn (Anna and Ewa, 2020).

COLUMBARIUM: a structure “with niches for urns containing the ashes of cremated bodies” (Anna and Ewa, 2020) that may be distributed as urn walls, urn steles and courtyards; the name may vary according to cultural motivations and management choices.

CATACOMB: an underground cemetery, especially under a city, consisting of tunnels and rooms where people used to be buried inside niches dug on the wall or on the floor.

MEMORIAL GARDEN: “distinct space dedicated to forms of burial other than inhumation“ (Anna and Ewa, 2020).

OTHER ELEMENTS RELATED TO THE CEMETERY:

MEMORIAL or MONUMENT: a structure or an object built as a remembrance in honour of someone or something (an event for example); in the cemetery it is placed above the sepulchre to identify the person buried and it can take different shapes: a headstone, a monument, a cross, a flat stone, kerbing, etc; typically made of marble, granite, or a combination of stone and bronze.

HEADSTONE: a memorial stone which stands at the head of a burying place with the name of the dead person engraved on it with the purpose of identifying the person buried and marking the burial place ; it may be called “tombstone” (Anna and Ewa, 2020), when located at the head of a tomb, or “gravestone”, when located at the head of a grave.

COFFIN: the case or box in which a dead body is buried or cremated; different materials may be used: wood, wicker/cane, cardboard, biodegradable materials, shrouds, etc; synonyms as “casket” (Neckel et al., 2017).

URN: container in which the final product of the cremation, the ashes, is stored; depending on local legislation it may be mandatory to store the urns in a special space within recognized cemetery structures, sometimes in smaller niches than those for the coffin; if family members are allowed to keep the urn with them, there are several alternatives available: the storage in urns of the most varied shapes, the use of urns to plant a tree or the legal scattering of ashes in nature.

CHAPEL: a small building or room with its own altar used for worship by some members of the Christian religion that offers exclusively funeral services; a funeral home that may have a public or a private use inside the cemetery.

APPENDIX A: LIST OF BURIAL SITES THAT CONTRIBUTED TO THE ANALYSIS OF CEMETERY CONFIGURATION

Interesting examples have been found in other structures that were not included in the methodology processes. The reason is that the data were collected prior to this research or they were analysed in a non-systemic way. Table 16 shows the complete list of cemeteries and churchyards used for the analysis of cemetery configuration.

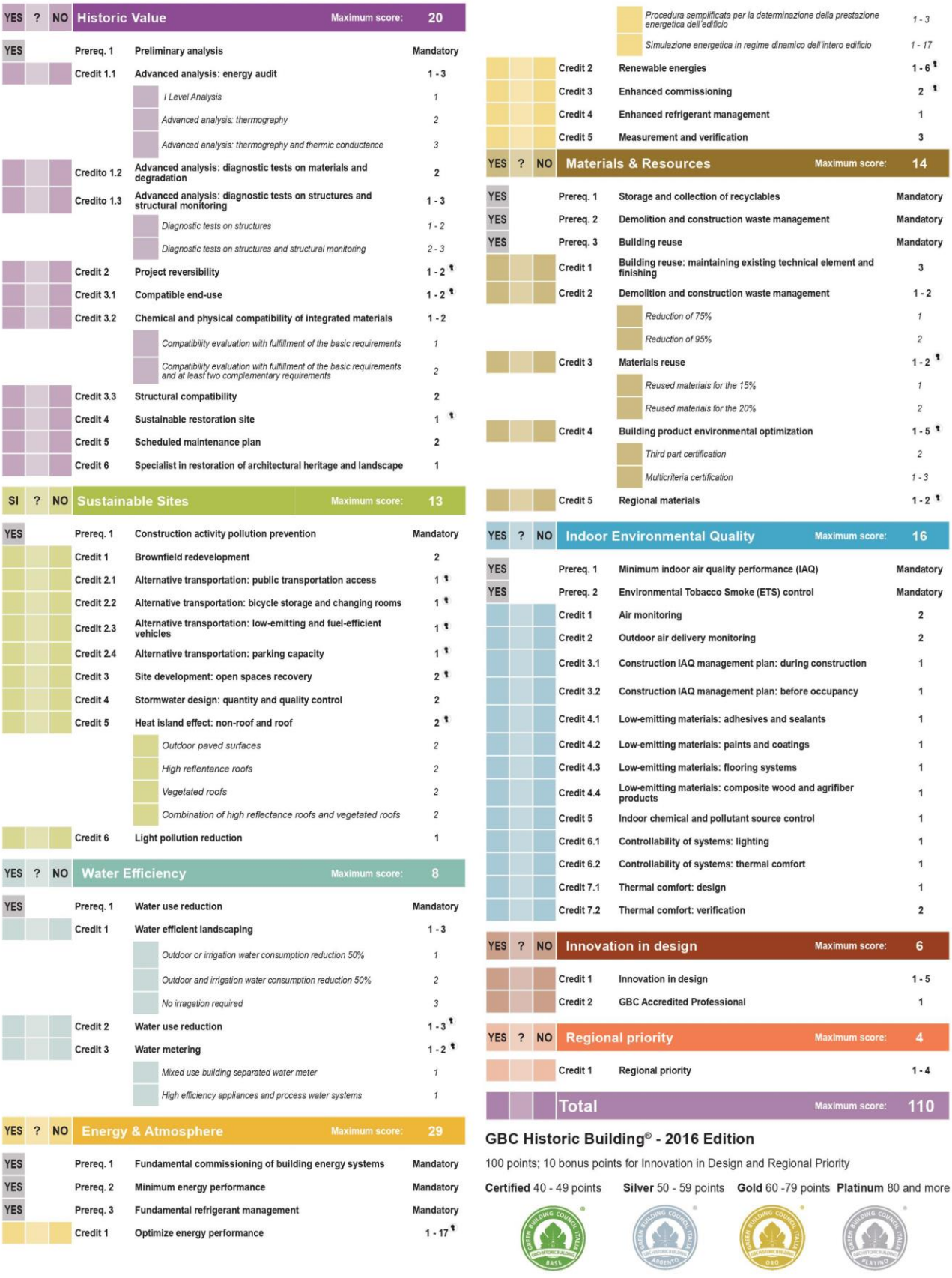
Table 16 - Complete list of cemeteries chosen for the analysis of cemetery configuration, followed by their location and the type of cemetery structure according to this research. The list is in alphabetical order by the original name of the cemetery.

N.	Cemetery Name	City (Country)	Type of Cemetery Structure
1	*Abbey Lane Cemetery*	Sheffield (UK)	Lawn Cemetery
2	*Abney Park Cemetery*	London (UK)	Lawn Cemetery
3	*Arlington National Cemetery*	Arlington (USA)	Lawn Cemetery
4	*Bushey Cemetery (old and new)*	London (UK)	Regular Cemetery
5	*Cemitério da Ordem Terceira de São Francisco de Assis*	São João del-Rei (Brazil)	Regular Cemetery
6	*Cemitério Municipal Água Verde*	Curitiba (Brazil)	Regular Cemetery
7	*Cimetière du Montparnasse*	Paris (France)	Monumental Cemetery
8	*Cimetière du Père-Lachaise*	Paris (France)	Monumental Cemetery
9	*Cimitero di San Cataldo*	Modena (Italy)	Regular Cemetery[58]
10	*Cimitero Ebraico di Ferrara*	Ferrara (Italy)	Lawn Cemetery
11	*Cimitero Monumentale della Certosa di Bologna*	Bologna (Italy)	Monumental Cemetery
12	*Cimitero Monumentale della Certosa di Ferrara*	Ferrara (Italy)	Monumental Cemetery
13	*Cimitero Monumentale di Milano*	Milan (Italy)	Monumental Cemetery
14	*City Road Cemetery and Crematorium*	Sheffield (UK)	Lawn Cemetery
15	*Crookes Cemetery*	Sheffield (UK)	Lawn Cemetery
16	*Glasgow Necropolis*	Glasgow (Scotland)	Lawn Cemetery
17	*Greyfriars Kirkyard*	Edinburgh (Scotland)	Churchyard
18	*Hutcliffe Wood Garden of Remembrance*	Sheffield (UK)	Garden of Remembrance
19	*Igreja de Nossa Senhora do Rosário dos Pretos*	Tiradentes (Brazil)	Churchyard
20	*Minharot Olam*	Jerusalem (Israel)	Underground Cemetery
21	*Necrópole Ecumênica Vertical Universal*	Curitiba (Brazil)	Vertical Cemetery
22	*St Nicholas' Churchyard*	Sheffield (UK)	Churchyard
23	*Tomb of Dante*	Ravenna (Italy)	Tomb / Mausoleum
24	*Wisewood Cemetery*	Sheffield (UK)	Lawn Cemetery
25	*York Cemetery*	York (UK)	Lawn Cemetery

[58] The *Cimitero di San Cataldo* (Modena, Italy) is considered a Regular Cemetery because following the previous classification, the cemetery is not composed predominantly of mausoleums

APPENDIX B: GBC HISTORIC BUILDING CHECK LIST

The GBC Historic Building Check List was extracted from Green Building Council Italia (2016a, p. 4).



YES	?	NO	Historic Value	Maximum score: 20	
YES			Prereq. 1	Preliminary analysis	Mandatory
			Credit 1.1	Advanced analysis: energy audit	1 - 3
				I Level Analysis	*1*
				Advanced analysis: thermography	*2*
				Advanced analysis: thermography and thermic conductance	*3*
			Credito 1.2	Advanced analysis: diagnostic tests on materials and degradation	2
			Credito 1.3	Advanced analysis: diagnostic tests on structures and structural monitoring	1 - 3
				Diagnostic tests on structures	*1 - 2*
				Diagnostic tests on structures and structural monitoring	*2 - 3*
			Credit 2	Project reversibility	1 - 2 ¹
			Credit 3.1	Compatible end-use	1 - 2 ¹
			Credit 3.2	Chemical and physical compatibility of integrated materials	1 - 2
				Compatibility evaluation with fulfillment of the basic requirements	*1*
				Compatibility evaluation with fulfillment of the basic requirements and at least two complementary requirements	*2*
			Credit 3.3	Structural compatibility	2
			Credit 4	Sustainable restoration site	1 ¹
			Credit 5	Scheduled maintenance plan	2
			Credit 6	Specialist in restoration of architectural heritage and landscape	1

SI	?	NO	Sustainable Sites	Maximum score: 13	
YES			Prereq. 1	Construction activity pollution prevention	Mandatory
			Credit 1	Brownfield redevelopment	2
			Credit 2.1	Alternative transportation: public transportation access	1 ¹
			Credit 2.2	Alternative transportation: bicycle storage and changing rooms	1 ¹
			Credit 2.3	Alternative transportation: low-emitting and fuel-efficient vehicles	1 ¹
			Credit 2.4	Alternative transportation: parking capacity	1 ¹
			Credit 3	Site development: open spaces recovery	2 ¹
			Credit 4	Stormwater design: quantity and quality control	2
			Credit 5	Heat island effect: non-roof and roof	2 ¹
				Outdoor paved surfaces	*2*
				High reflentance roofs	*2*
				Vegetated roofs	*2*
				Combination of high reflectance roofs and vegetated roofs	*2*
			Credit 6	Light pollution reduction	1

YES	?	NO	Water Efficiency	Maximum score: 8	
YES			Prereq. 1	Water use reduction	Mandatory
			Credit 1	Water efficient landscaping	1 - 3
				Outdoor or irrigation water consumption reduction 50%	*1*
				Outdoor and irrigation water consumption reduction 50%	*2*
				No irragation required	*3*
			Credit 2	Water use reduction	1 - 3 ¹
			Credit 3	Water metering	1 - 2 ¹
				Mixed use building separated water meter	*1*
				High efficiency appliances and process water systems	*1*

YES	?	NO	Energy & Atmosphere	Maximum score: 29	
YES			Prereq. 1	Fundamental commissioning of building energy systems	Mandatory
YES			Prereq. 2	Minimum energy performance	Mandatory
YES			Prereq. 3	Fundamental refrigerant management	Mandatory
			Credit 1	Optimize energy performance	1 - 17 ¹
				Procedura semplificata per la determinazione della prestazione energetica dell'edificio	*1 - 3*
				Simulazione energetica in regime dinamico dell'intero edificio	*1 - 17*
			Credit 2	Renewable energies	1 - 6 ¹
			Credit 3	Enhanced commissioning	2 ¹
			Credit 4	Enhanced refrigerant management	1
			Credit 5	Measurement and verification	3

YES	?	NO	Materials & Resources	Maximum score: 14	
YES			Prereq. 1	Storage and collection of recyclables	Mandatory
YES			Prereq. 2	Demolition and construction waste management	Mandatory
YES			Prereq. 3	Building reuse	Mandatory
			Credit 1	Building reuse: maintaining existing technical element and finishing	3
			Credit 2	Demolition and construction waste management	1 - 2
				Reduction of 75%	*1*
				Reduction of 95%	*2*
			Credit 3	Materials reuse	1 - 2 ¹
				Reused materials for the 15%	*1*
				Reused materials for the 20%	*2*
			Credit 4	Building product environmental optimization	1 - 5 ¹
				Third part certification	*2*
				Multicriteria certification	*1 - 3*
			Credit 5	Regional materials	1 - 2 ¹

YES	?	NO	Indoor Environmental Quality	Maximum score: 16	
YES			Prereq. 1	Minimum indoor air quality performance (IAQ)	Mandatory
YES			Prereq. 2	Environmental Tobacco Smoke (ETS) control	Mandatory
			Credit 1	Air monitoring	2
			Credit 2	Outdoor air delivery monitoring	2
			Credit 3.1	Construction IAQ management plan: during construction	1
			Credit 3.2	Construction IAQ management plan: before occupancy	1
			Credit 4.1	Low-emitting materials: adhesives and sealants	1
			Credit 4.2	Low-emitting materials: paints and coatings	1
			Credit 4.3	Low-emitting materials: flooring systems	1
			Credit 4.4	Low-emitting materials: composite wood and agrifiber products	1
			Credit 5	Indoor chemical and pollutant source control	1
			Credit 6.1	Controllability of systems: lighting	1
			Credit 6.2	Controllability of systems: thermal comfort	1
			Credit 7.1	Thermal comfort: design	1
			Credit 7.2	Thermal comfort: verification	2

YES	?	NO	Innovation in design	Maximum score: 6	
			Credit 1	Innovation in design	1 - 5
			Credit 2	GBC Accredited Professional	1

YES	?	NO	Regional priority	Maximum score: 4	
			Credit 1	Regional priority	1 - 4

			Total	Maximum score: 110

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100 points; 10 bonus points for Innovation in Design and Regional Priority

Certified 40 - 49 points **Silver** 50 - 59 points **Gold** 60 -79 points **Platinum** 80 and more

APPENDIX C: SUSTAINABLE SITES INITIATIVE RATING SYSTEM SCORECARD

The Sustainable SITES Initiative Rating System Scorecard was extracted from the SITES Certification Resources website (https://sustainablesites.org/resources) on 21 May 2021.

SITES v2 Scorecard Summary

YES	?	NO			
0	0	0	**1: SITE CONTEXT**	**Possible Points:**	**13**
Y			**CONTEXT P1.1**	Limit development on farmland	
Y			**CONTEXT P1.2**	Protect floodplain functions	
Y			**CONTEXT P1.3**	Conserve aquatic ecosystems	
Y			**CONTEXT P1.4**	Conserve habitats for threatened and endangered species	
			CONTEXT C1.5	Redevelop degraded sites	3 to 6
			CONTEXT C1.6	Locate projects within existing developed areas	4
			CONTEXT C1.7	Connect to multi-modal transit networks	2 to 3
0	0	0	**2: PRE-DESIGN ASSESSMENT + PLANNING**	**Possible Points:**	**3**
Y			**PRE-DESIGN P2.1**	Use an integrative design process	
Y			**PRE-DESIGN P2.2**	Conduct a pre-design site assessment	
Y			**PRE-DESIGN P2.3**	Designate and communicate VSPZs	
			PRE-DESIGN C2.4	Engage users and stakeholders	3
0	0	0	**3: SITE DESIGN - WATER**	**Possible Points:**	**23**
Y			**WATER P3.1**	Manage precipitation on site	
Y			**WATER P3.2**	Reduce water use for landscape irrigation	
			WATER C3.3	Manage precipitation beyond baseline	4 to 6
			WATER C3.4	Reduce outdoor water use	4 to 6
			WATER C3.5	Design functional stormwater features as amenities	4 to 5
			WATER C3.6	Restore aquatic ecosystems	4 to 6
0	0	0	**4: SITE DESIGN - SOIL + VEGETATION**	**Possible Points:**	**40**
Y			**SOIL+VEG P4.1**	Create and communicate a soil management plan	
Y			**SOIL+VEG P4.2**	Control and manage invasive plants	
Y			**SOIL+VEG P4.3**	Use appropriate plants	
			SOIL+VEG C4.4	Conserve healthy soils and appropriate vegetation	4 to 6
			SOIL+VEG C4.5	Conserve special status vegetation	4
			SOIL+VEG C4.6	Conserve and use native plants	3 to 6
			SOIL+VEG C4.7	Conserve and restore native plant communities	4 to 6
			SOIL+VEG C4.8	Optimize biomass	1 to 6
			SOIL+VEG C4.9	Reduce urban heat island effects	4
			SOIL+VEG C4.10	Use vegetation to minimize building energy use	1 to 4
			SOIL+VEG C4.11	Reduce the risk of catastrophic wildfire	4
0	0	0	**5: SITE DESIGN - MATERIALS SELECTION**	**Possible Points:**	**41**
Y			**MATERIALS P5.1**	Eliminate the use of wood from threatened tree species	
			MATERIALS C5.2	Maintain on-site structures and paving	2 to 4
			MATERIALS C5.3	Design for adaptability and disassembly	3 to 4
			MATERIALS C5.4	Use salvaged materials and plants	3 to 4
			MATERIALS C5.5	Use recycled content materials	3 to 4
			MATERIALS C5.6	Use regional materials	3 to 5
			MATERIALS C5.7	Support responsible extraction of raw materials	1 to 5
			MATERIALS C5.8	Support transparency and safer chemistry	1 to 5
			MATERIALS C5.9	Support sustainability in materials manufacturing	5
			MATERIALS C5.10	Support sustainability in plant production	1 to 5

YES	?	NO			
0	0	0	**6: SITE DESIGN - HUMAN HEALTH + WELL-BEING**	**Possible Points:**	**30**
			HHWB C6.1	Protect and maintain cultural and historic places	2 to 3
			HHWB C6.2	Provide optimum site accessibility, safety, and wayfinding	2
			HHWB C6.3	Promote equitable site use	2
			HHWB C6.4	Support mental restoration	2
			HHWB C6.5	Support physical activity	2
			HHWB C6.6	Support social connection	2
			HHWB C6.7	Provide on-site food production	3 to 4
			HHWB C6.8	Reduce light pollution	4
			HHWB C6.9	Encourage fuel efficient and multi-modal transportation	4
			HHWB C6.10	Minimize exposure to environmental tobacco smoke	1 to 2
			HHWB C6.11	Support local economy	3
0	0	0	**7: CONSTRUCTION**	**Possible Points:**	**17**
Y			**CONSTRUCTION P7.1**	Communicate and verify sustainable construction practices	
Y			**CONSTRUCTION P7.2**	Control and retain construction pollutants	
Y			**CONSTRUCTION P7.3**	Restore soils disturbed during construction	
			CONSTRUCTION C7.4	Restore soils disturbed by previous development	3 to 5
			CONSTRUCTION C7.5	Divert construction and demolition materials from disposal	3 to 4
			CONSTRUCTION C7.6	Divert reusable vegetation, rocks, and soil from disposal	3 to 4
			CONSTRUCTION C7.7	Protect air quality during construction	2 to 4
0	0	0	**8. OPERATIONS + MAINTENANCE**	**Possible Points:**	**22**
Y			**O+M P8.1**	Plan for sustainable site maintenance	
Y			**O+M P8.2**	Provide for storage and collection of recyclables	
			O+M C8.3	Recycle organic matter	3 to 5
			O+M C8.4	Minimize pesticide and fertilizer use	4 to 5
			O+M C8.5	Reduce outdoor energy consumption	2 to 4
			O+M C8.6	Use renewable sources for landscape electricity needs	3 to 4
			O+M C8.7	Protect air quality during landscape maintenance	2 to 4
0	0	0	**9. EDUCATION + PERFORMANCE MONITORING**	**Possible Points:**	**11**
			EDUCATION C9.1	Promote sustainability awareness and education	3 to 4
			EDUCATION C9.2	Develop and communicate a case study	3
			EDUCATION C9.3	Plan to monitor and report site performance	4
0	0	0	**10. INNOVATION OR EXEMPLARY PERFORMANCE**	**Bonus Points:**	**9**
			INNOVATION C10.1	Innovation or exemplary performance	3 to 9

YES	?	NO			
0	0	0	TOTAL ESTIMATED POINTS	Total Possible Points:	200

KEY		SITES Certification levels	Points
YES	Project confident points are achievable	CERTIFIED	70
?	Project striving to achieve points, not 100% confident	SILVER	85
NO	Project is unable to achieve these credit points	GOLD	100
		PLATINUM	135

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